Creating plots in R using ggplot2 - part 6: weighted scatterplots

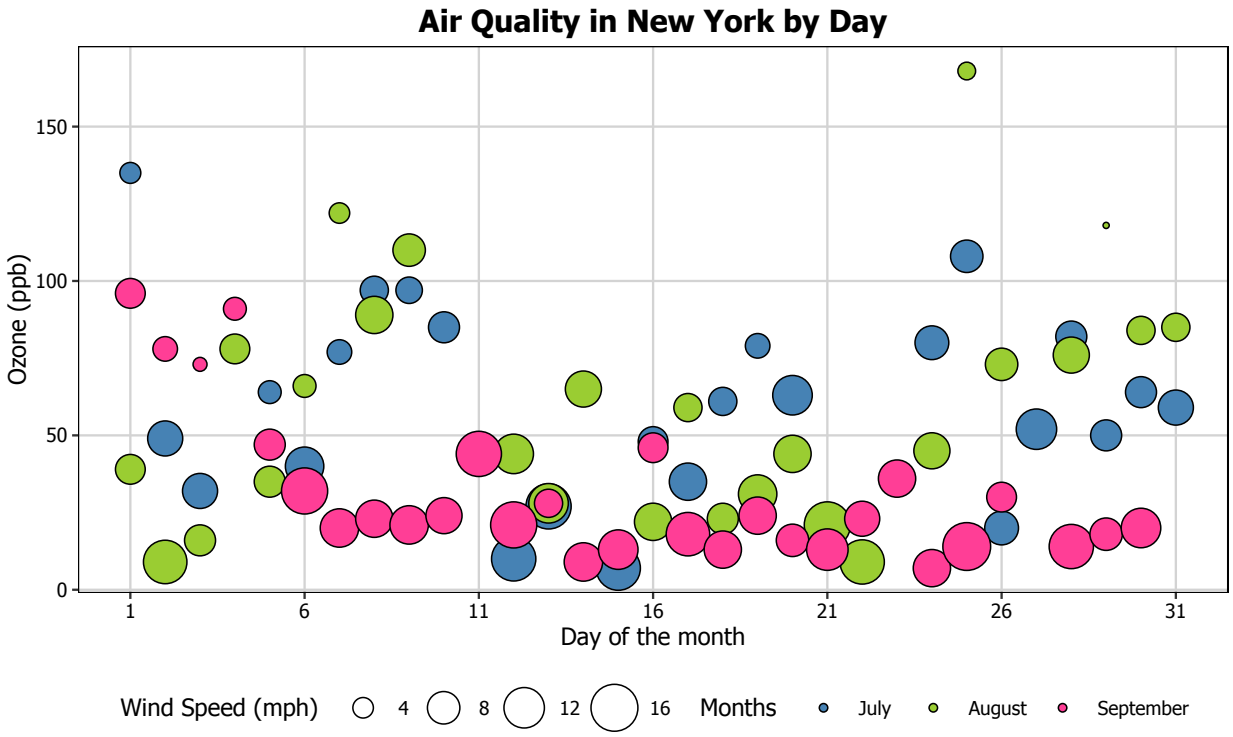
Jodie Burchell
Mauricio Vargas Sepúlveda

2016-05-13

Contents

This is the sixth tutorial in a series on using `ggplot2` I am creating with Jodie Burchell. In this tutorial we will demonstrate some of the many options the `ggplot2` package has for creating and customising weighted scatterplots. These plots are also called 'balloon plots' or 'bubble plots'. We will use R's airquality dataset in the `datasets` package. In order to reduce the complexity of these data a little, we will only be looking at the final three months in the dataset (July, August and September).

In this tutorial, we will work towards creating the weighted scatterplot below. We will take you from a basic scatterplot and explain all the customisations we add to the code step-by-step.



The first thing to do is load in the data and the libraries, as below:

```
library(ggplot2)
library(ggthemes)
library(extrafont)
library(plyr)
library(scales)

data(airquality)
```

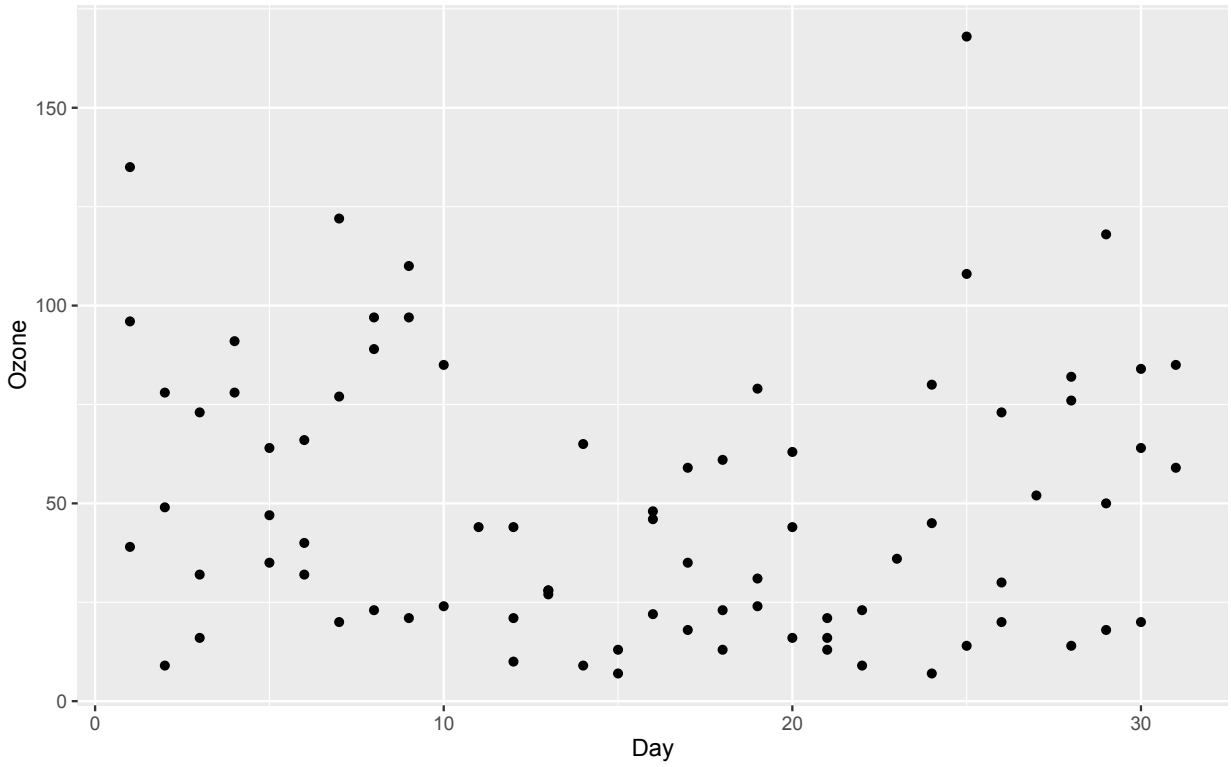
We will then trim the data down to the final three months and turn the `Month` variable into a labelled factor variable. We end up with a new dataset called `aq_trim`.

```
aq_trim <- airquality[which(airquality$Month == 7 |
airquality$Month == 8 |
airquality$Month == 9), ]
aq_trim$Month <- factor(aq_trim$Month,
labels = c("July", "August", "September"))
```

Basic weighted scatterplot

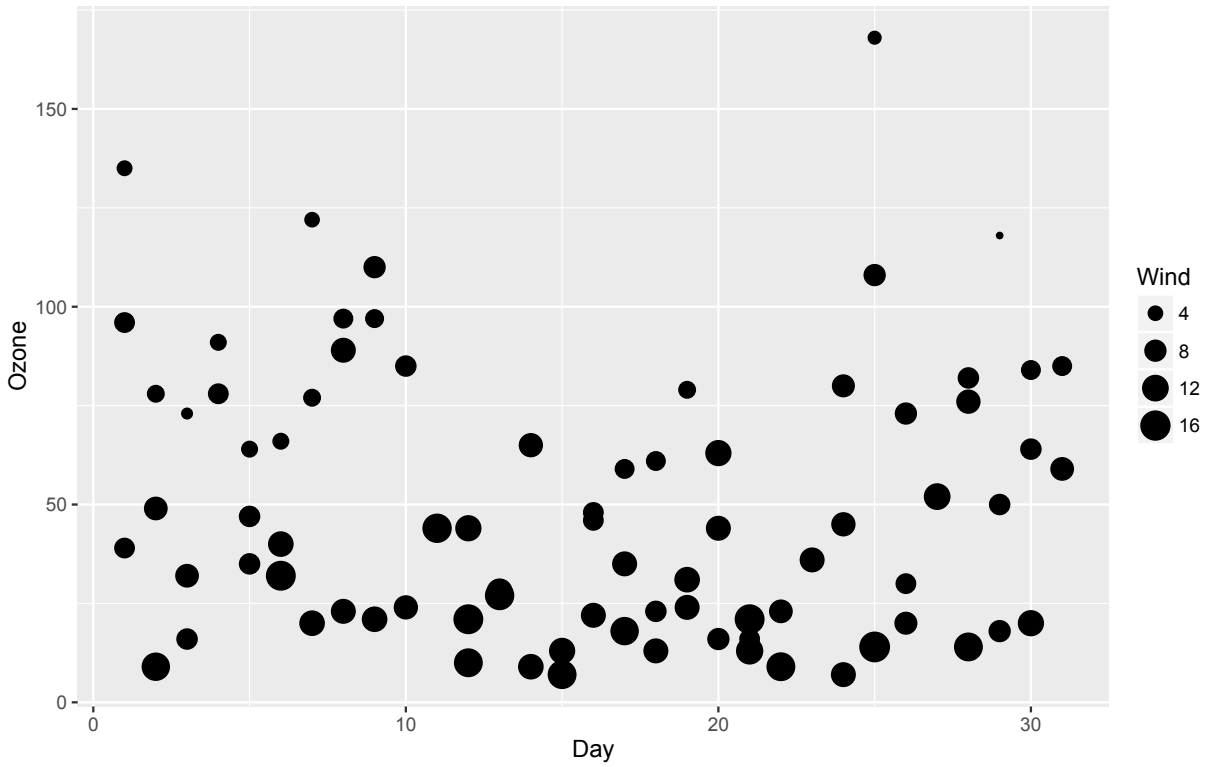
Let's start really slowly by revisiting how to create a basic scatterplot. In order to initialise this plot we tell ggplot that `aq_trim` is our data, and specify that our x-axis plots the `Day` variable and our y-axis plots the `Ozone` variable. We then instruct ggplot to render this as a scatterplot by adding the `geom_point()` option.

```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone)) +
      geom_point()
p6
```



In order to turn this into a weighted scatterplot, we simply add the `size` argument to `ggplot(aes())`. In this case, we want to weight the points by the `Wind` variable.

```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind)) +
  geom_point()
p6
```

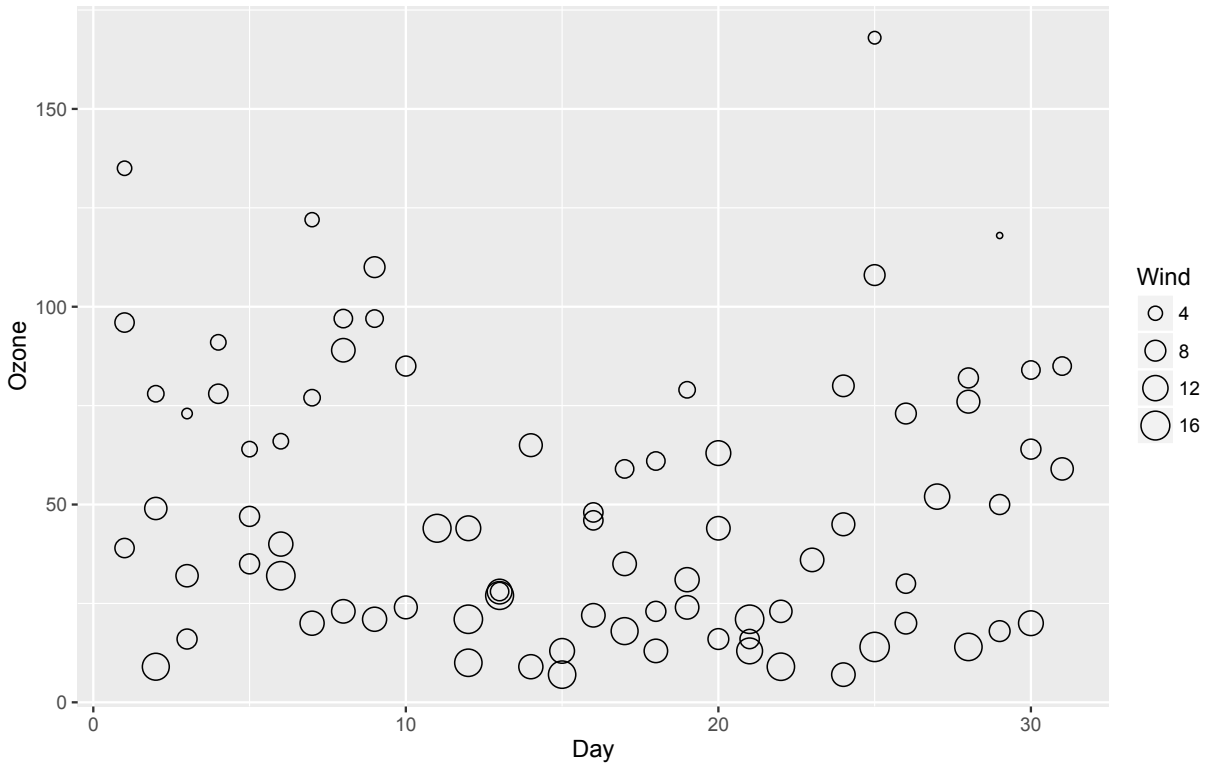


You can see we already have an interesting looking pattern, where days with higher wind speed tend to have lower ozone (or in other words, better air quality). Now let's make it beautiful!

Changing the shape of the data points

Perhaps we want the data points to be a different shape than a solid circle. We can change these by adding the `shape` argument to `geom_point`. An explanation of the allowed arguments for shape are described in this article. In this case, we will use shape 21, which is a circle that allows different colours for the outline and fill.

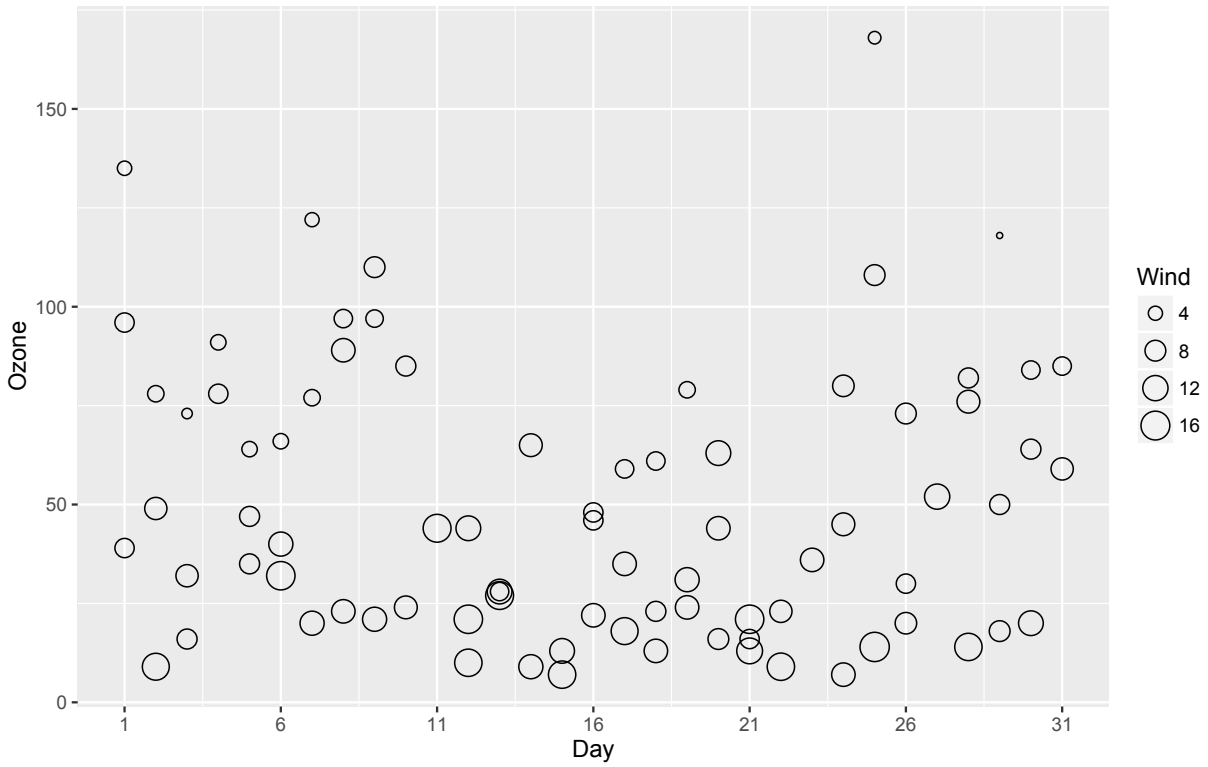
```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind)) +
  geom_point(shape = 21)
p6
```



Adjusting the axis scales

To change the x-axis tick marks, we use the `scale_x_continuous` option. Similarly, to change the y-axis we use the `scale_y_continuous` option. Here we will change the x-axis to every 5 days, rather than 10, and change the range from 1 to 31 (as 0 is not a valid value for this variable).

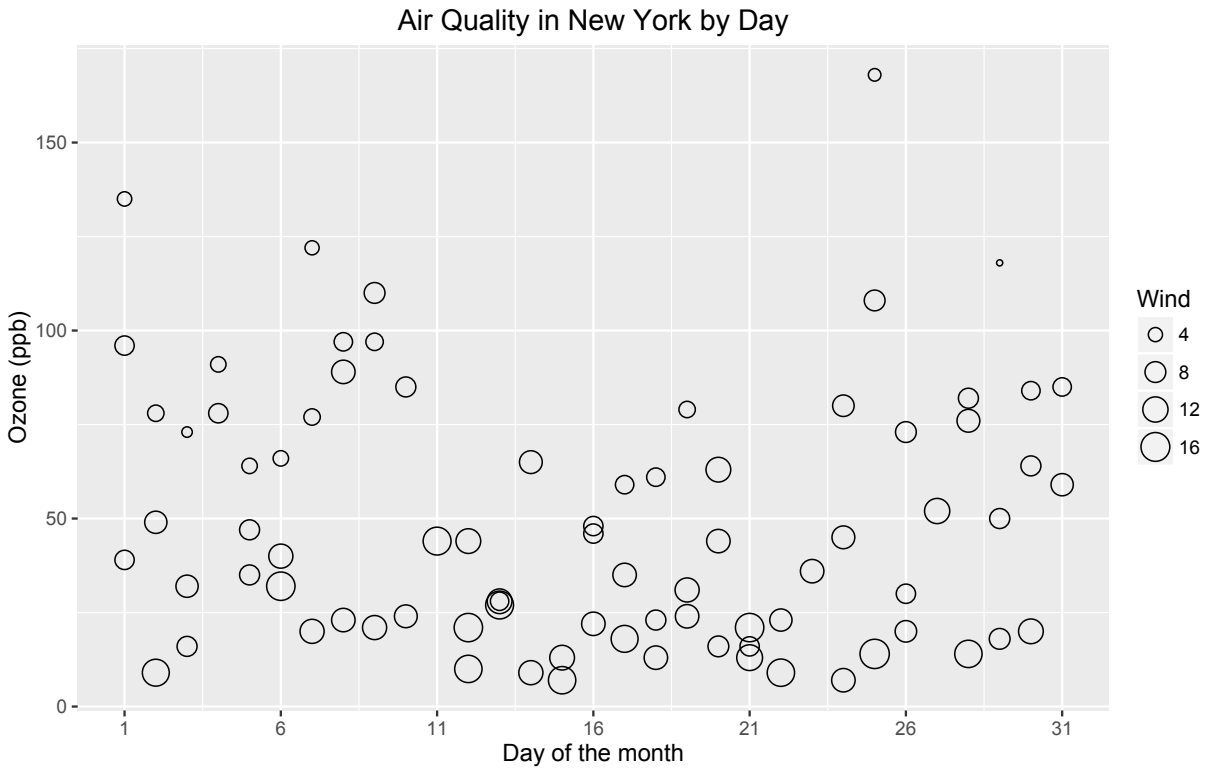
```
p6 <- p6 + scale_x_continuous(breaks = seq(1, 31, 5))
p6
```



Adjusting axis labels & adding title

To add a title, we include the option `ggtitle` and include the name of the graph as a string argument. To change the axis names we add `x` and `y` arguments to the `labs` command.

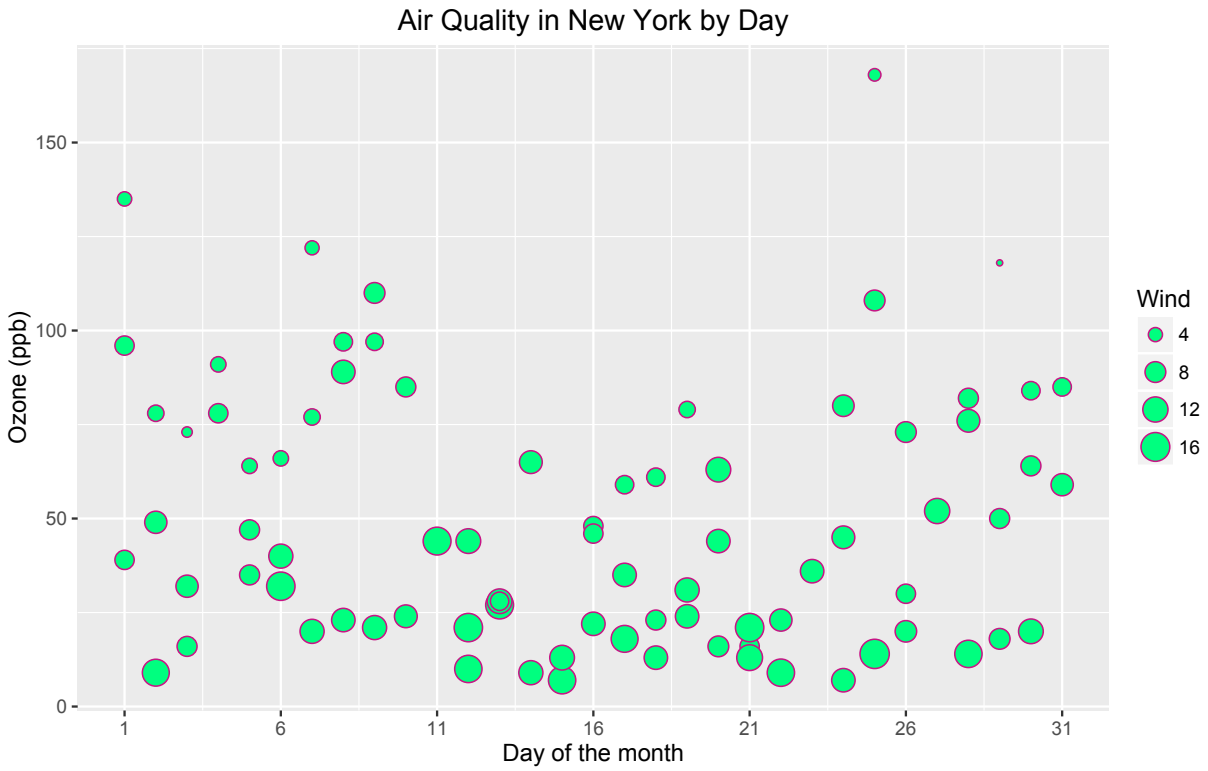
```
p6 <- p6 + ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)")
p6
```



Adjusting the colour palette

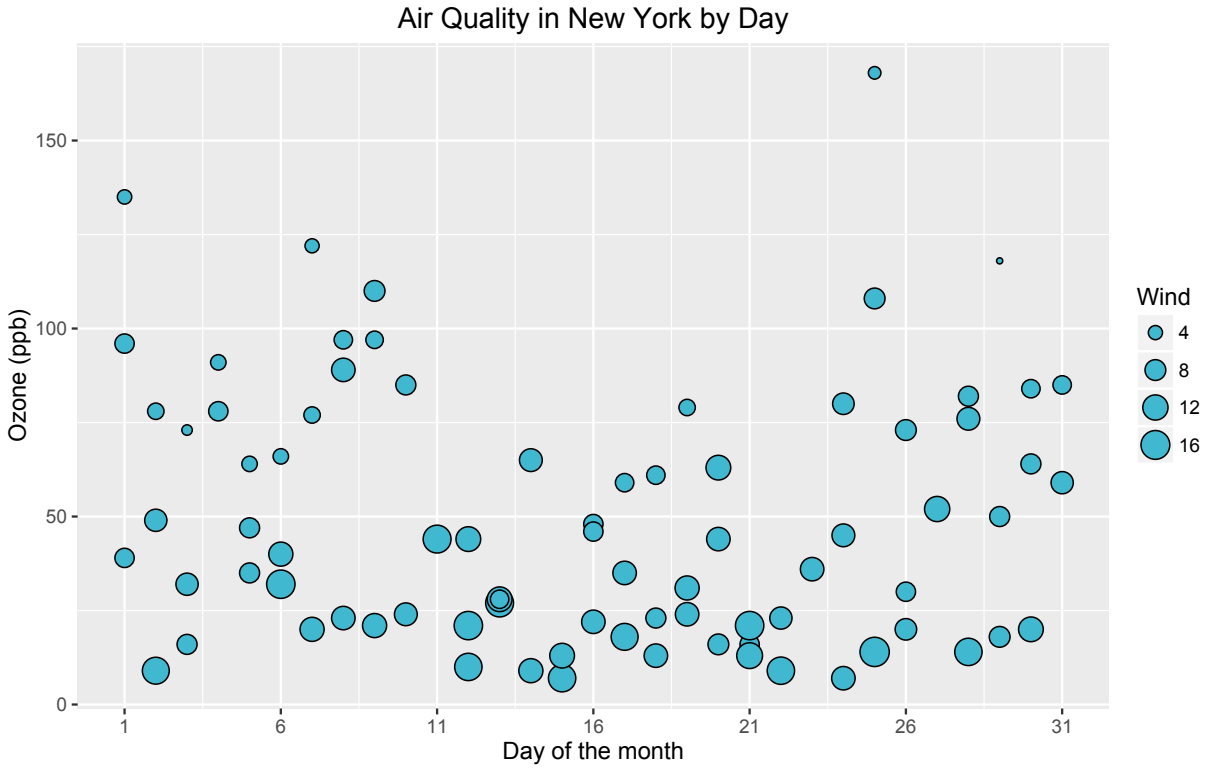
There are a few options for adjusting the colour. The most simple is to make every point one fixed colour. You can reference colours by name, with the full list of colours recognised by R here. Let's try making the outline `mediumvioletred` and the fill `springgreen`.

```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind)) +
  geom_point(shape = 21, colour = "mediumvioletred", fill = "springgreen") +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)") +
  scale_x_continuous(breaks = seq(1, 31, 5))
p6
```



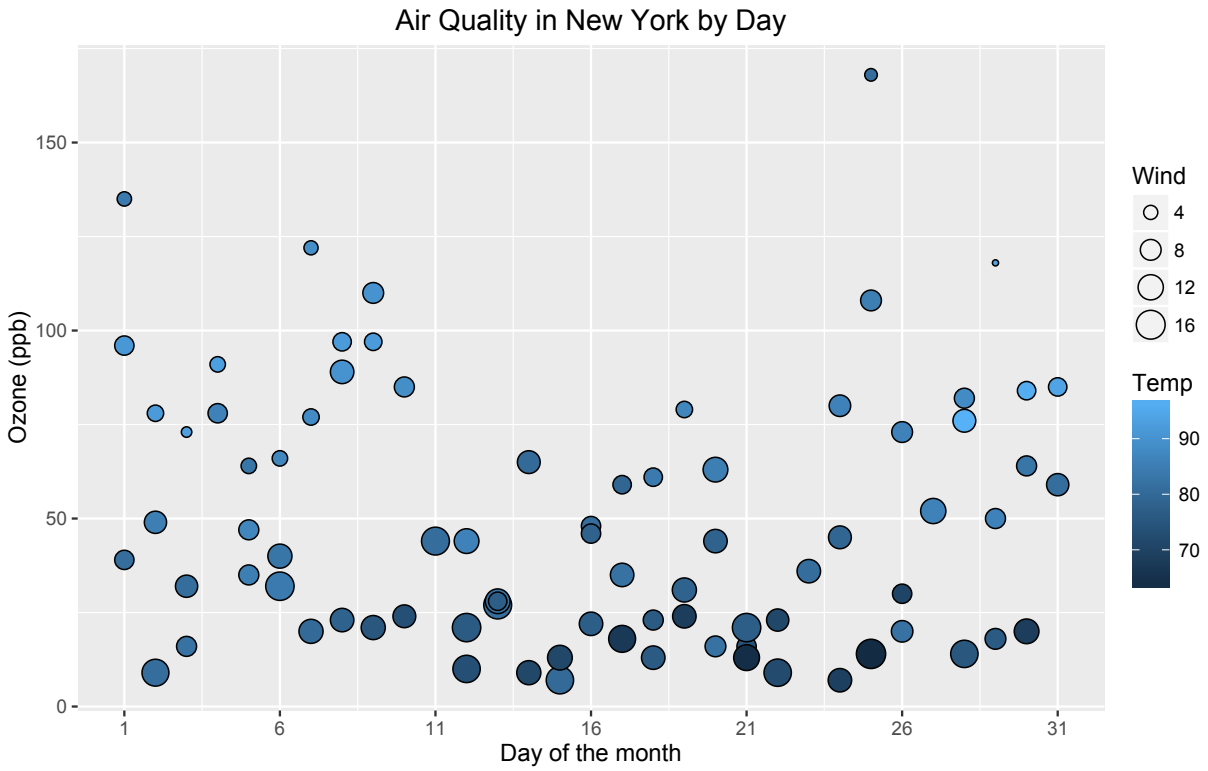
You can change the colours using specific HEX codes instead. Here we have made the outline #000000 (black) and the fill "#40b8d0 (vivid cyan).

```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind)) +
  geom_point(shape = 21, colour = "#000000", fill = "#40b8d0") +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)") +
  scale_x_continuous(breaks = seq(1, 31, 5))
p6
```



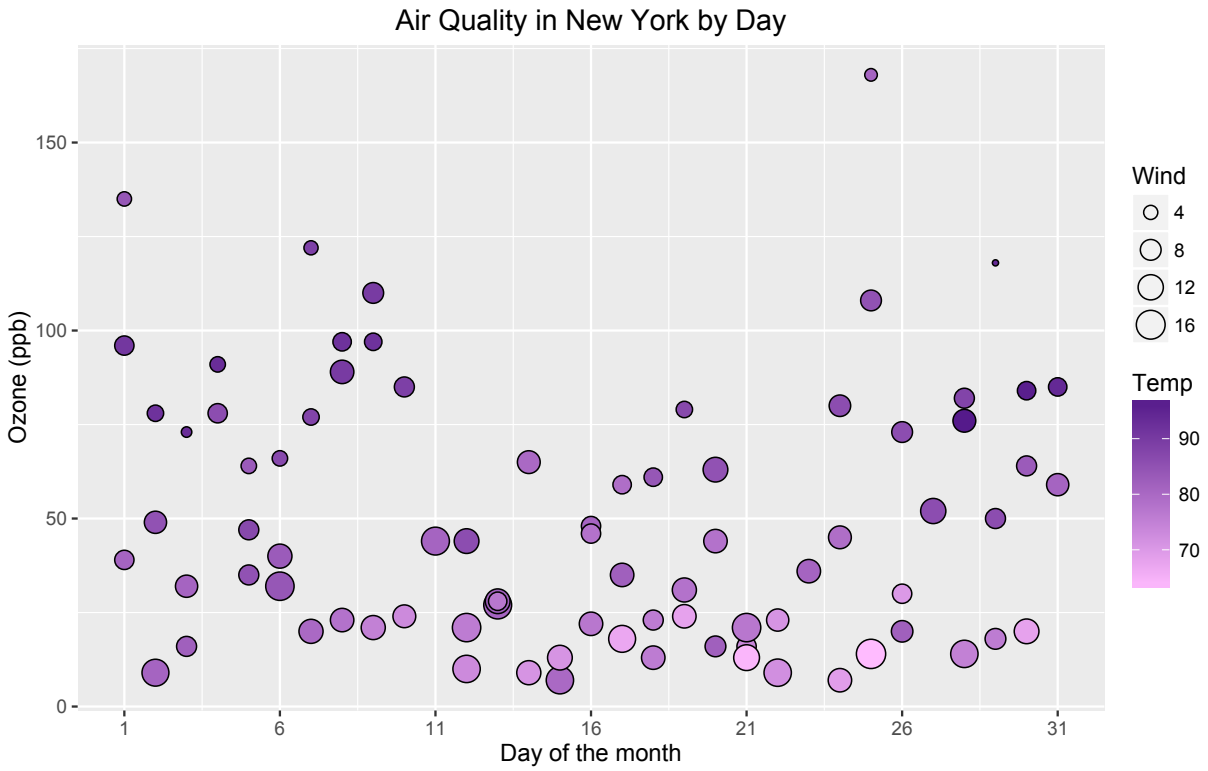
You can also change the colour of the data points according to the levels of another variable. This can be done either as a continuous gradient, or as a levels of a factor variable. Let's change the colour by the values of temperature:

```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind, fill = Temp)) +
  geom_point(shape = 21) +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)") +
  scale_x_continuous(breaks = seq(1, 31, 5))
p6
```



We can change the gradient's colours by adding the `scale_fill_continuous` option. The `low` and `high` arguments specify the range of colours the gradient should transition between.

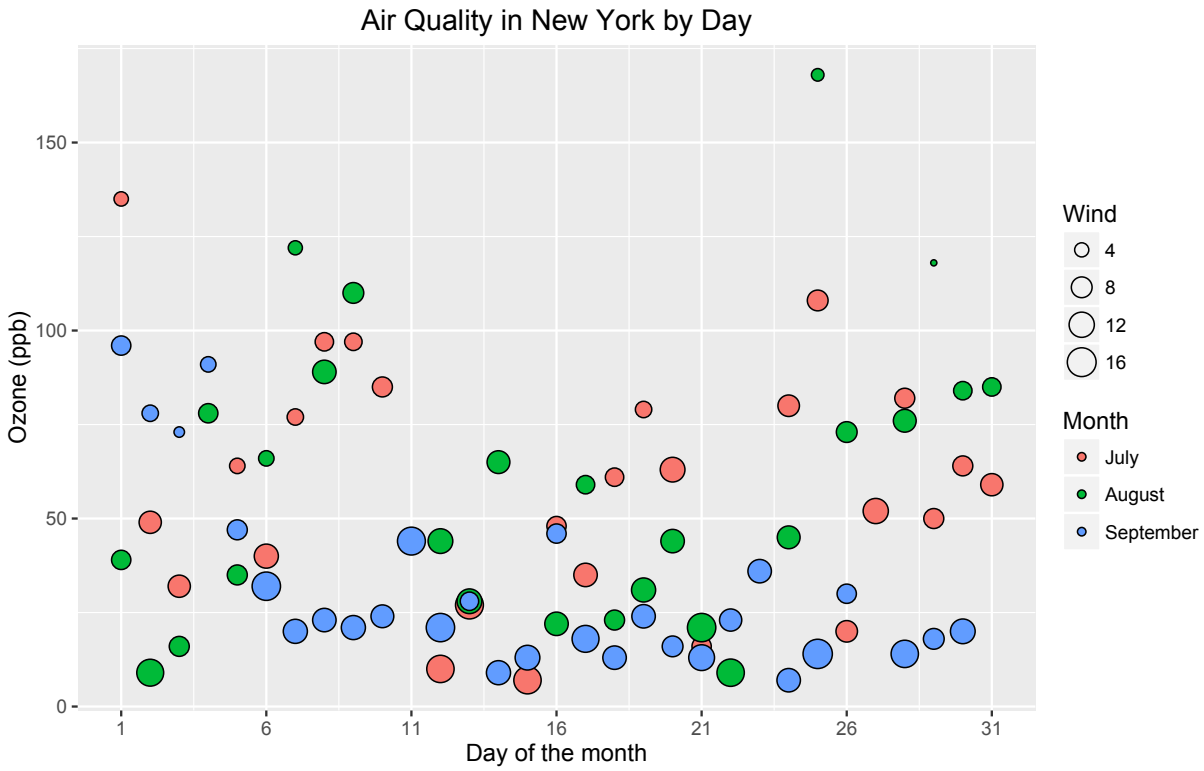
```
p6 <-p6 + scale_fill_continuous(low = "plum1", high = "purple4")
p6
```



We can see that higher temperatures seem to have higher ozone levels.

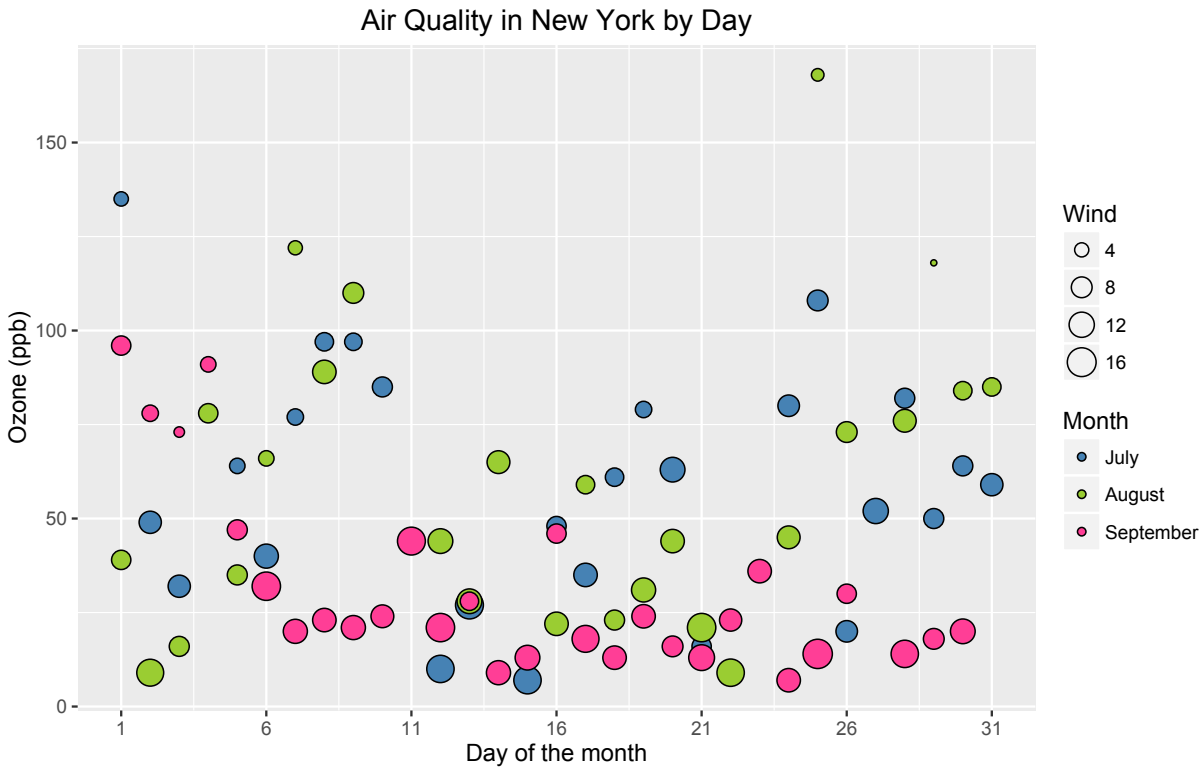
Let's now change the colours of the data points by a factor variable, `Month`.

```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind, fill = Month)) +
  geom_point(shape = 21) +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)") +
  scale_x_continuous(breaks = seq(1, 31, 5))
p6
```



Again, we can change the colours of these data points, this time using `scale_fill_manual`.

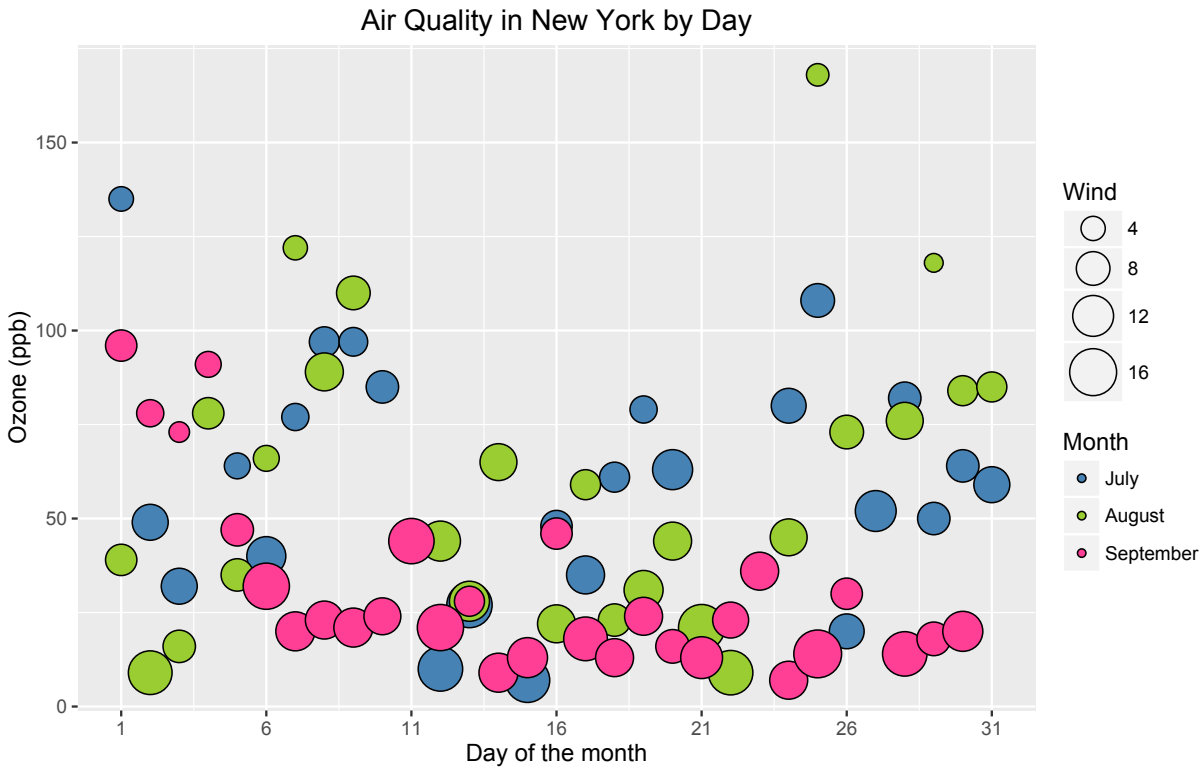
```
fill = c("steelblue", "yellowgreen", "violetred1")

p6 <- p6 + scale_fill_manual(values = fill)
p6
```



Adjusting the size of the data points

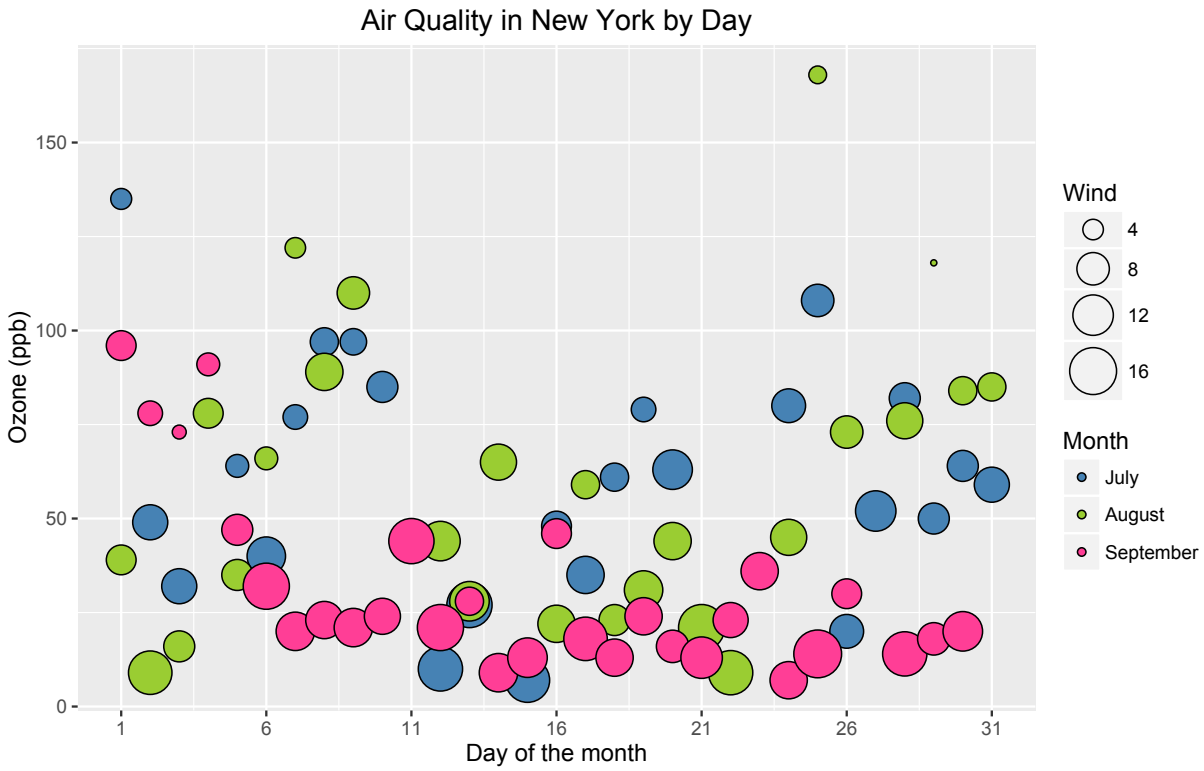
The default size of the the data points in a weighted scatterplot is mapped to the radius of the plots. If we want the data points to be proportional to the value of the weighting variable (e.g., a wind speed of 0 mph would have a value of 0), we need to use the `scale_size_area`.

```
p6 <- p6 + scale_size_area(max_size = 10)
p6
```



For our graph, this makes the pattern for `Wind` a little hard to see. Another way to adjust the size of the data points is to use `scale_size` and specify a desired range.

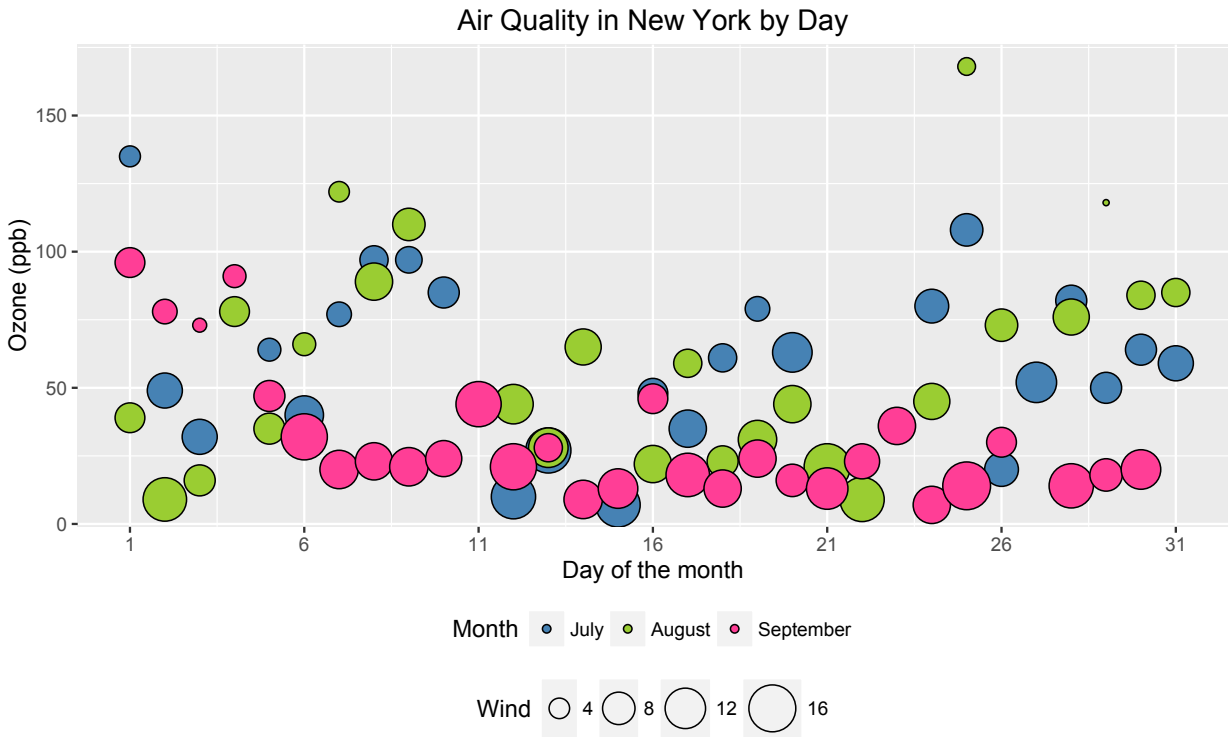
```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind, fill = Month)) +
  geom_point(shape = 21) +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)") +
  scale_x_continuous(breaks = seq(1, 31, 5)) +
  scale_fill_manual(values = fill) +
  scale_size(range = c(1, 10))
p6
```



Adjusting legend position

To adjust the position of the legend from the default spot of right of the graph, we add the `theme` option and specify the `legend.position = "bottom"` argument. We can also change the legend shape using the `legend.direction = "horizontal"` argument.

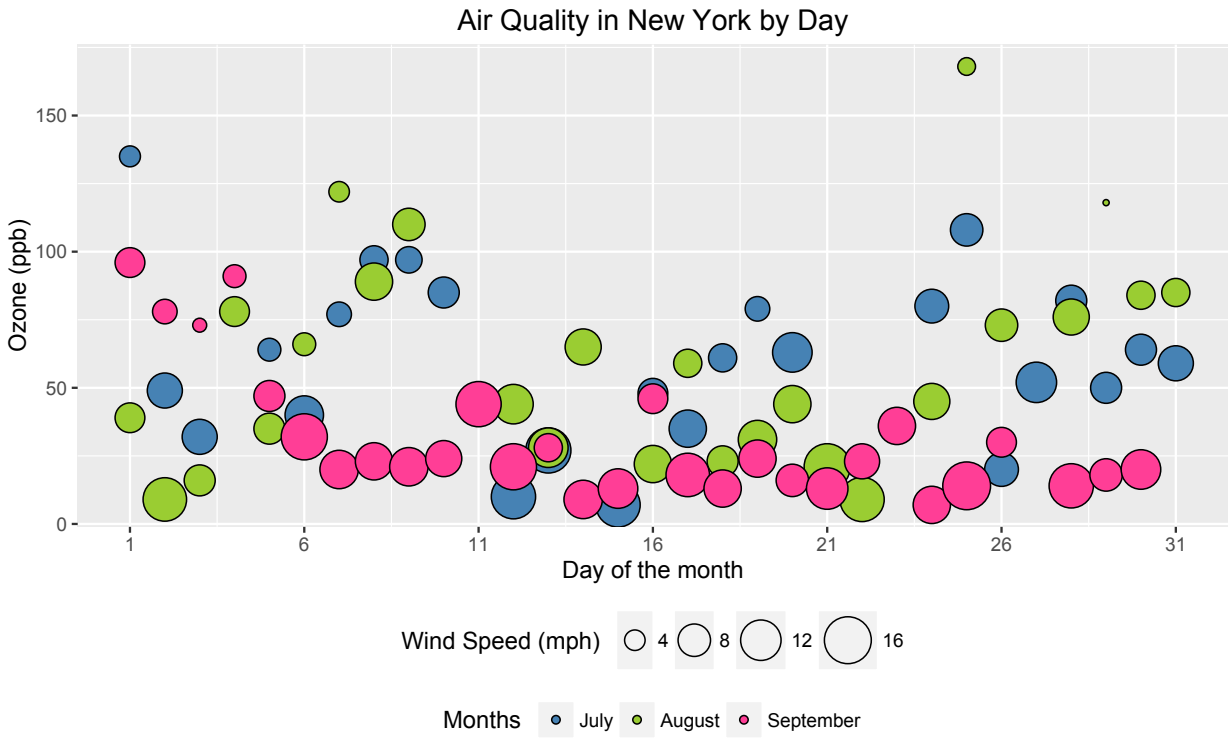
```
p6 <- p6 + theme(legend.position = "bottom", legend.direction = "horizontal")
p6
```



Changing the legend titles

To change the titles of the two legends, we use the `labs` option. In order to tell ggplot2 exactly what legend you're referring to, just have a look in the `ggplot` option and see what argument you used to create the legend in the first place. In this case we used the `size` argument for "Wind" and `fill` for "Month", so we pass these to `labs` with our new titles.

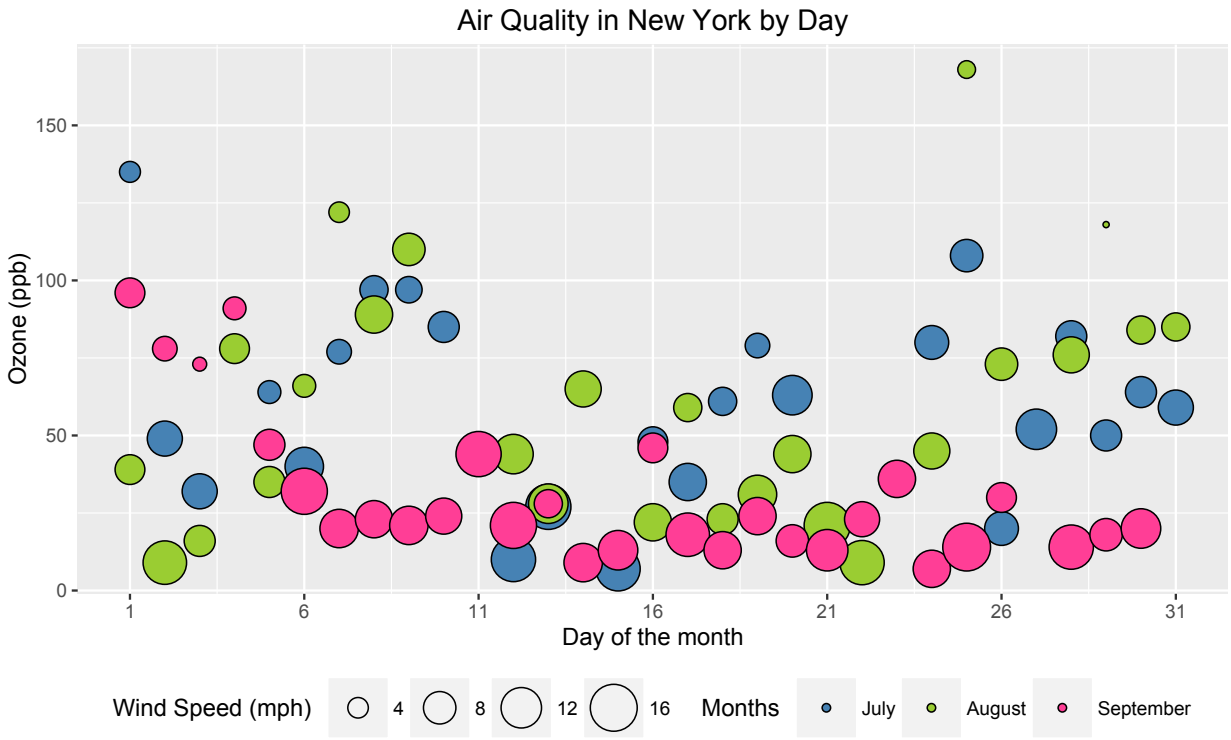
```
p6 <- p6 + labs(size = "Wind Speed (mph) ", fill = "Months ")
p6
```



Creating horizontal legends

It looks a little awkward having the two titles sitting on top of each other, as well as taking up unnecessary space. To place the legends next to each other, we use the `legend.box = "horizontal"` argument in `theme`. Because the boxes around the legend keys aren't even in each of the legends, this means the legends don't align properly. To fix this, we change the box size around the legend keys using `legend.key.size`. We need to load in the `grid` package to get this argument to work.

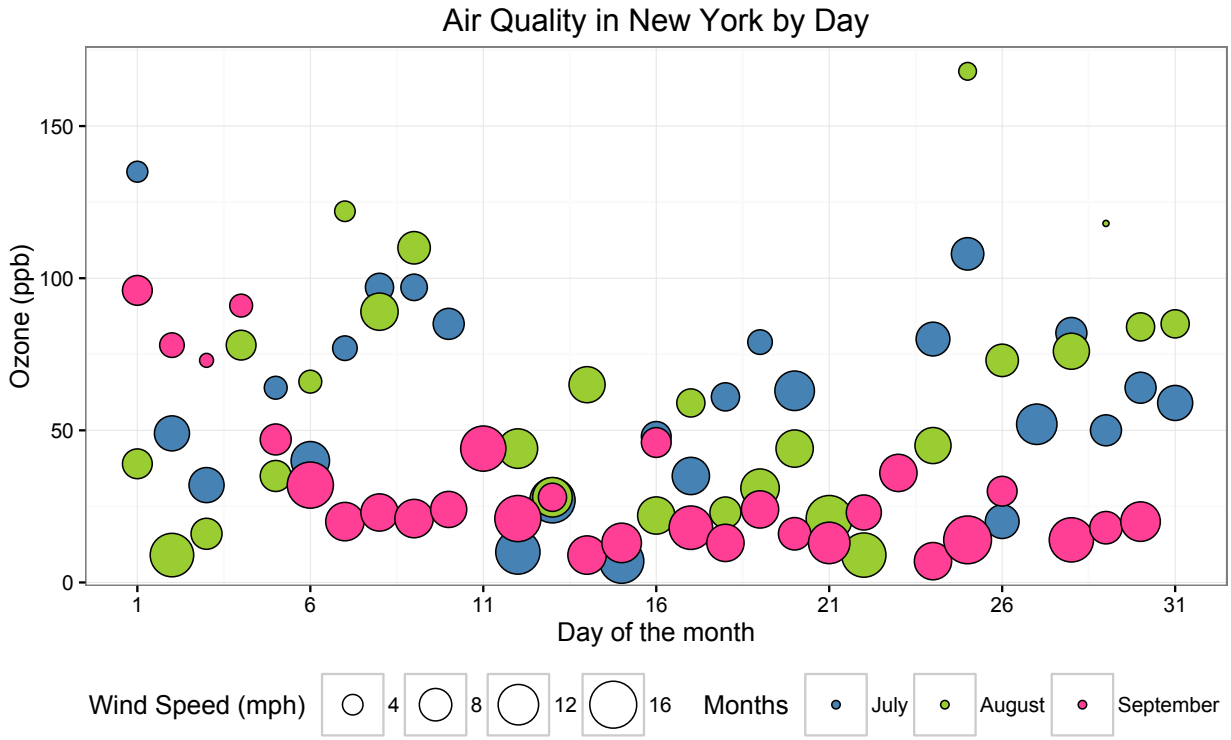
```
p6 <- p6 + theme(legend.box = "horizontal", legend.key.size = unit(1, "cm"))
p6
```



Using the white theme

As explained in the previous posts, we can also change the overall look of the plot using themes. We'll start using a simple theme customisation by adding `theme_bw()` after `ggplot()`. As you can see, we can further tweak the graph using the `theme` option, which we've used so far to change the legend.

```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind, fill = Month)) +
  geom_point(shape = 21) +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)",
    size = "Wind Speed (mph) ", fill = "Months ") +
  scale_x_continuous(breaks = seq(1, 31, 5)) +
  scale_fill_manual(values = fill) +
  scale_size(range = c(1, 10)) +
  theme_bw() +
  theme(legend.position="bottom", legend.direction="horizontal",
    legend.box = "horizontal",
    legend.key.size = unit(1, "cm"))
p6
```

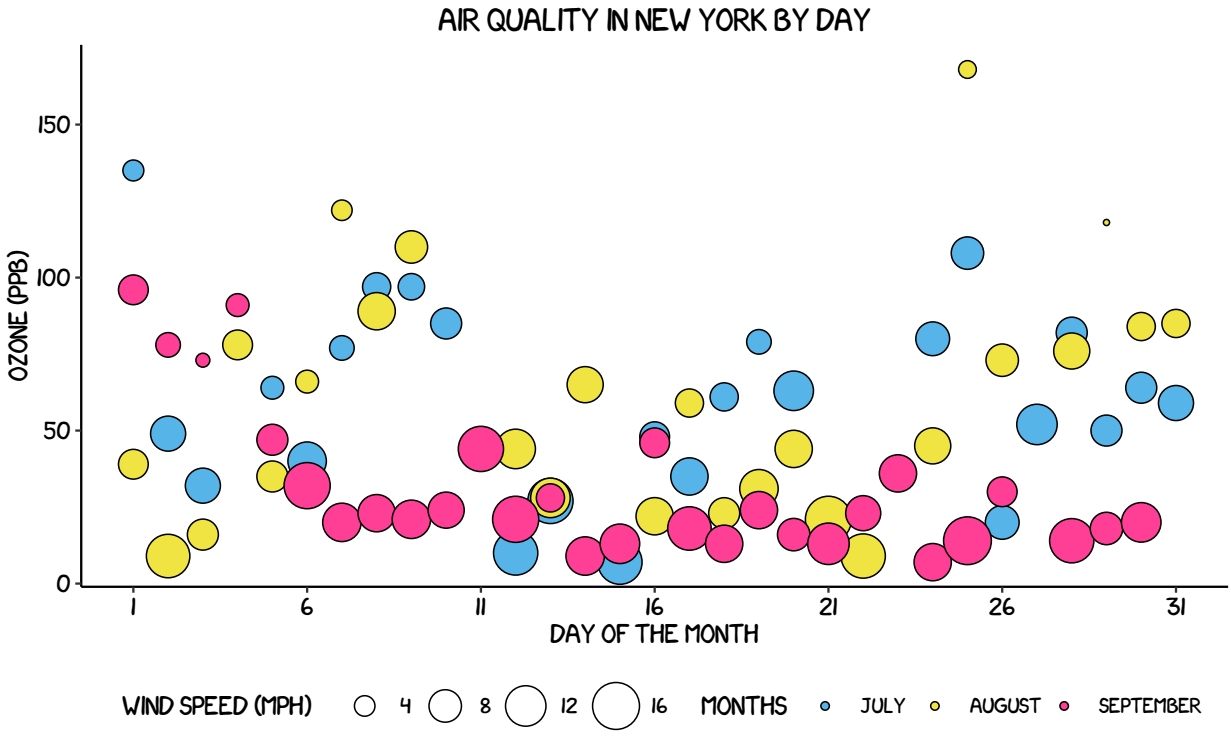


Creating an XKCD style chart

Of course, you may want to create your own themes as well. `ggplot2` allows for a very high degree of customisation, including allowing you to use imported fonts. Below is an example of a theme Mauricio was able to create which mimics the visual style of XKCD. In order to create this chart, you first need to import the XKCD font, and load it into R using the `extrafont` package.

```
fill <- c("#56B4E9", "#F0E442", "violetred1")

p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind, fill = Month)) +
  geom_point(shape = 21) +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)",
    size = "Wind Speed (mph) ", fill = "Months ") +
  scale_x_continuous(breaks = seq(1, 31, 5)) +
  scale_fill_manual(values = fill) +
  scale_size(range = c(1, 10)) +
  theme(axis.line.x = element_line(size=.5, colour = "black"),
    axis.line.y = element_line(size=.5, colour = "black"),
    axis.text.x=element_text(colour="black", size = 10),
    axis.text.y=element_text(colour="black", size = 10),
    legend.position="bottom",
    legend.direction="horizontal",
    legend.box = "horizontal",
    legend.key.size = unit(1, "cm"),
    legend.key = element_blank(),
    panel.grid.major = element_blank(),
```

```
    panel.grid.minor = element_blank(),
    panel.border = element_blank(),
    panel.background = element_blank(),
    plot.title=element_text(family="xkcd-Regular"),
    text=element_text(family="xkcd-Regular"))
p6
```

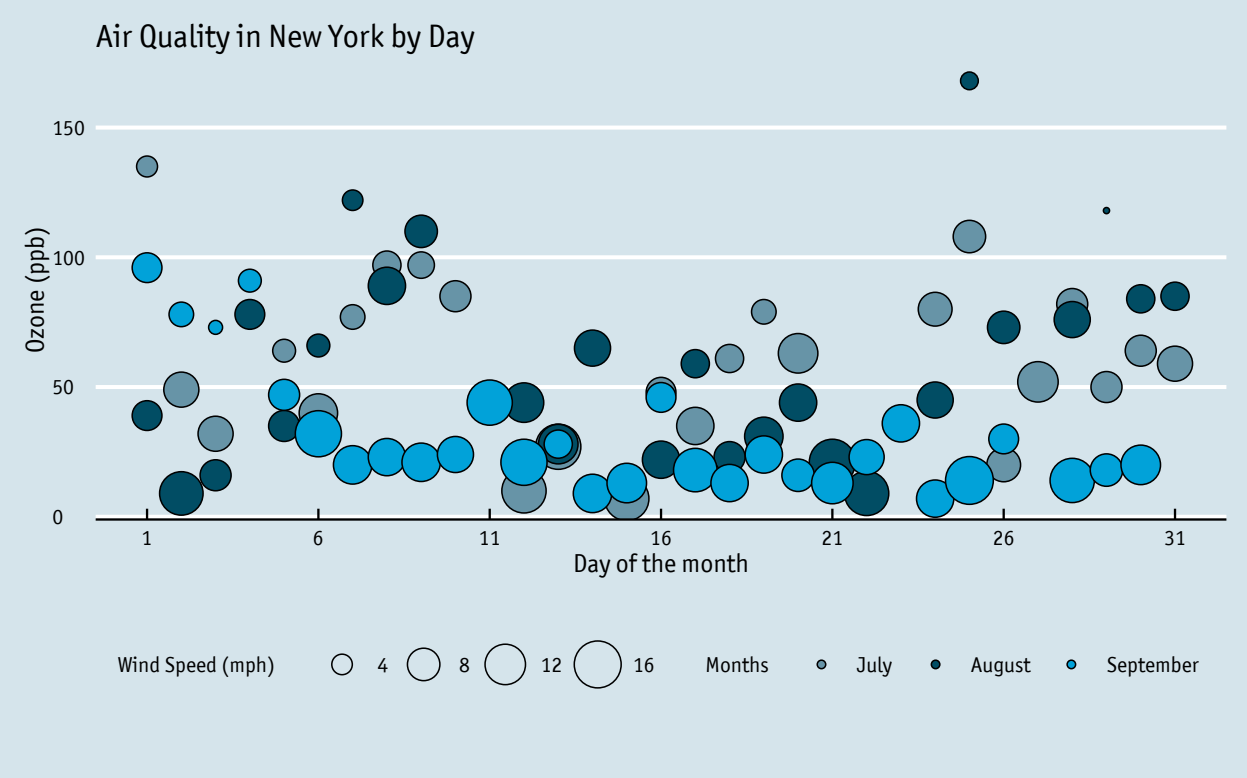


Using 'The Economist' theme

There are a wider range of pre-built themes available as part of the `ggthemes` package (more information on these here). Below we've applied `theme_economist()`, which approximates graphs in the Economist magazine. It is also important that the font change argument inside `theme` is optional and it's only to obtain a more similar result compared to the original. For an exact result you need 'Officina Sans' which is a commercial font and is available here.

```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind, fill = Month)) +
  geom_point(shape = 21) +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)", size = "Wind Speed (mph) ", fill = "Months ") +
  scale_x_continuous(breaks = seq(1, 31, 5)) +
  scale_size(range = c(1, 10)) +
  theme_economist() + scale_fill_economist() +
  theme(axis.line.x = element_line(size=.5, colour = "black"),
    axis.title = element_text(size = 12),
    legend.position="bottom",
    legend.direction="horizontal",
```

```
    legend.box = "horizontal",
    legend.key.size = unit(1, "cm"),
    legend.text = element_text(size = 10),
    text = element_text(family = "OfficinaSanITC-Book"),
    plot.title = element_text(family="OfficinaSanITC-Book"))
p6
```

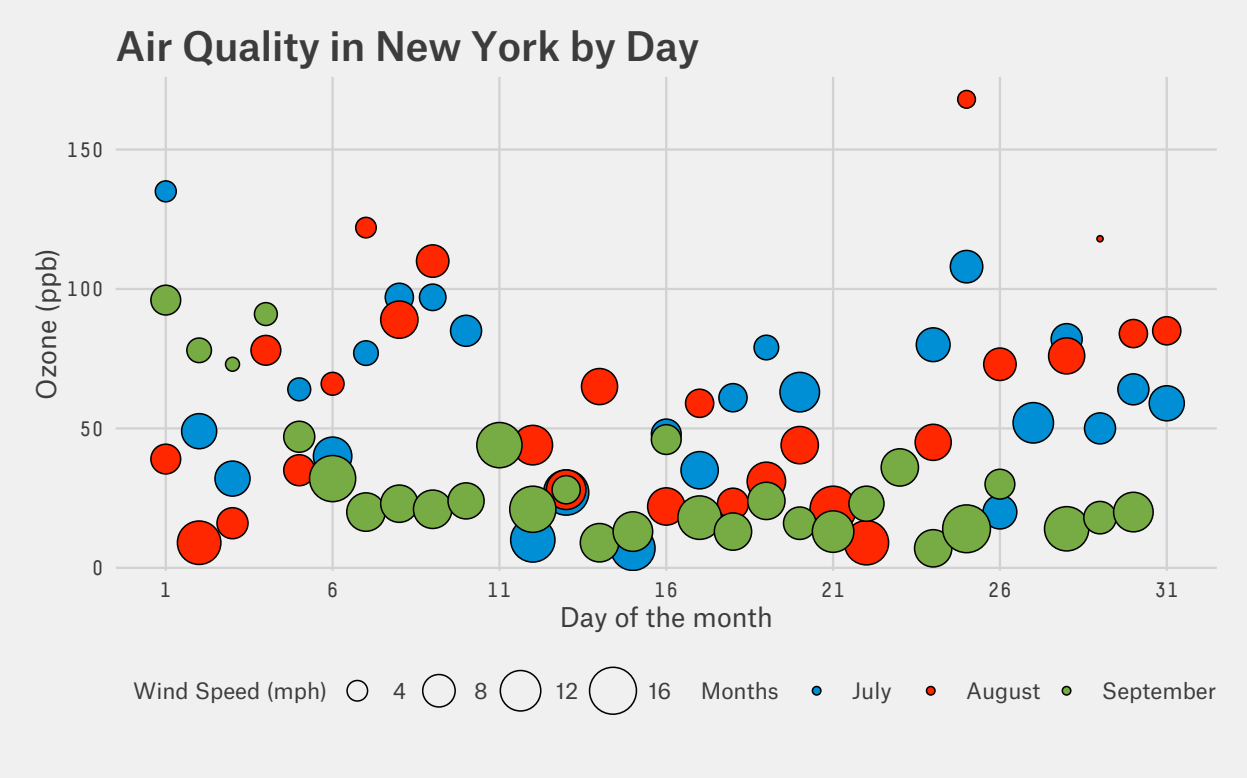


Using 'Five Thirty Eight' theme

Below we've applied `theme_fivethirtyeight()`, which approximates graphs in the nice FiveThirtyEight website. Again, it is also important that the font change is optional and it's only to obtain a more similar result compared to the original. For an exact result you need 'Atlas Grotesk' and 'Decima Mono Pro' which are commercial font and are available here and here.

```
p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind, fill = Month)) +
  geom_point(shape = 21) +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)", size = "Wind Speed (mph) ", fill = "Months ") +
  scale_x_continuous(breaks = seq(1, 31, 5)) +
  scale_size(range = c(1, 10)) +
  theme_fivethirtyeight() + scale_fill_fivethirtyeight() +
  theme(axis.title = element_text(family="Atlas Grotesk Regular"),
    legend.position="bottom",
    legend.direction="horizontal",
    legend.box = "horizontal",
    legend.key.size = unit(1, "cm"),
```

```
    legend.title=element_text(family="Atlas Grotesk Regular", size = 10),
    legend.text=element_text(family="Atlas Grotesk Regular", size = 10),
    plot.title=element_text(family="Atlas Grotesk Medium"),
    text=element_text(family="DecimaMonoPro"))
p6
```



Creating your own theme

As before, you can modify your plots a lot as `ggplot2` allows many customisations. Here we present our original result shown at the top of page.

```
fill = c("steelblue", "yellowgreen", "violetred1")

p6 <- ggplot(aq_trim, aes(x = Day, y = Ozone, size = Wind, fill = Month)) +
  geom_point(shape = 21) +
  ggtitle("Air Quality in New York by Day") +
  labs(x = "Day of the month", y = "Ozone (ppb)", size = "Wind Speed (mph) ", fill = "Months ") +
  scale_x_continuous(breaks = seq(1, 31, 5)) +
  scale_size(range = c(1, 10)) +
  scale_fill_manual(values = fill) +
  theme(panel.border = element_rect(colour = "black", fill=NA, size=.5),
    axis.text.x=element_text(colour="black", size = 9),
    axis.text.y=element_text(colour="black", size = 9),
    legend.position="bottom",
    legend.direction="horizontal",
    legend.box = "horizontal",
```

```
    legend.key.size = unit(1, "cm"),
    legend.key = element_blank(),
    panel.grid.major = element_line(colour = "#d3d3d3"),
    panel.grid.minor = element_blank(),
    panel.border = element_blank(), panel.background = element_blank(),
    plot.title = element_text(size = 14, family = "Tahoma", face = "bold"),
    text=element_text(family="Tahoma"))
p6
```