DATA 608 Meetup 7: Working With Color

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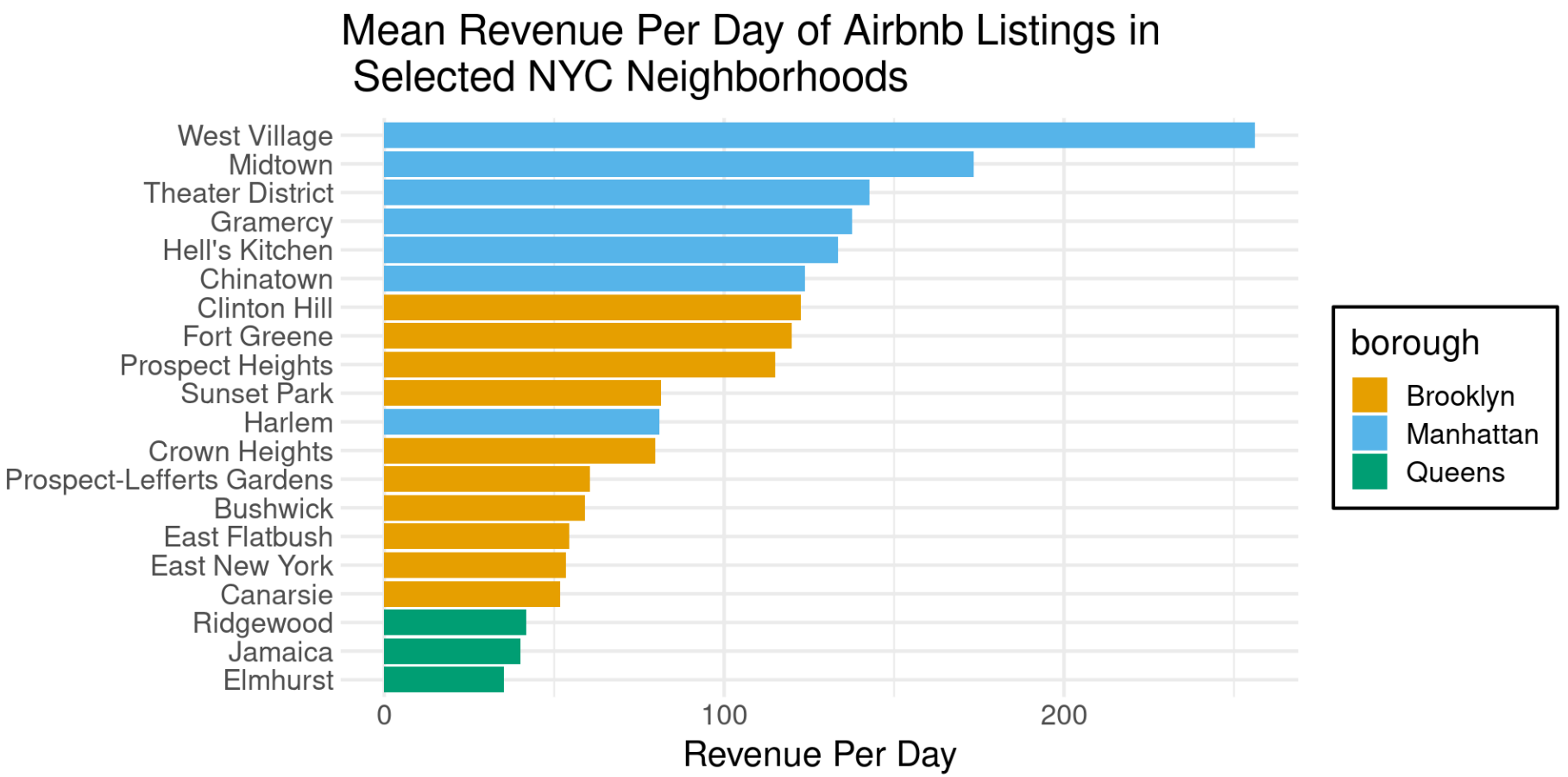
Weekly Summary

- This week is all about how to control colors in R
- Chapter 4 (and 19) of Fundamentals
- Chapter 4 of Storytelling
- Okabe-Ito Page https://jfly.uni-koeln.de/color/
- New Assignment: Airbnb Revenues in NYC
- No Discussion Next Two Weeks

Three Uses of Color

- Color to Distinguish



Three Uses of Color

- Qualitative Colormaps

Okabe Ito

Three Uses of Color

- Qualitative Colormaps

ColorBrewer Dark2

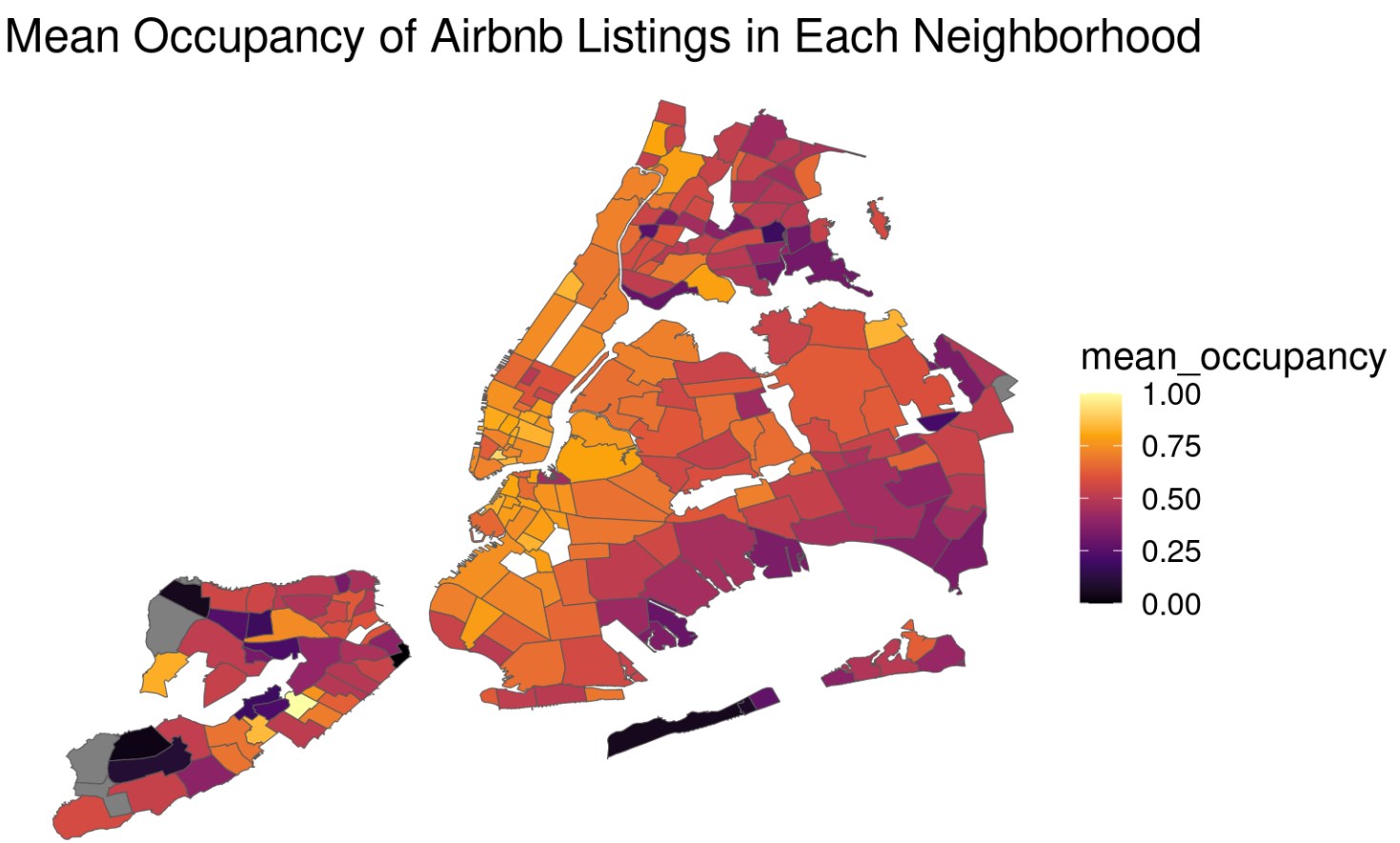
Three Uses of Color

- Qualitative Colormaps

ggplot2 hue

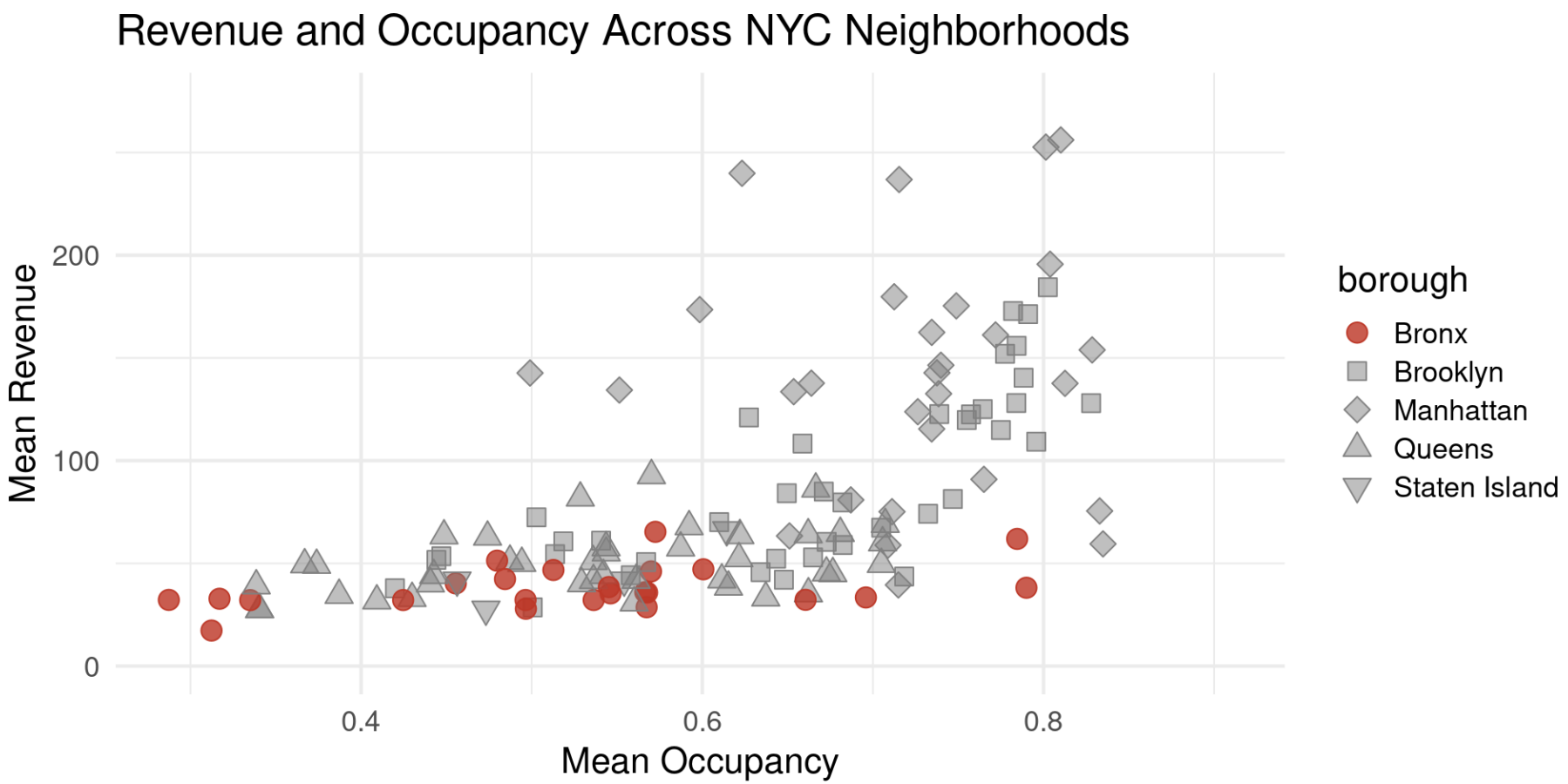
Three Uses of Color

- Represent Numerical Values



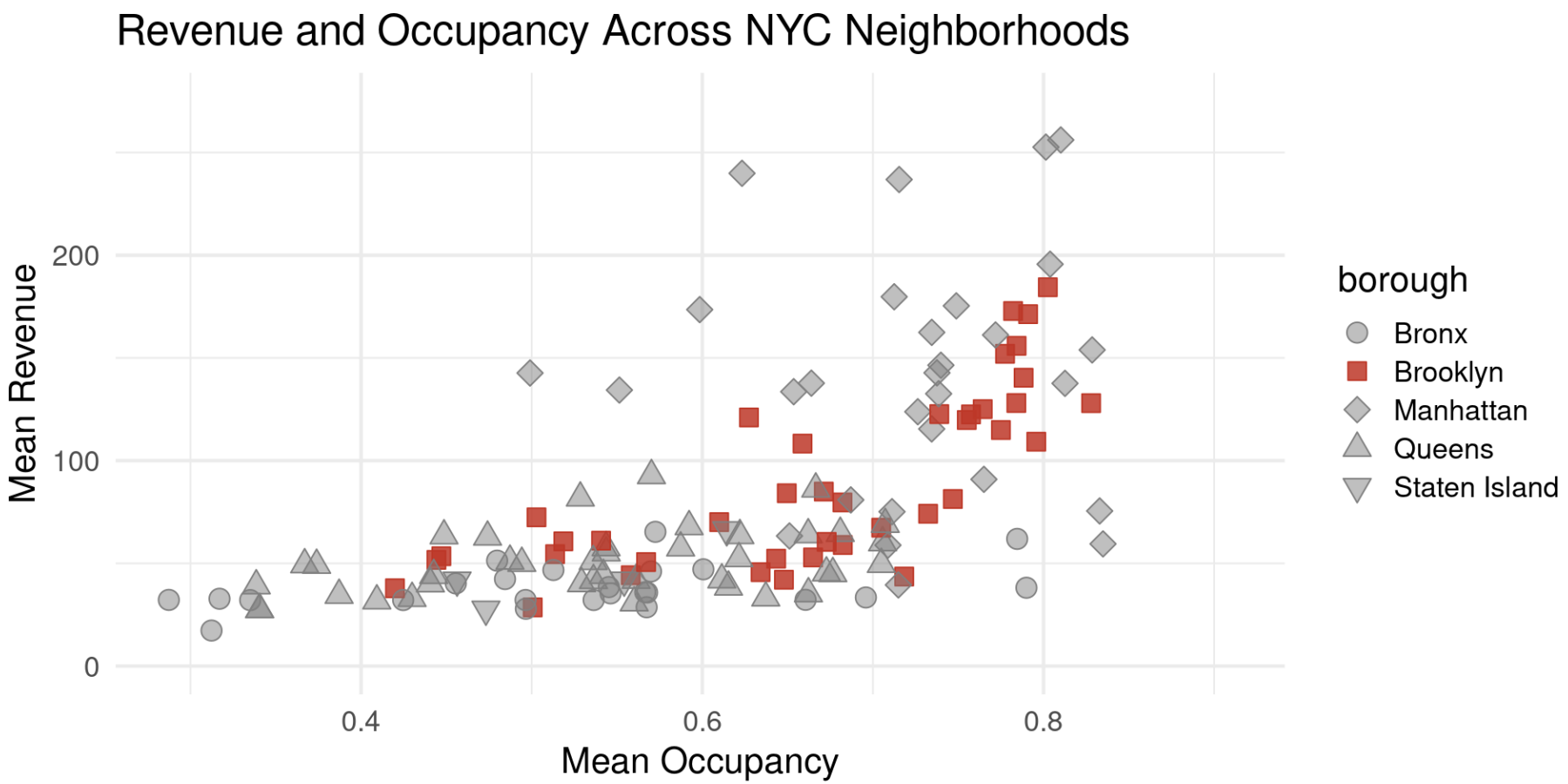
Three Uses of Color

- Highlighting



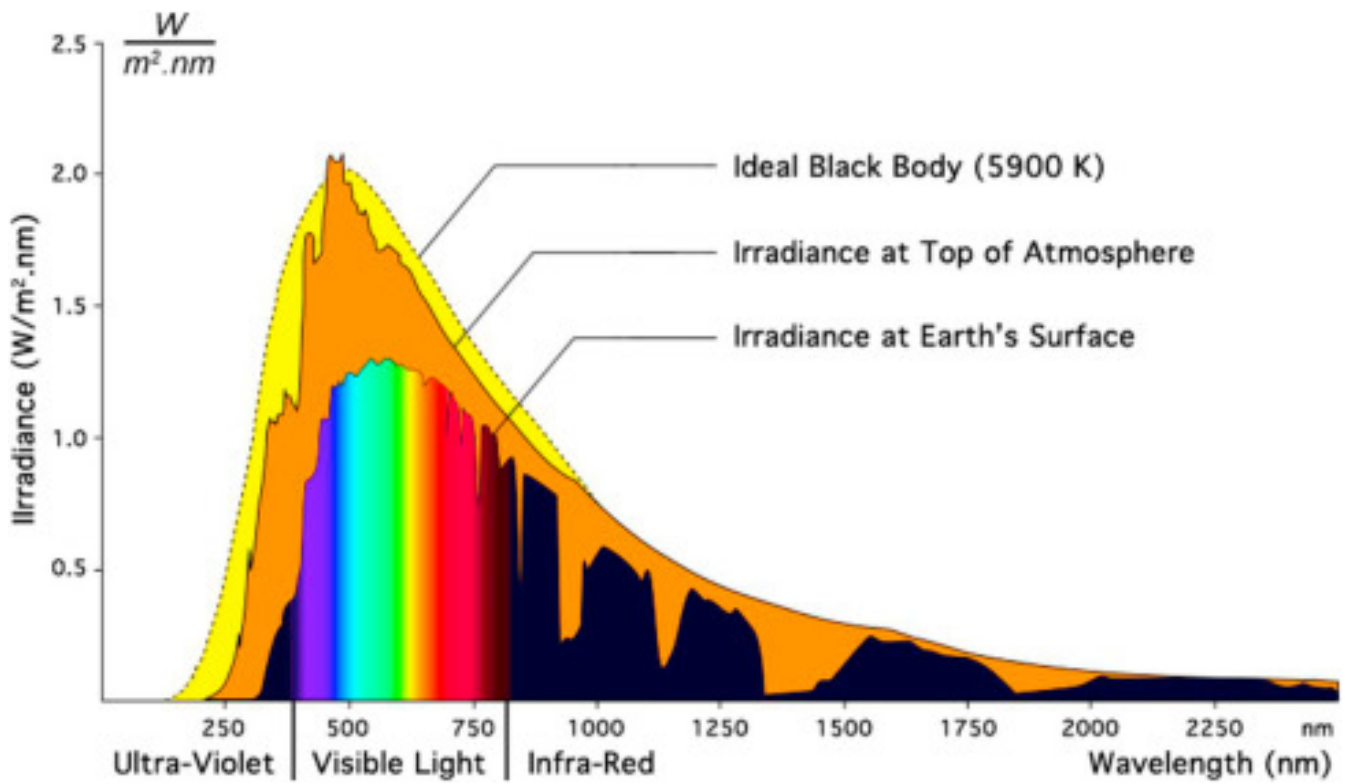
Three Uses of Color

- Highlighting



What are colors?

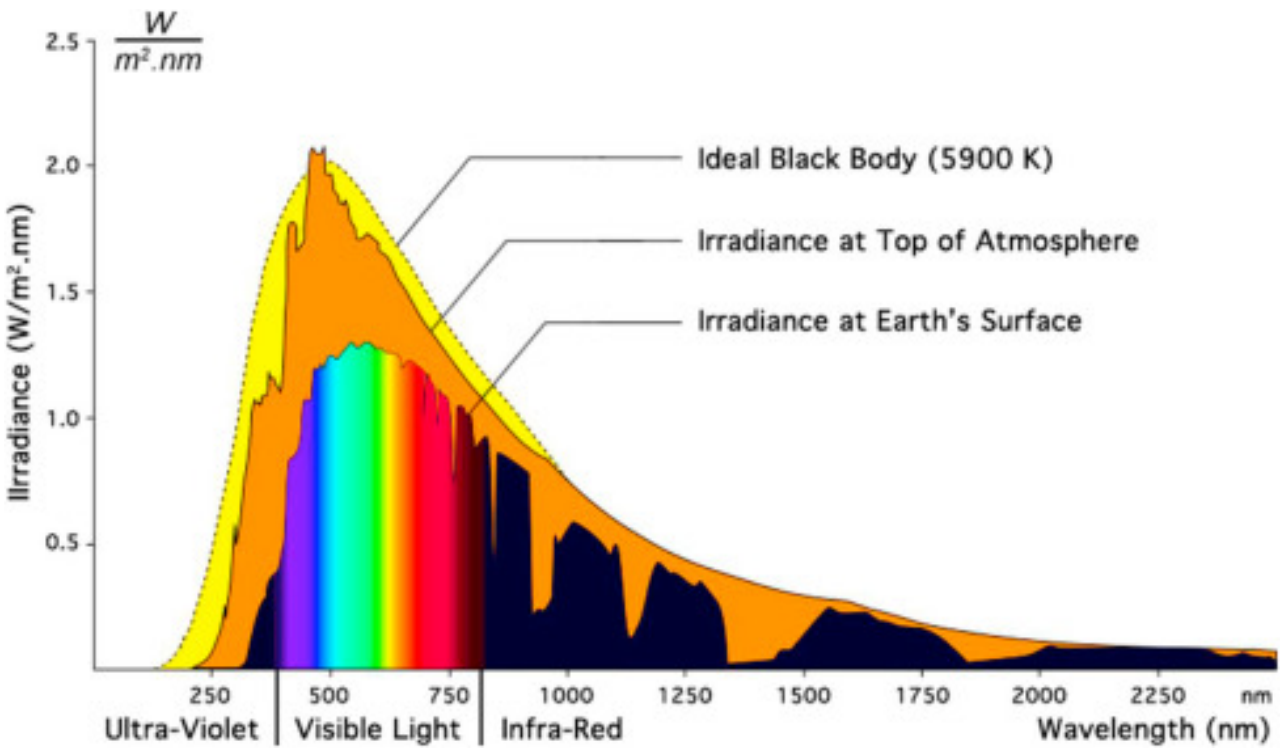
- Light is composed of a spectrum of photons each with different wavelength/energy



Wang and Yu 2023

What are colors?

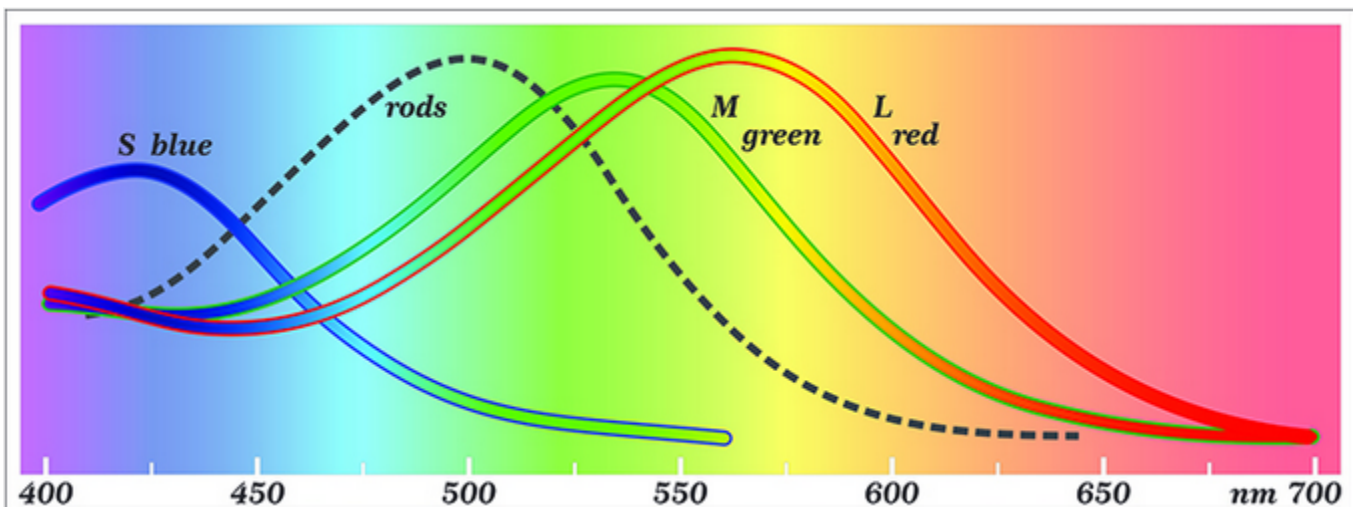
- Primary Colors each represent single wavelength
- ROYGBIV



Wang and Yu 2023

Color Perception

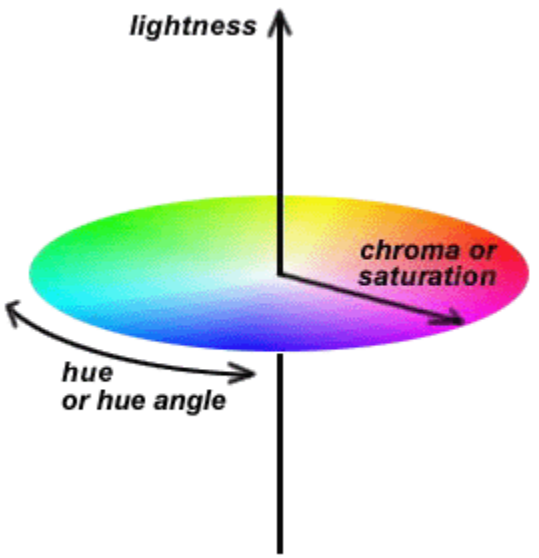
- We don’t see spectrum
- Our eyes have 3 types of cone cells that sense color
- Each responds to a part of the spectrum



Color Perception

- Our cones reduce the full spectrum to 3 numbers

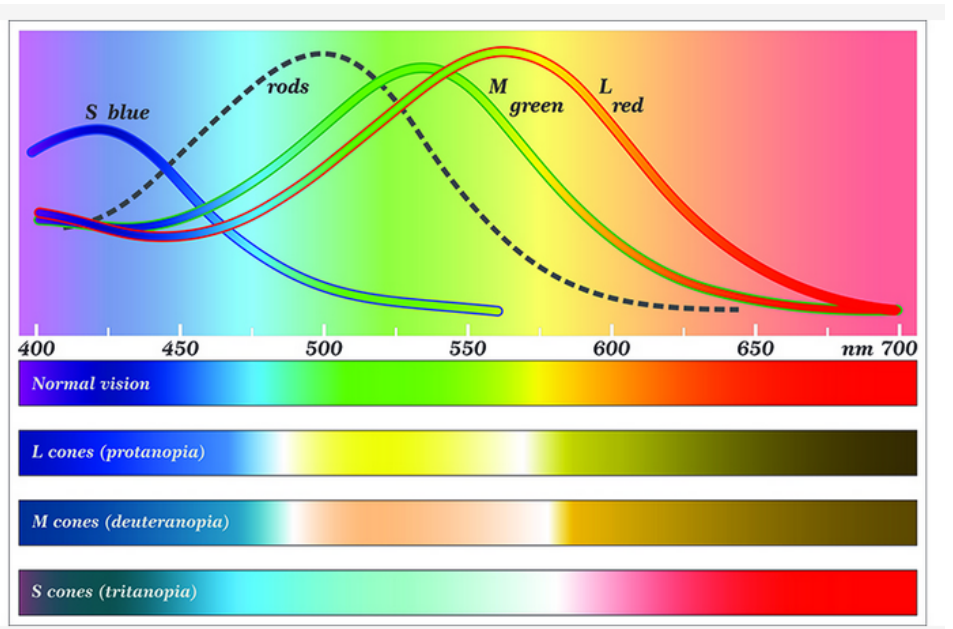
- Different 3D encodings:
  - RGB mix + Luminance
  - HCL (Hue + Chroma + Luminance)



handprint.com

Color Vision Variability

- Number and function of each cone type can vary from person to person
- Different types of color perception referred to as colorblindness



datacolor.com

Checking your Color Palettes

- www.daltonlens.com
  - Simulates on Images or even entire slidedeck
  - All types of colorblindness

Checking your Color Palettes

- www.daltonlens.com

Simulation method

Brettel 1997 | Viénot 1999 | Machado 2009 | Vischeck (GIMP)

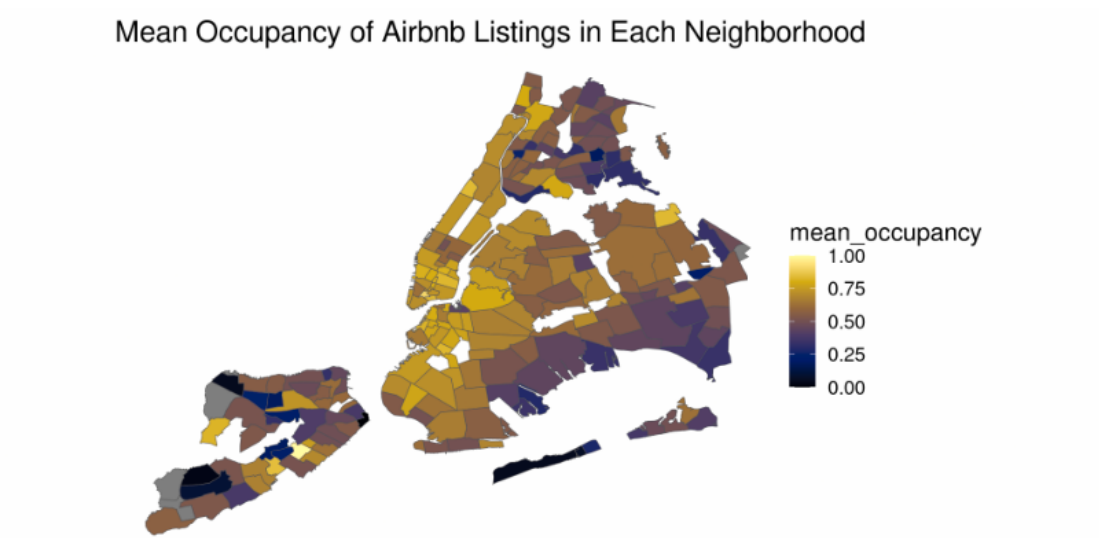
Machado 2009 (missing sRGB) | Coblis V1 | Coblis V2

Severity: 0.8

A severity of 1 means full protanopia/deuteranopia/tritanopia.

No CVD (original) | Protan (red-blind) | Deutan (green-blind) | Tritan (blue-blind)

Python progress... done

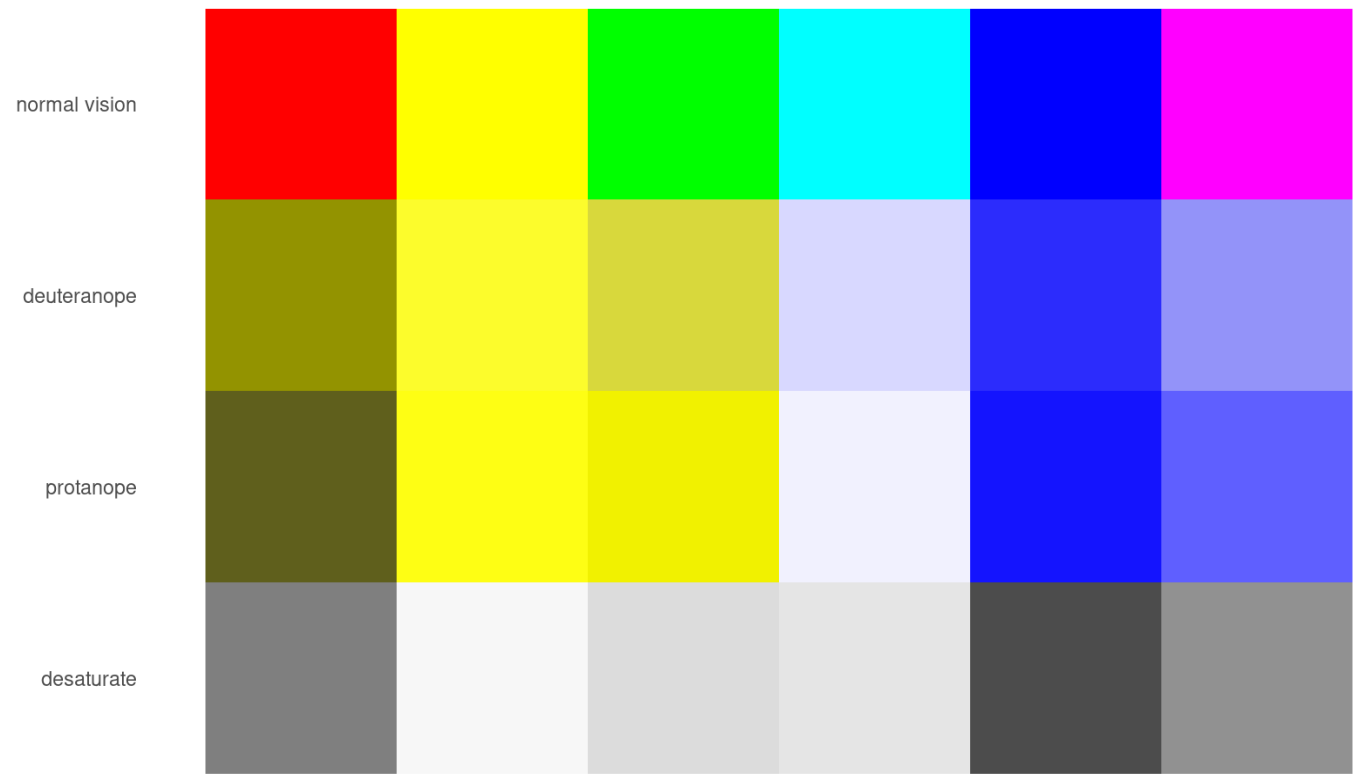


Hint: click on the image at any time to show the original.

Checking your Color Palettes

- `colorBlindnes` simulator

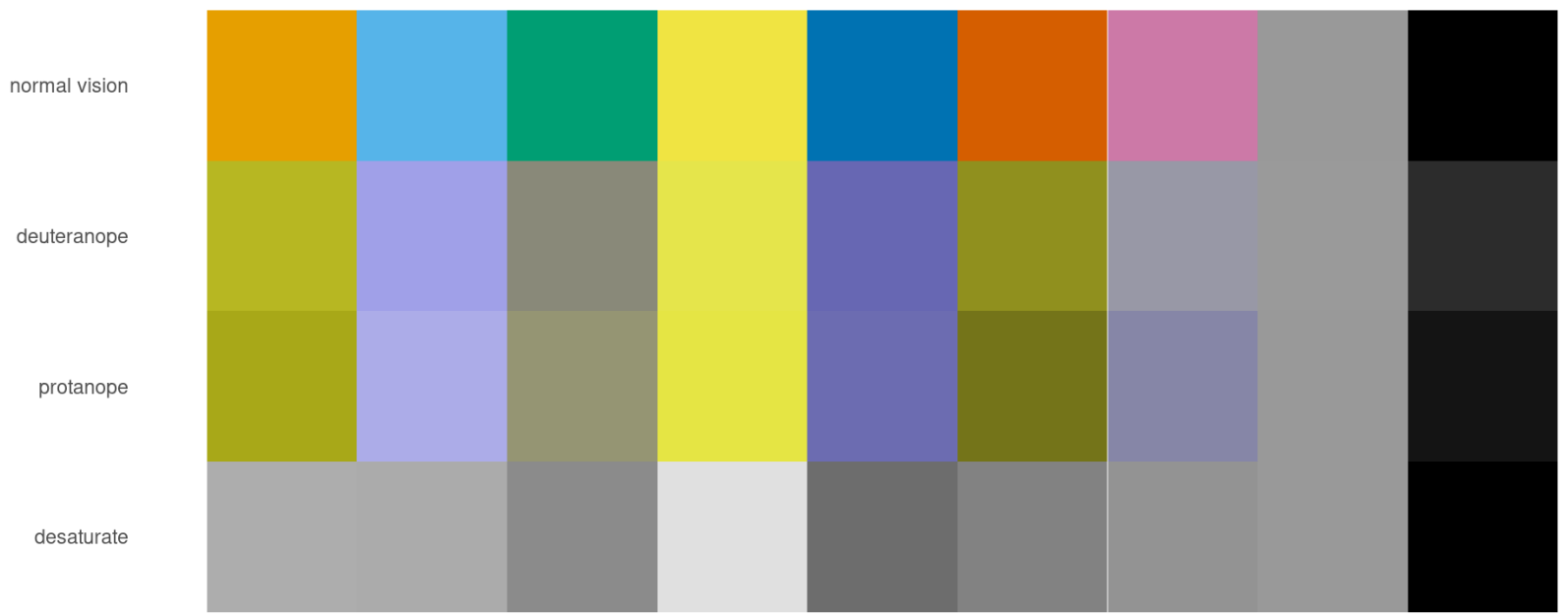
```
1  colorBlindness::displayAllColors(rainbow(6))
```



Checking your Color Palettes

- `colorBlindnes` simulator

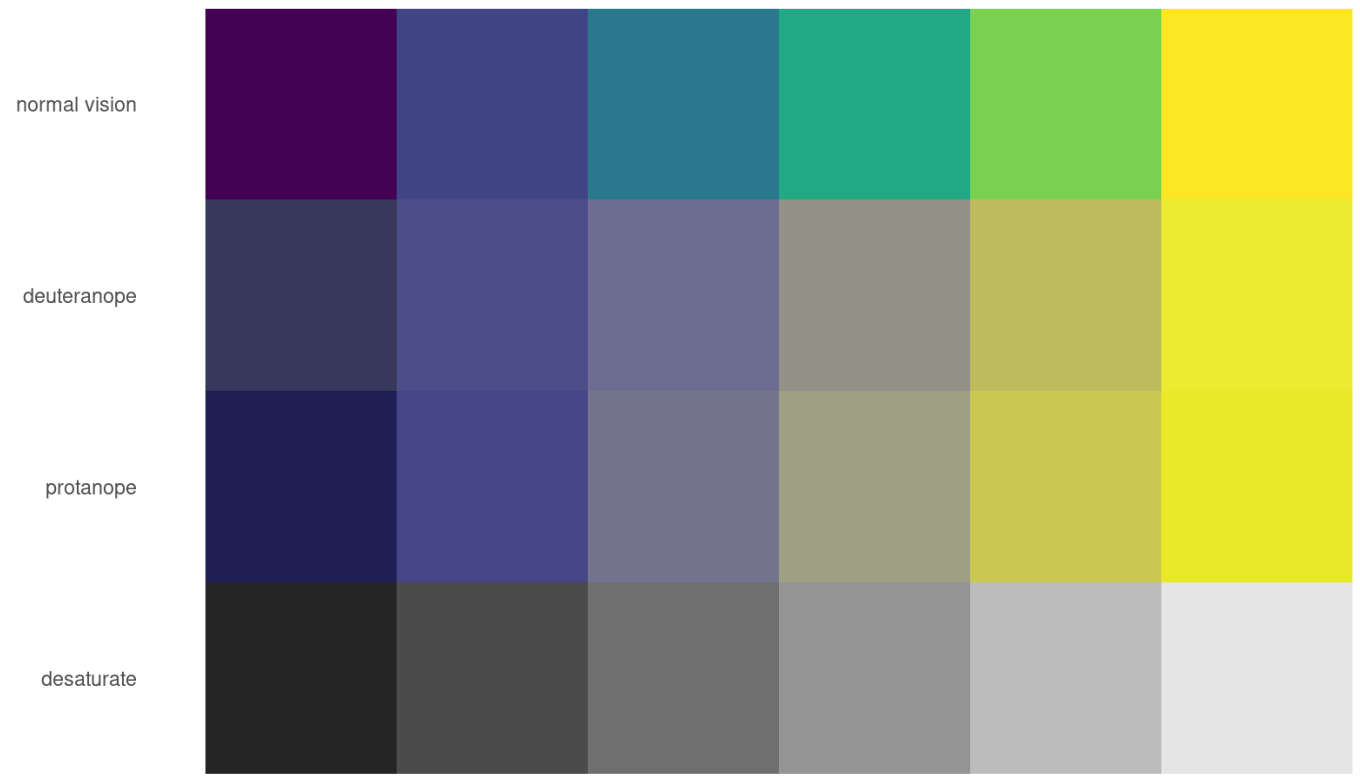
```
1  colorBlindness::displayAllColors(ggokabeito::palette_okabe_ito(1:9))
```



Checking your Color Palettes

- `colorBlindnes` simulator

```
1  colorBlindness::displayAllColors(viridis::viridis(6))
```



What I Do

- Stick with known accessible palettes
- `viridis` and `okabe-ito` families
- Luminance based
- Avoid red-green gradients

`ggplot` color scale functions

- Similar to how you control axis scales
- `scale_*aes*_*name_of_color_function*`
- `scale_color_xxxx` controls color (usually border)
- `scale_fill_xxxx` controls fill
- `xxxx` is usually the name of a package or color scheme

Atlas of color qualtitative packages

Color Packages

Command	Package	Color Safety?
`scale_fill_hue`	`ggplot2`	No
`scale_fill_brewer`	`RColorBrewer`	Some
`scale_fill_paleteer_d`	`paleteer`	Many
`scale_fill_okabe_ito`	`ggokabeito`	Yes
`scale_fill_OkabeIto`	`colorblindr`	Yes

RColorBrewer

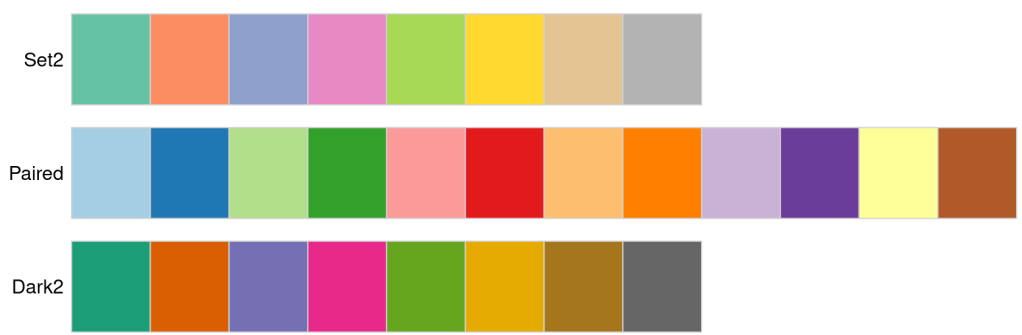
- Designed for discrete values on maps

```
1  display.brewer.all(type = "qual")
```

RColorBrewer

- 3 Colorblind friendly palettes
- Only friendly up to 3 categories (`Set2` and `Dark2`) or 4 categories (`Paired`)

```
1  display.brewer.all(type = "qual",colorblindFriendly = TRUE)
```



RColorBrewer

- Code for Column Plot

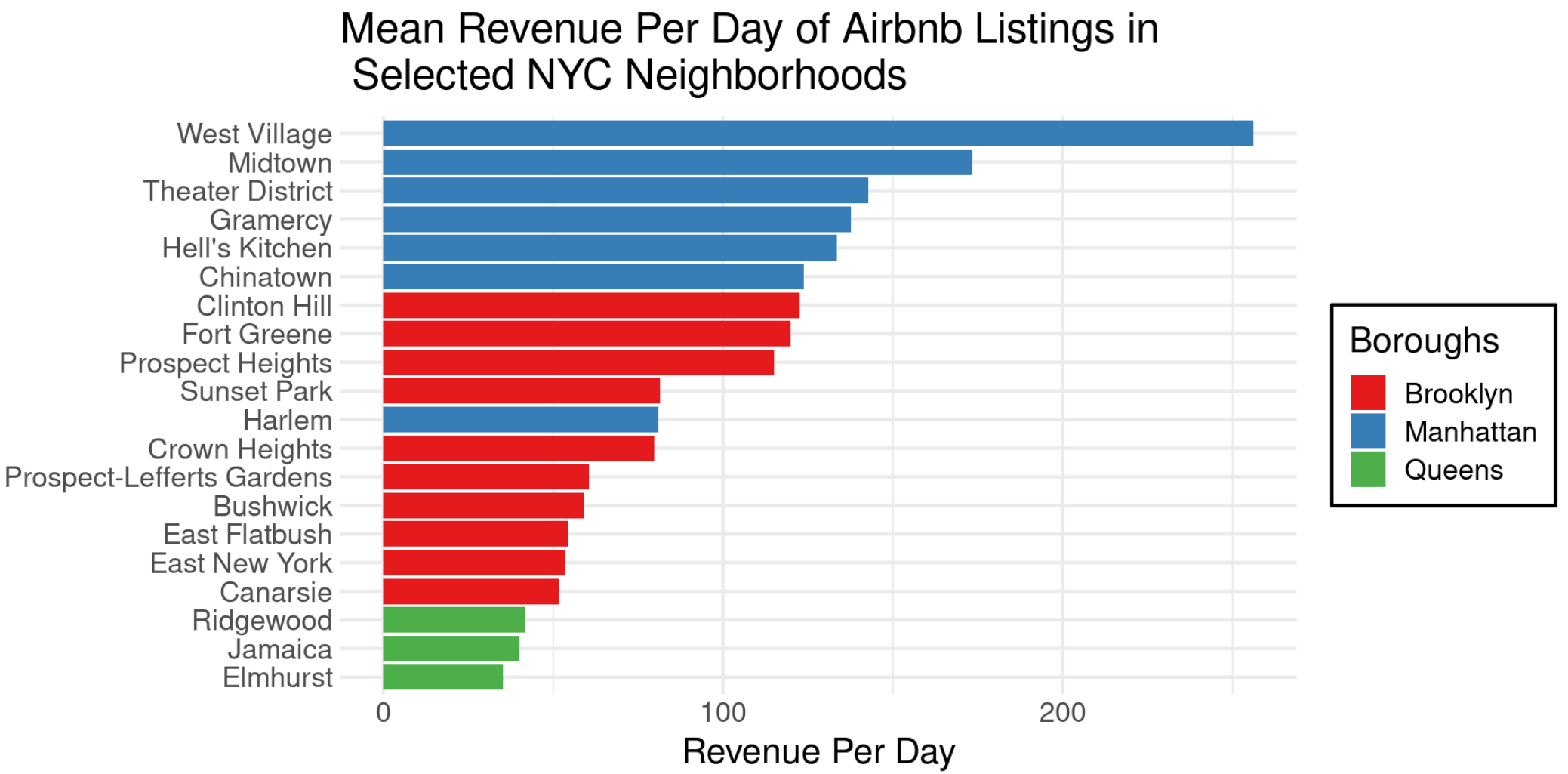
```
p1 = neighborhood_df |>
  ggplot(aes(x=mean_revenue,
             y=mean_revenue,
             fill = borough)) +
  geom_col() +
  scale_y_continuous(
    name = "Revenue Per Day"
  ) +
  coord_flip() +
  theme_minimal(base_size=16) +
  theme(axis.title.y = element_blank(),
        axis.line.y = element_blank(),
        axis.ticks.length = unit(0, "pt"),
        #axis.text.y = element_text(size = 10, color = borough_colors),
        legend.background = element_rect(fill = "#ffffffb0")) +
  labs(title = "Mean Revenue Per Day of Airbnb Listings in\n Selected NYC N
```

RColorBrewer

- `scale_fill_brewer()`
- `palette` can choose from list of palettes
- `name` gives legend label

```
1 p1 +
2   scale_fill_brewer(name = "Boroughs",
3                     palette = "Set1")
```

RColorBrewer



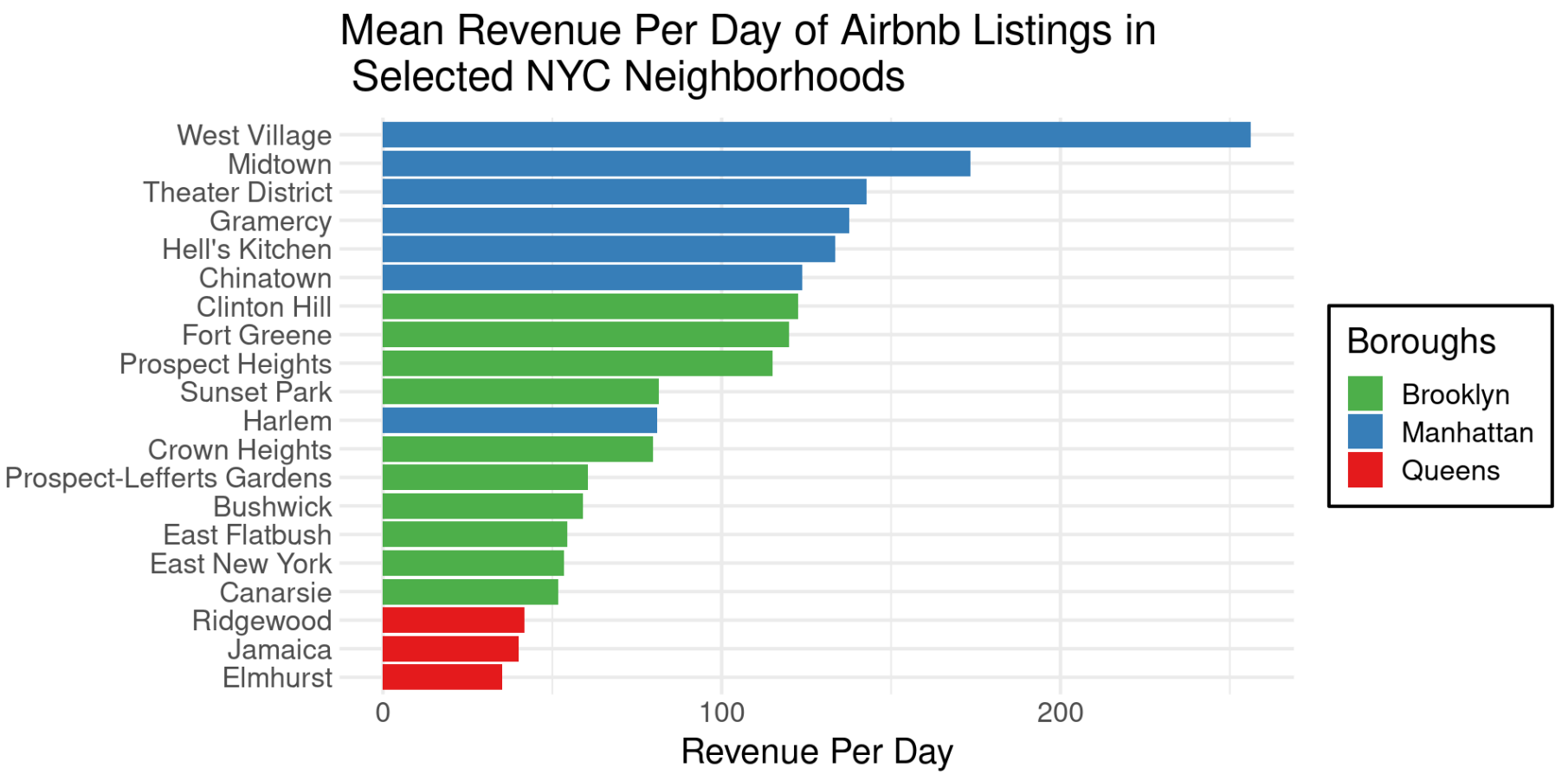
RColorBrewer

- Use `direction=-1` to reverse the colors

```
p_nabes +
  scale_fill_brewer(name = "Boroughs",
                    direction = -1,
                    palette = "Set1")
```

RColorBrewer

- Use `direction=-1` to reverse the colors



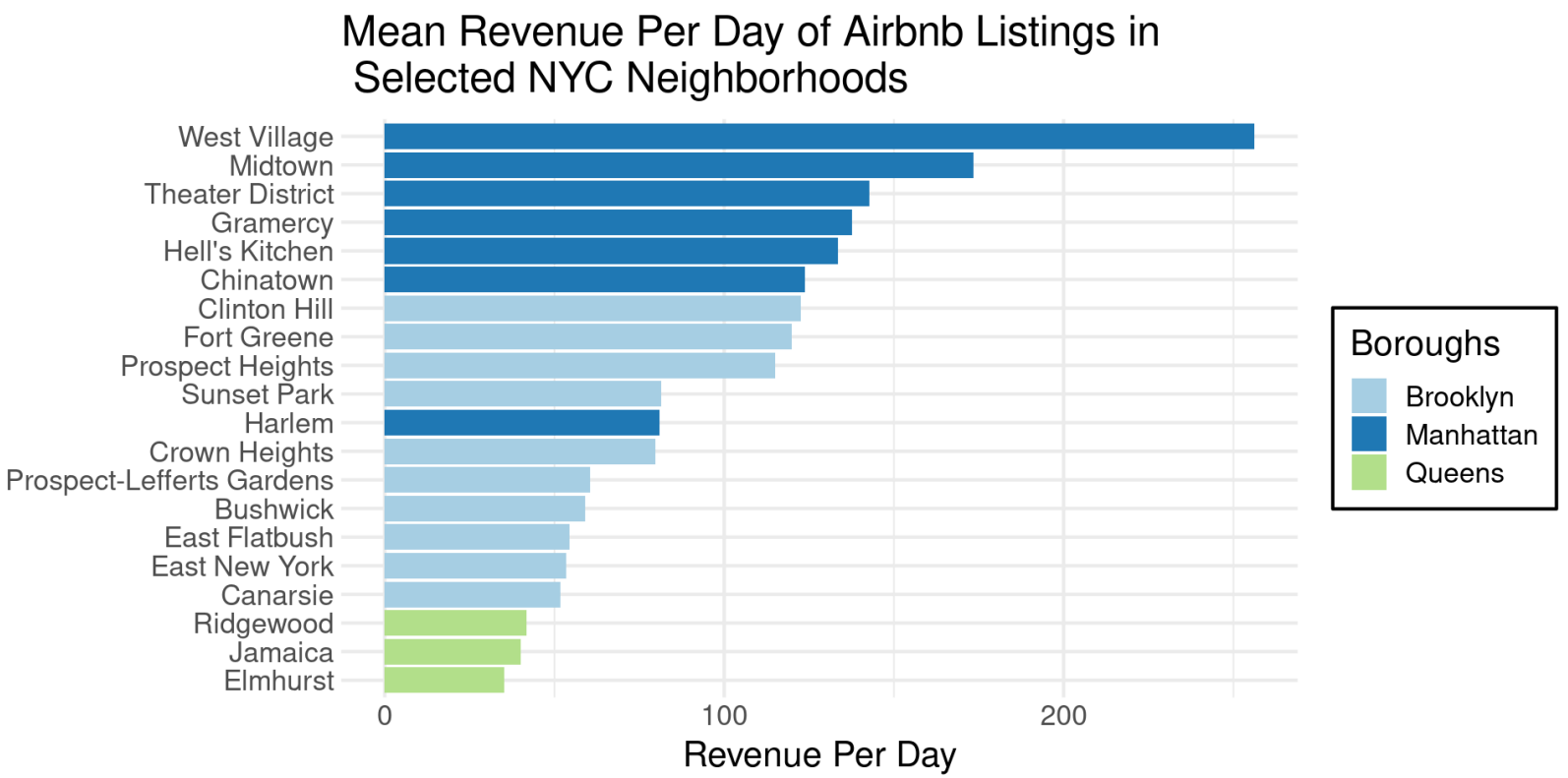
RColorBrewer

- If you forget names, you can use `type="qual"` and `palette= number`:

```
p_nabes +
  scale_fill_brewer(name = "Boroughs",
                    type = "qual",
                    palette = 3)
```

RColorBrewer

- If you forget names, you can use `type="qual"` and `palette= number`:

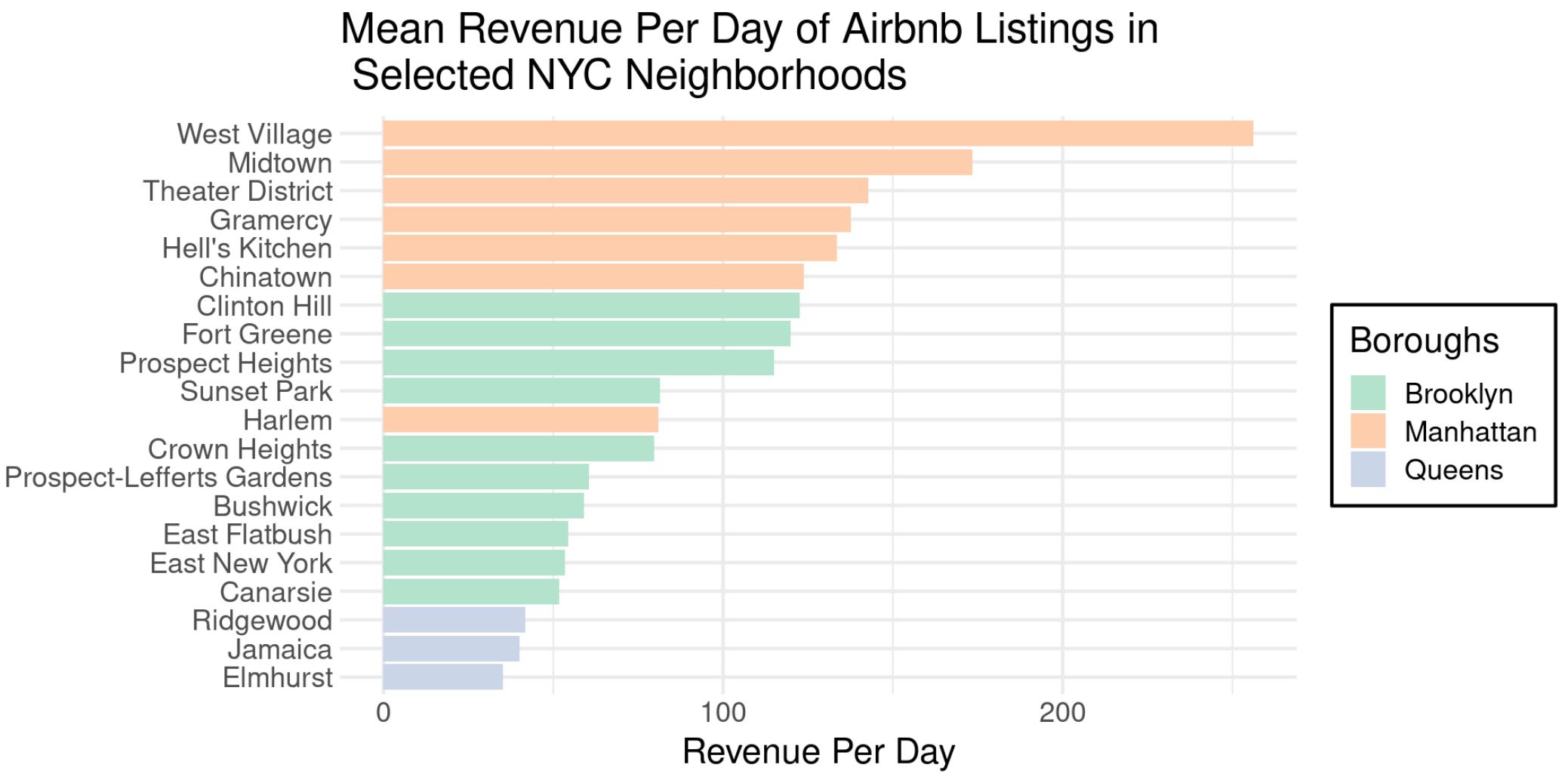


RColorBrewer

- `na.value="grey30"` tells us the color for missing values
- `guide = colorbar, legend, or colorsteps` says type of colorbar

```
p_nabes +
  scale_fill_brewer(name = "Boroughs",
                    type = "qual",
                    palette = 2,
                    aesthetics = c("color,fill"),
                    na.value = "grey70")
```

RColorBrewer



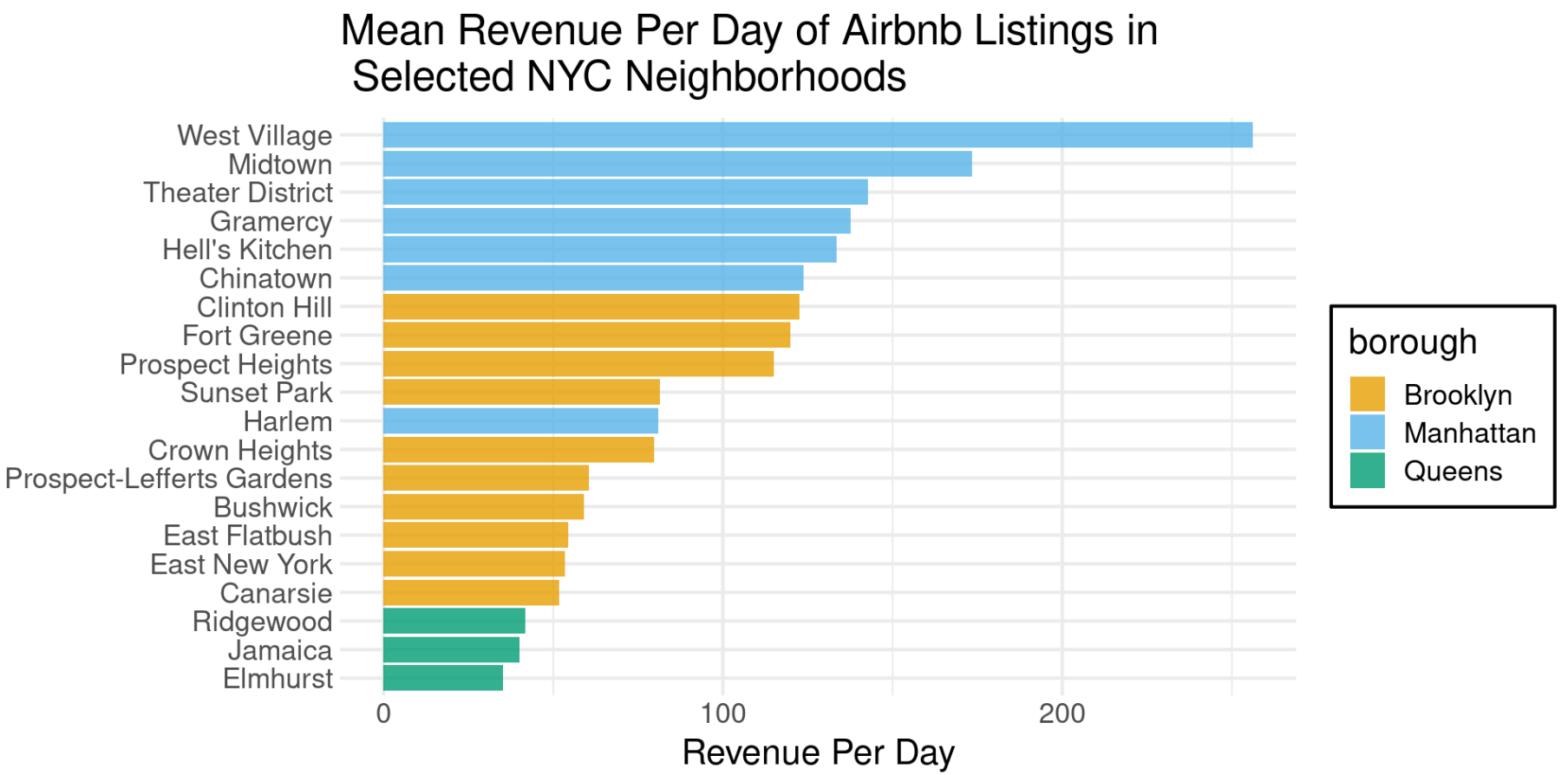
ggokabeito

- `scale_fill_okabe_ito`
- Takes many of same arguments as `scale_fill_brewer`
- Also can give “order” for colorscale

```
1 p_nabes +
2   scale_fill_okabe_ito(order = 1:9,alpha=0.8)
```

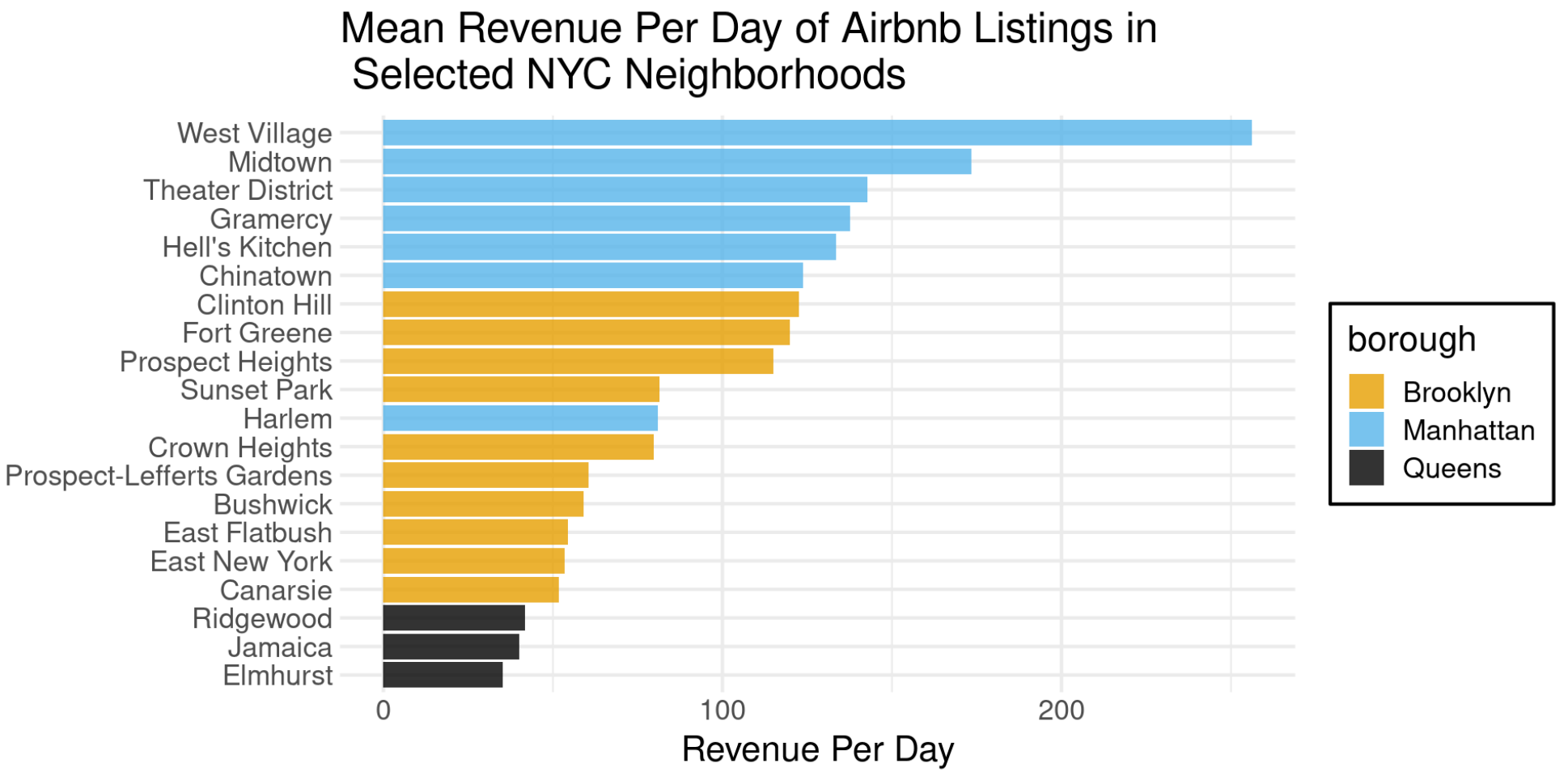
ggokabeito

- `scale_fill_okabe_ito`



ggokabeito order

```
1  p_nabes +
2    scale_fill_okabe_ito(order = c(1,2,9,3,4,5,6,7,8),alpha=0.8)
```



Tons of other options....

- The main options all work like this
- Default arguments plus some special options
- `colorspace` package is really nice and brings a bit of order

Choosing Discrete Colors

- For Categorical Data
  - Each Color above 6 should make you wince
  - For colorblind friendliness, becomes very hard
- Don’t represent numbers
  - Maximally Distinctive

Color for Scatterplots

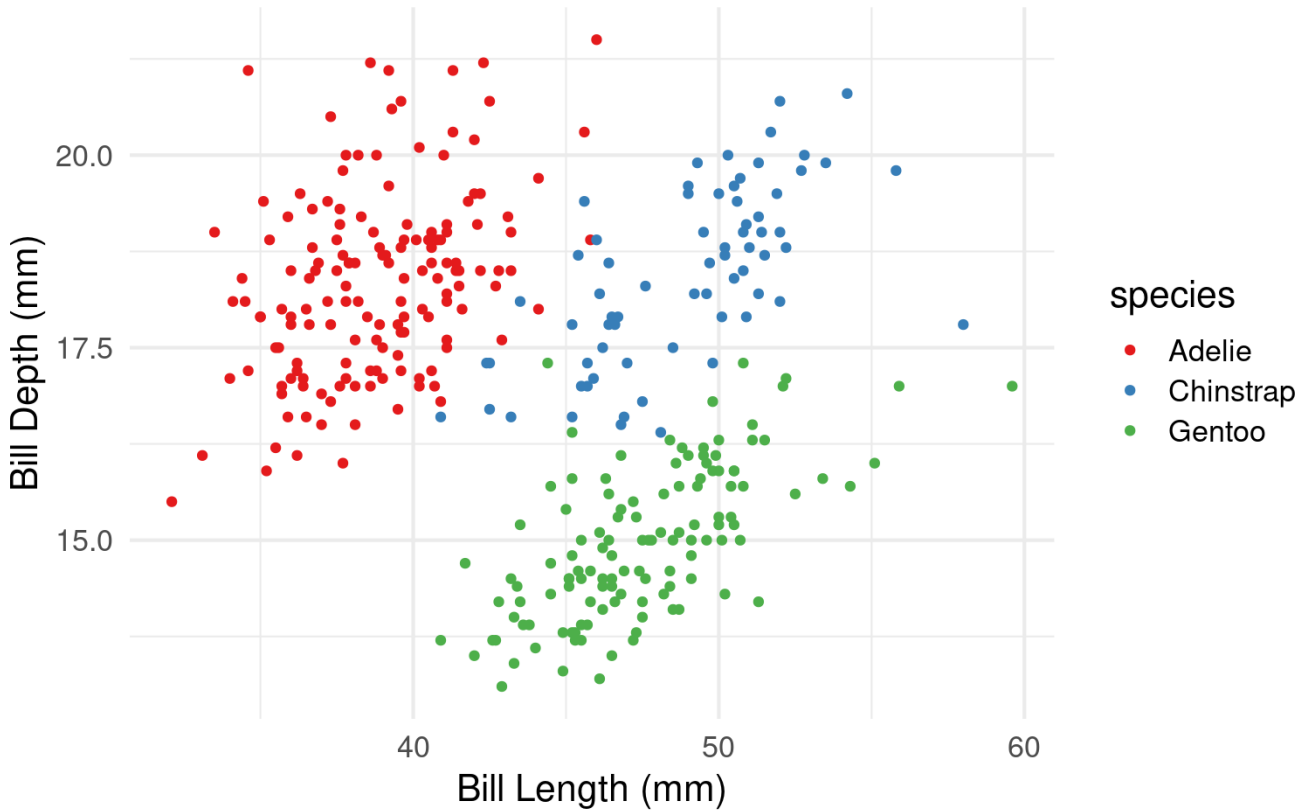
- Brighter Colors Better for Small Points

```
library(palmerpenguins)



point = penguins |>  ggplot(aes(bill_length_mm, bill_depth_mm)) +
  geom_point(aes(colour = species))  +
  theme_minimal(base_size=16) +
  labs(x = "Bill Length (mm)", y =
         "Bill Depth (mm)")

# three palettes
#point + scale_colour_brewer(palette = "Set1")
#point + scale_colour_brewer(palette = "Set2")
#point + scale_colour_brewer(palette = "Pastel1")
```

Color for Scatterplots

- Brighter Colors Better for Small Points

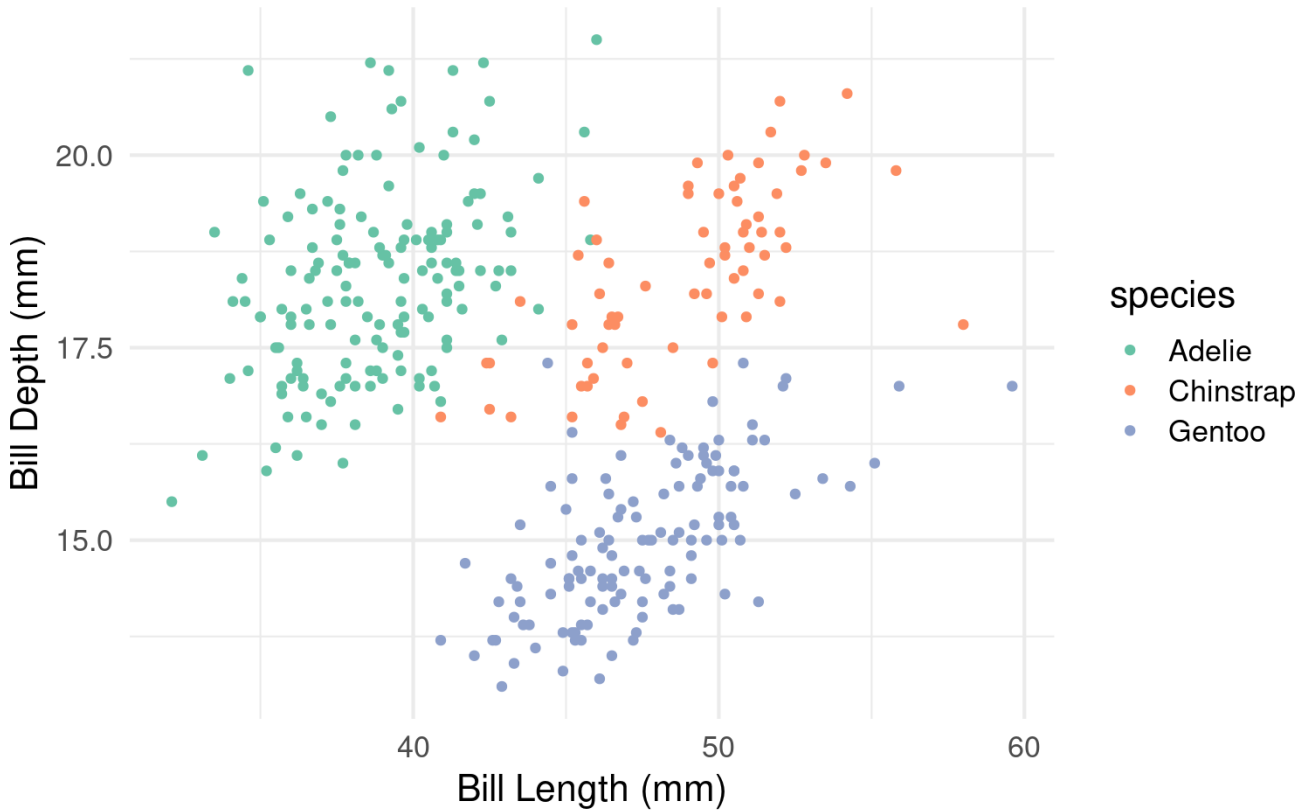
```
1  point + scale_colour_brewer(palette = "Set1")
```



Color for Scatterplots

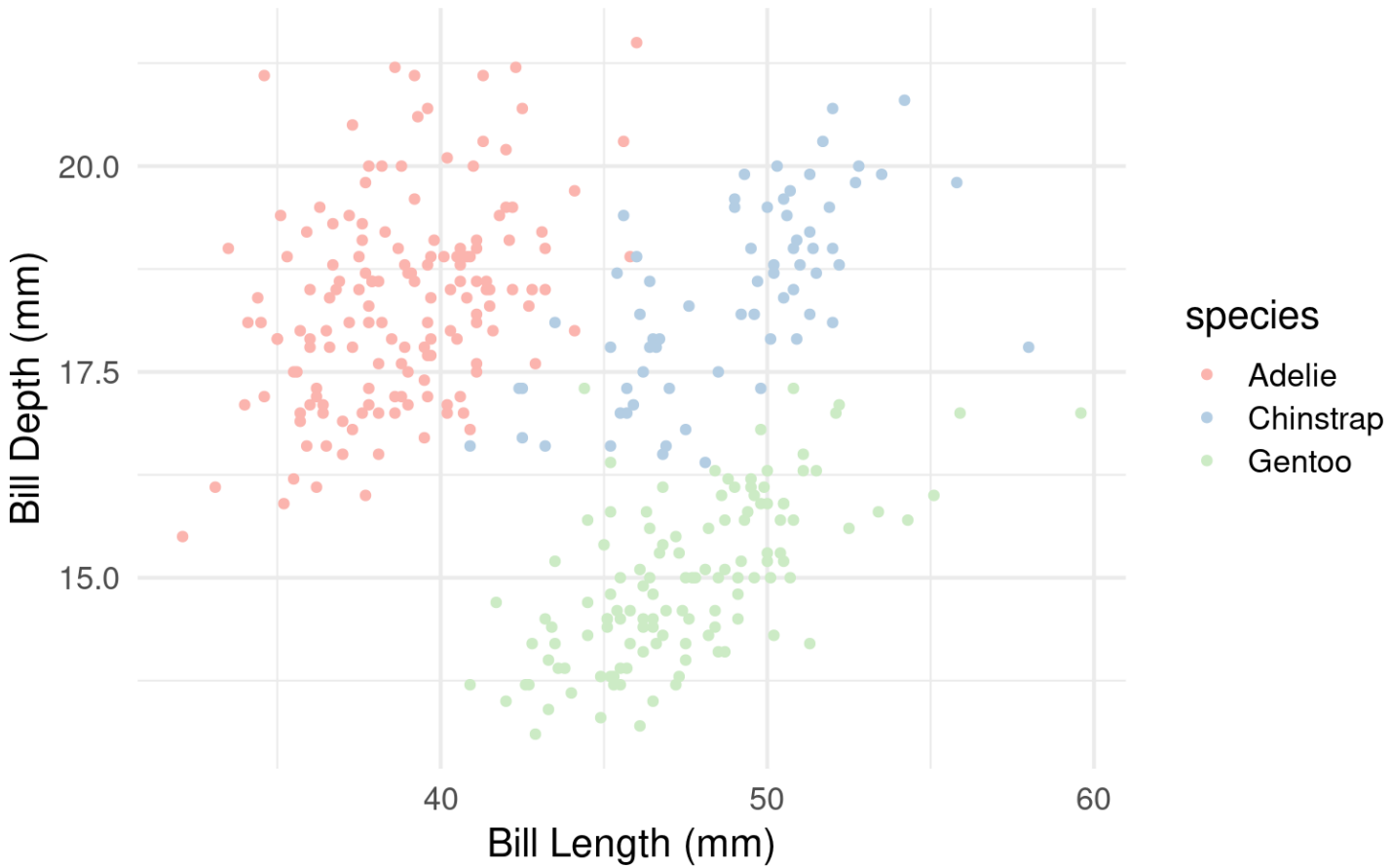
- Brighter Colors Better for Small Points

```
1  point + scale_colour_brewer(palette = "Set2")
```



Color for Scatterplots

- Brighter Colors Better for Small Points



Color for Fill

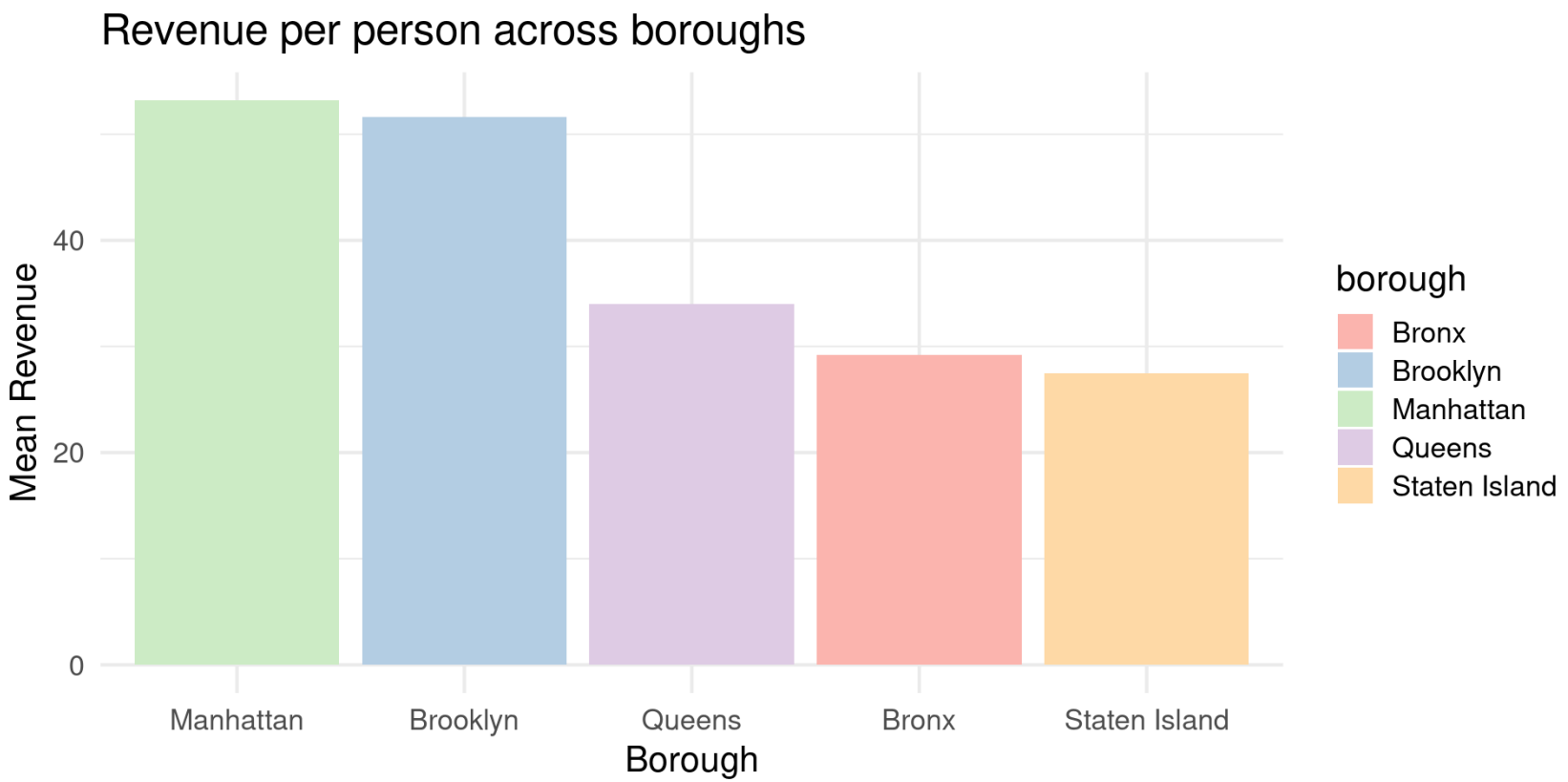
- Subtler colors work better for Areas

```
plot = nyc_bnb |> group_by(borough) |> filter(number_of_reviews_ltm>20) |>
  summarise(revenue = mean(revenue/accommodates,na.rm=TRUE)) |>
  ggplot(aes(x=fct_reorder(borough,desc(revenue)),y=revenue,fill=borough))
  geom_col() +
  theme_minimal(base_size=16) +
  labs(x = "Borough", y =
         "Mean Revenue",
       title = "Revenue per person across boroughs")
```

Color for Fill

- Subtler colors work better for Areas

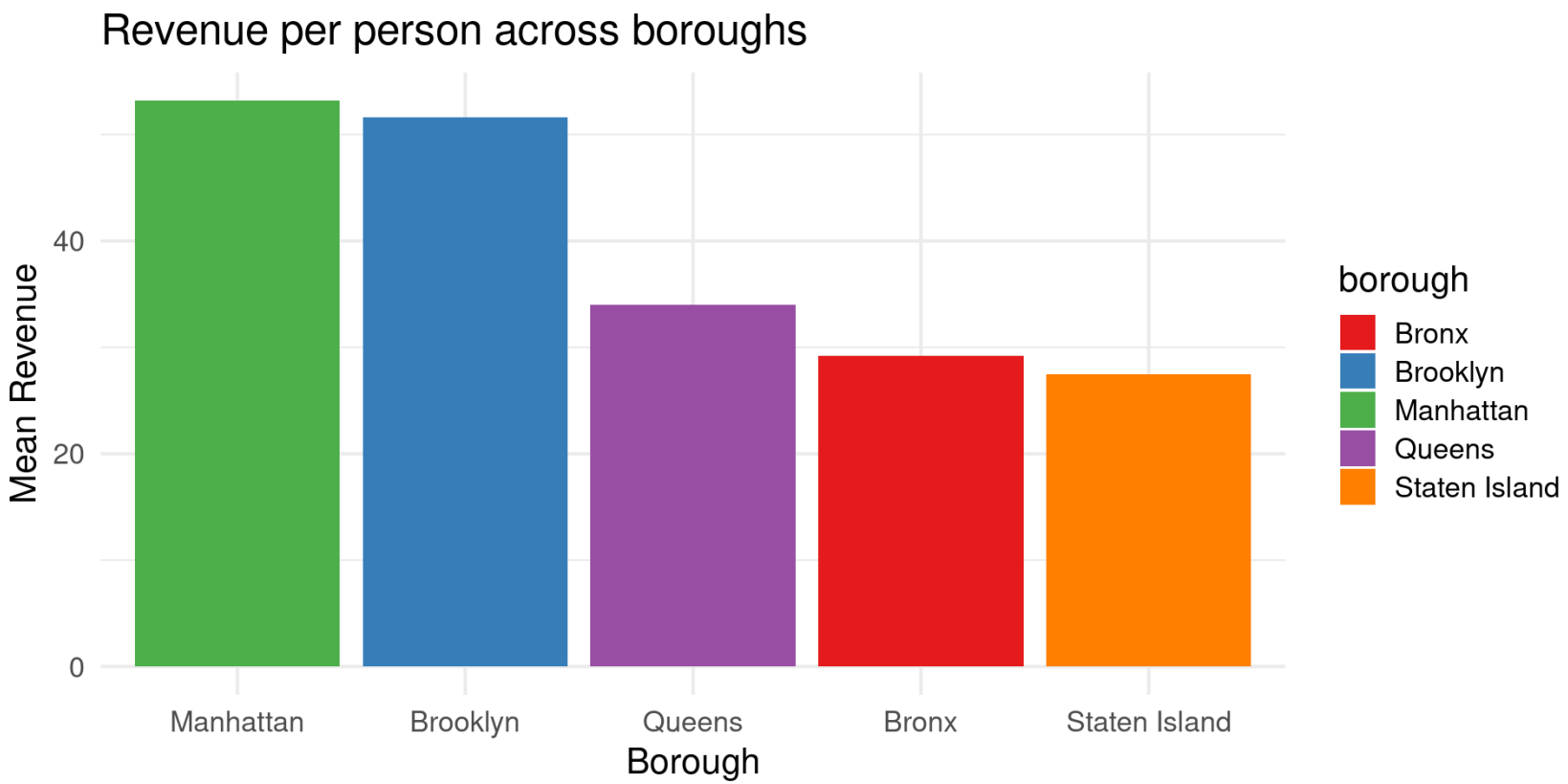
```
1  plot + scale_fill_brewer(palette = "Pastel1")
```



Color for Fill

- Subtler colors work better for Areas

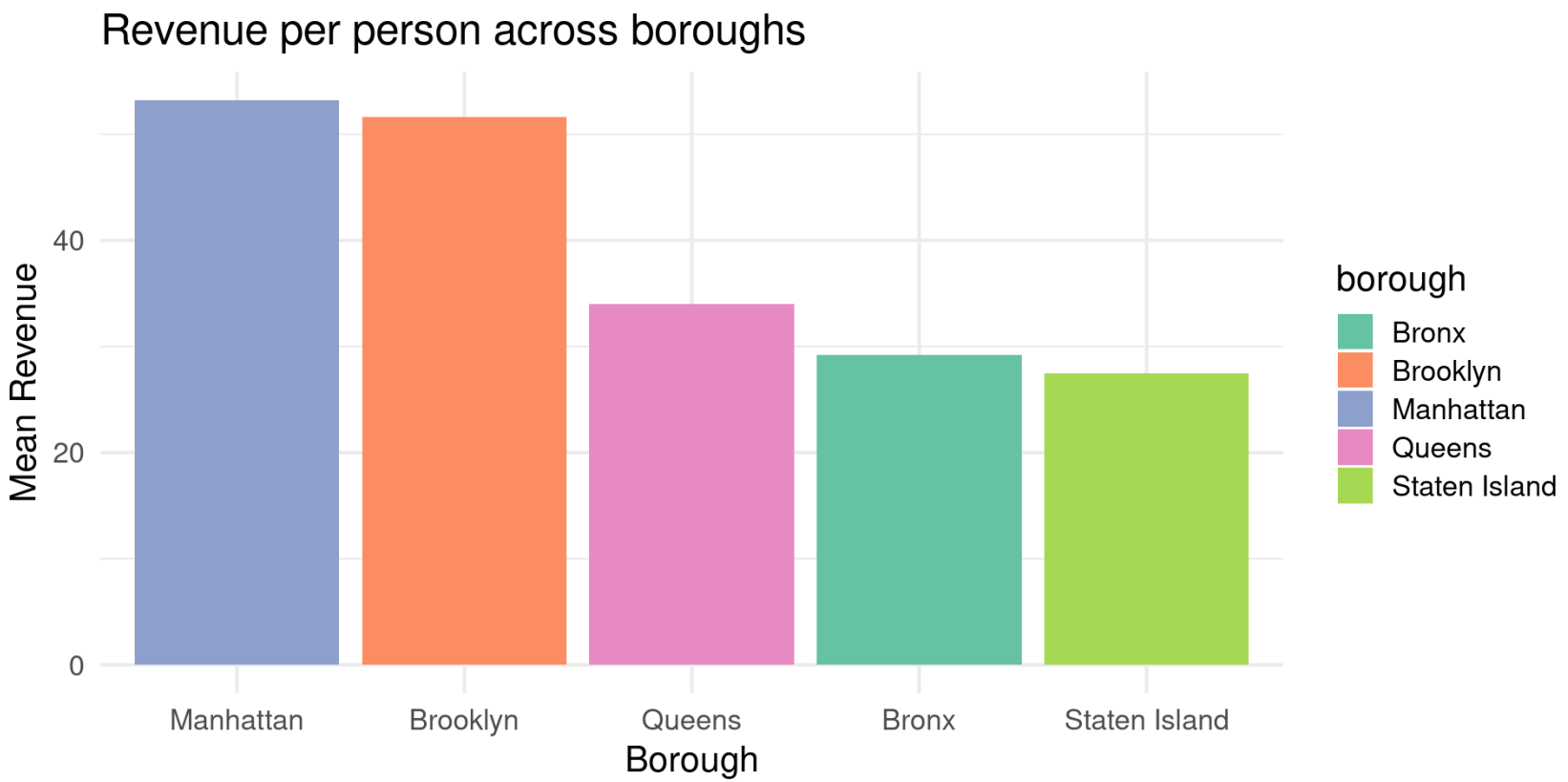
```
1  plot + scale_fill_brewer(palette = "Set1")
```



Color for Fill

- Subtler colors work better for Areas

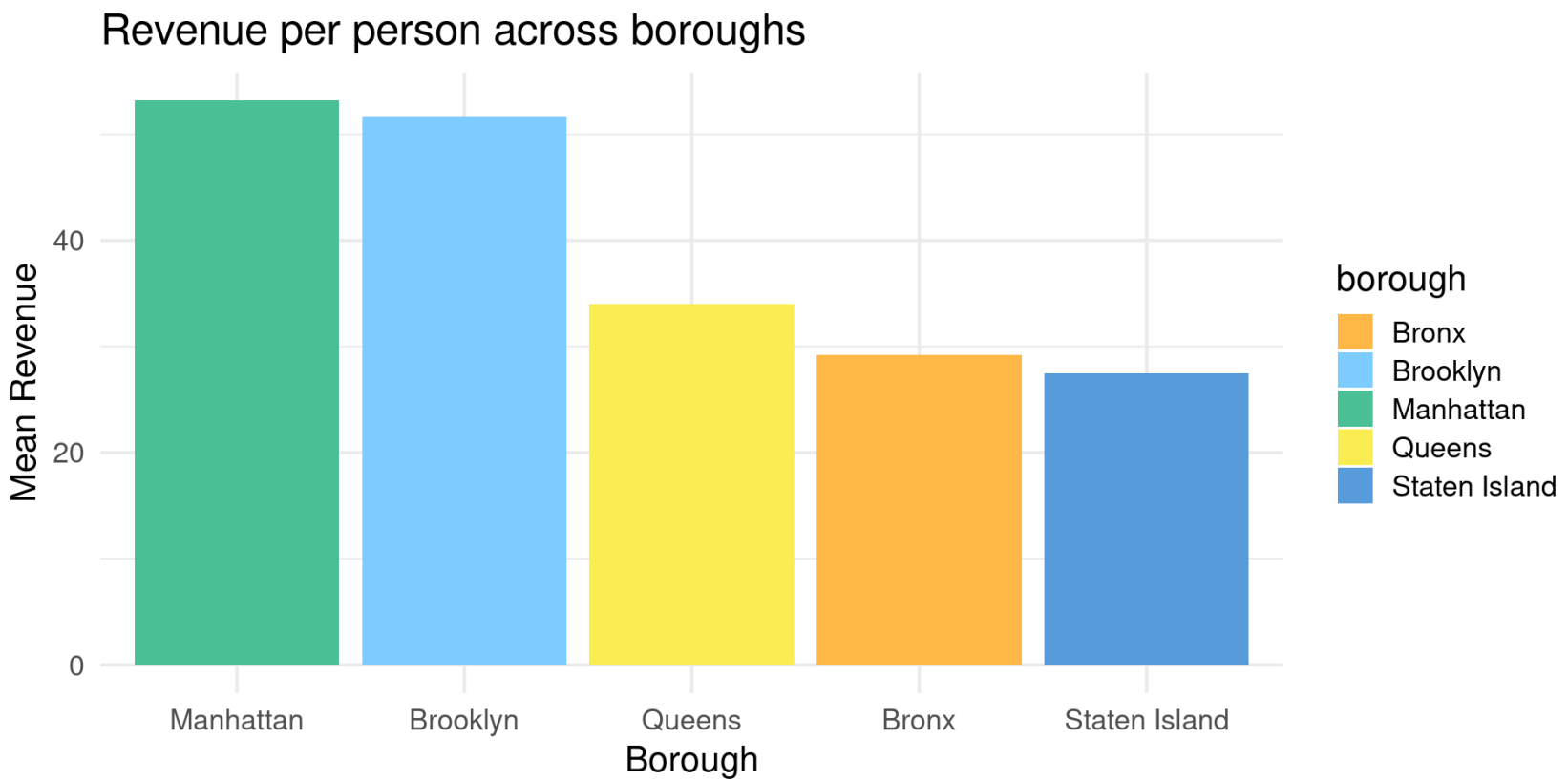
```
1 plot + scale_fill_brewer(palette = "Set2")
```



Color for Fill

- Colorspace controls for accents

```
1 plot + scale_fill_OkabeIto(darken=-0.3)
```



Setting Colors Manually

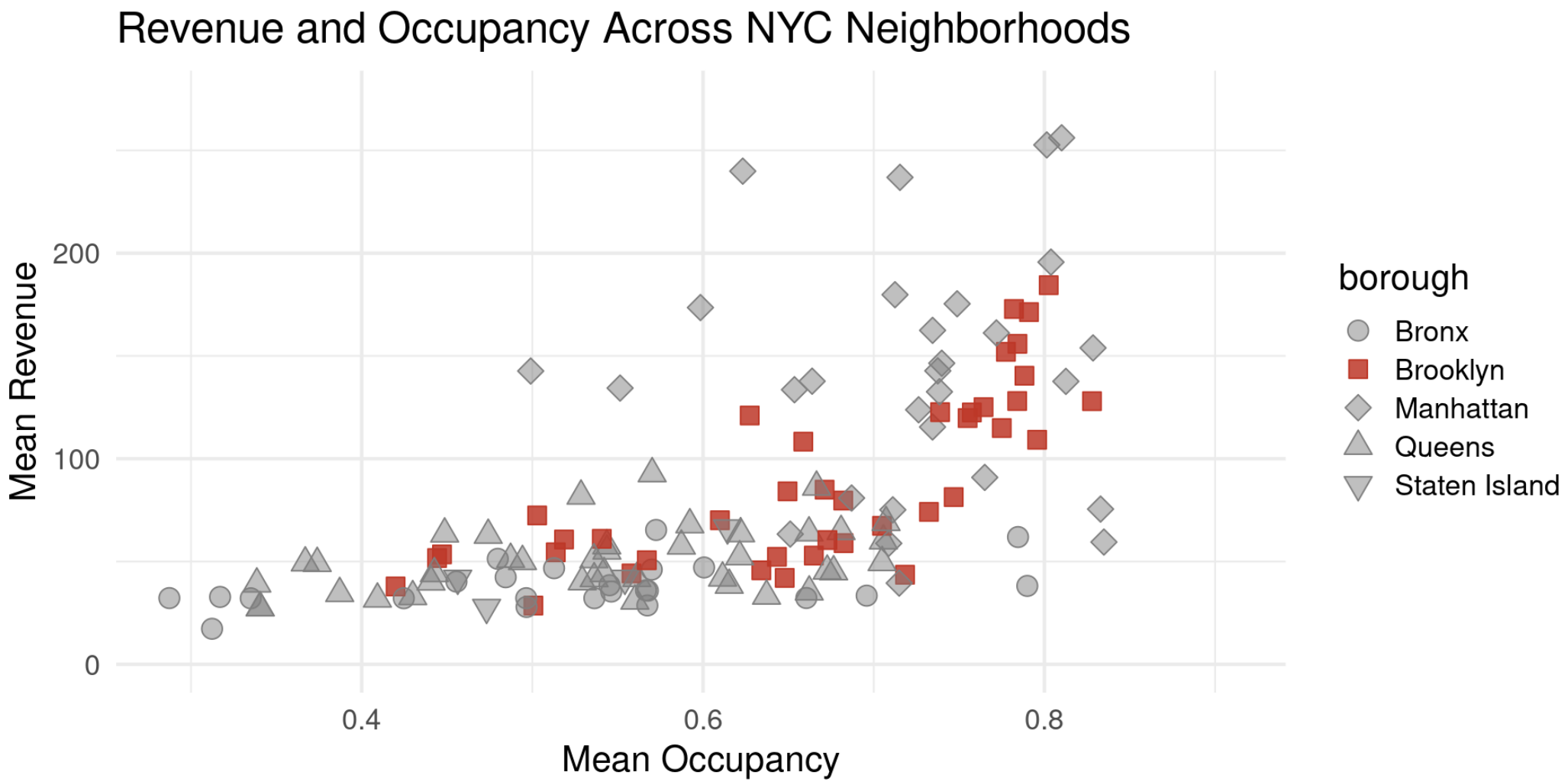
- In many cases want to pick the colors for each category
- Especially important for accenting color palettes
- `alpha` modifies the colors and creates fill vector

```
colors <- c("#808080","#BD3828", rep("#808080", 3))
fills <- c(
  alpha(colors[1], .5),
  alpha(colors[2],0.85),
  alpha(colors[3:5], .5)
)
```

Setting Colors Manually

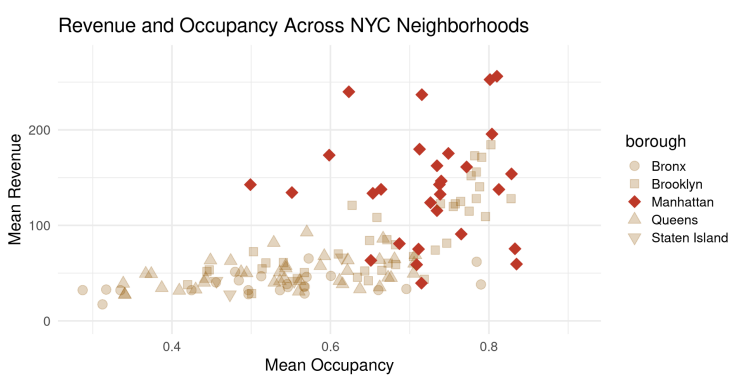
```
neighborhood_df |> filter(!is.na(borough) & num_listings>20) |>
  ggplot(aes(x=mean_occupancy,y=mean_revenue,color=borough,shape=borough,fi
  geom_point(size=4) +
  scale_y_continuous(limits = c(0,275)) +
    scale_shape_manual(values = 21:25) +
   scale_color_manual(values = colors) +
  scale_fill_manual(values = fills) +
  theme_minimal(base_size = 16) +
  labs(title = "Revenue and Occupancy Across NYC Neighborhoods")+
  xlab("Mean Occupancy") +
  ylab("Mean Revenue")
```

Setting Colors Manually



More scale_fill_manual

```
plot_2 +
    scale_color_manual(values =
                           c("Manhattan"="#BD3828",
                             "Brooklyn" = "#92540040",
                  "Staten Island" = "#92540040",
                  "Queens" = "#92540040",
                  "Bronx" = "#92540040")) +
   scale_fill_manual(values =
                         c("Manhattan"="#BD3828",
                           "Brooklyn" = "#92540040",
                  "Staten Island" = "#92540040",
                  "Queens" = "#92540040",
                  "Bronx" = "#92540040"))
```



What do Codes Mean?

```
"#BD3828"
"#808080"
"#92540050"
```

- (Red)(Green)(Blue)(alpha)
- Each is a two hex numbers:
  - (1,2,3,4,5,6,7,8,9,A,B,C,D,E,F)

Codes for Okabe-Ito

Name	Hex code
orange	#E69F00
sky blue	#56B4E9
bluish green	#009E73
yellow	#F0E442
blue	#0072B2
vermilion	#D55E00
reddish purple	#CC79A7
black	#000000

How to get the codes?

- Different functions:

```
brewer.pal(12,"Paired")
```

```
 [1] "#A6CEE3" "#1F78B4" "#B2DF8A" "#33A02C" "#FB9A99" "#E31A1C" "#FDBF6F"
 [8] "#FF7F00" "#CAB2D6" "#6A3D9A" "#FFFF99" "#B15928"
```

```
palette_okabe_ito()
```

```
[1] "#E69F00" "#56B4E9" "#009E73" "#F0E442" "#0072B2" "#D55E00" "#CC79A7"
[8] "#999999" "#000000"
```

```
darken(palette_OkabeIto,-0.3)
```

```
[1] "#F4BA73" "#ABC7DE" "#0BC490" "#F2EBAE" "#589BDB" "#E78F72" "#C9AABA"
[8] "#B7B7B7"
```

Thanks!