# Workshop 5.2: The Grammar of Graphics

Murray Logan

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# Section 1

# Graphics in R

# Options

- Traditional (base) graphics
  - isolated instructions to the device
- Grid graphics
  - instruction sets
  - lattice
  - ggplot2

# Packages

```
> library(ggplot2)
> library(grid)
> library(gridExtra)
> library(scales)
```

# Graphics infrustructure

- layers of data driven objects
- coordinate system
- scales
- faceting
- themes

# ggplot

```
> head(BOD)
```

```
  Time demand
1    1    8.3
2    2   10.3
3    3   19.0
4    4   16.0
5    5   15.6
6    7   19.8
```

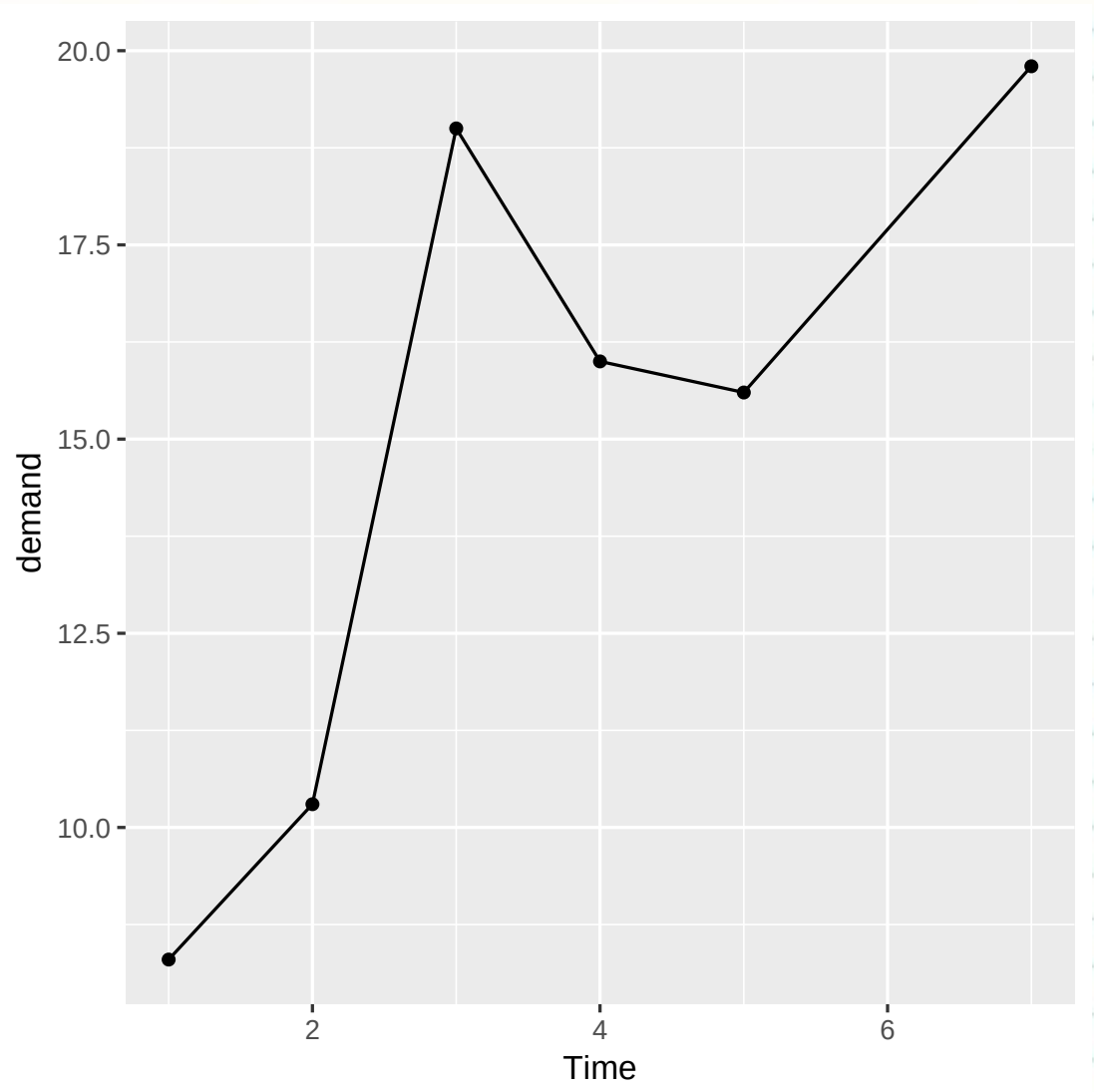
```
> summary(BOD)
```

```
      Time           demand     
 Min.   :1.000   Min.   : 8.30  
 1st Qu.:2.250   1st Qu.:11.62  
 Median :3.500   Median :15.80  
 Mean   :3.667   Mean   :14.83  
 3rd Qu.:4.750   3rd Qu.:18.25  
 Max.   :7.000   Max.   :19.80  
```

# ggplot

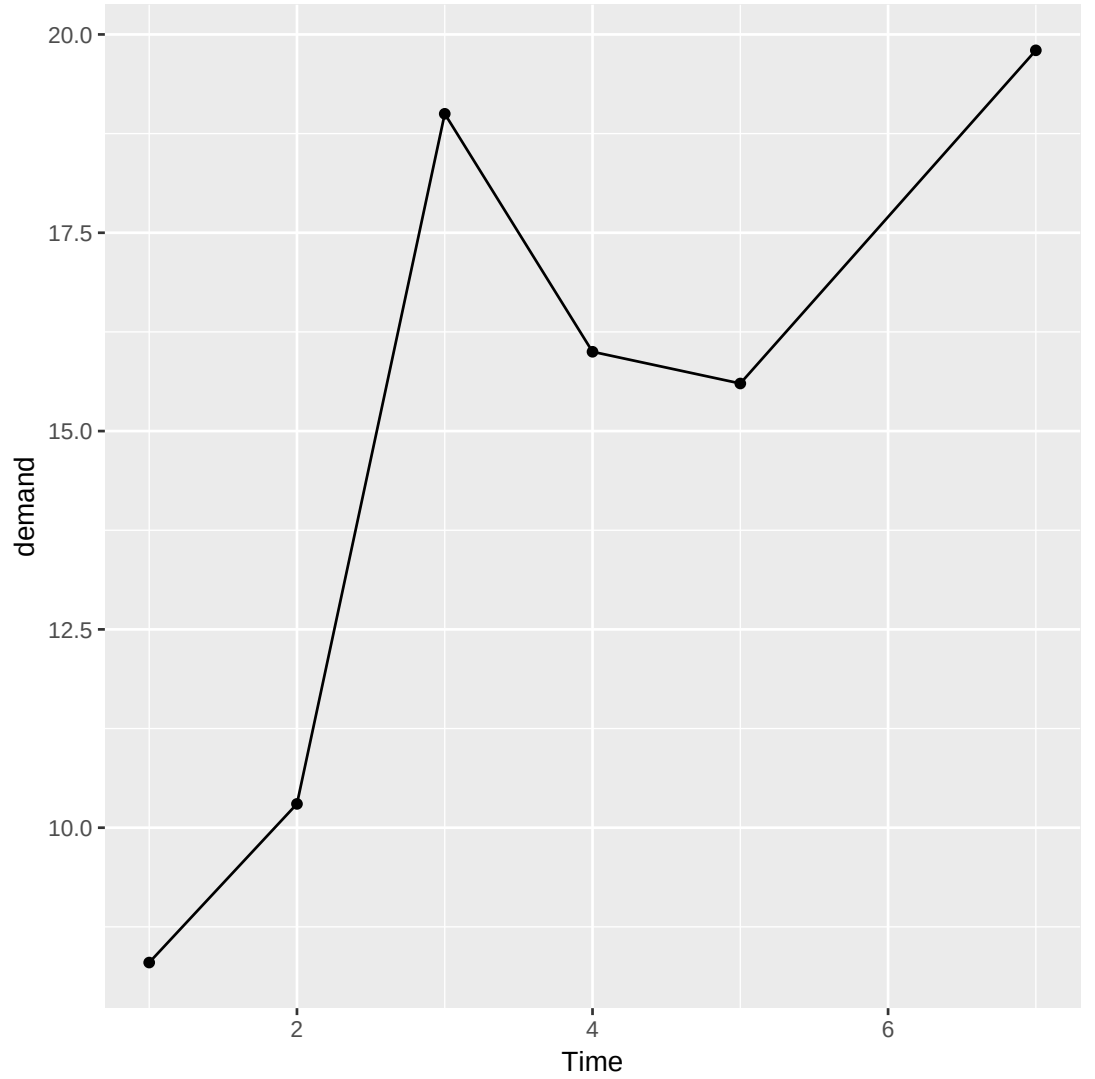
```
>  p <- ggplot() +
+   #single layer - points
+   layer(data=BOD, #data.frame
+     mapping=aes(y=demand,x=Time),
+     stat="identity", #use original data
+     geom="point", #plot data as points
+     position="identity",
+     params = list(na.rm = TRUE),
+     show.legend = FALSE
+   )+ #layer of lines
+   layer( data=BOD, #data.frame
+     mapping=aes(y=demand,x=Time),
+     stat="identity", #use original data
+     geom="line", #plot data as a line
+     position="identity",
+     params = list(na.rm = TRUE),
+     show.legend = FALSE
+   ) +
+   coord_cartesian() + #cartesian coordinates
+   scale_x_continuous() + #continuous x axis
+   scale_y_continuous()  #continuous y axis
> p #print the plot
```

# ggplot



# ggplot

```
> ggplot(data=BOD, map=aes(y=demand,x=Time)) + geom_point()+geom_line()
```



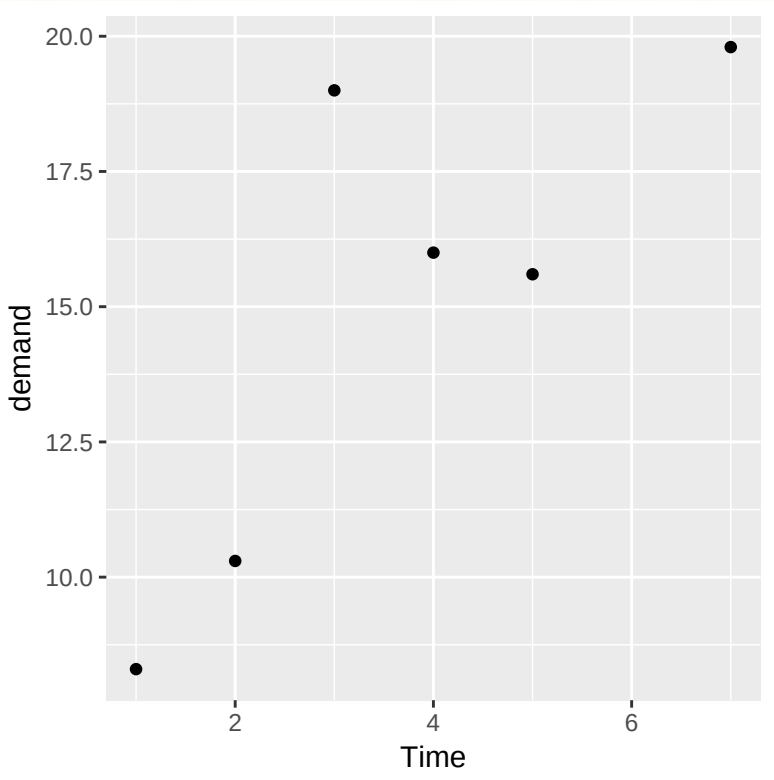
# Overview

- data

```
> p<-ggplot(data=BOD)
```

- layers (geoms)

```
> p<-p + geom_point(aes(y=demand, x=Time))
> p
```



# Overview

- data

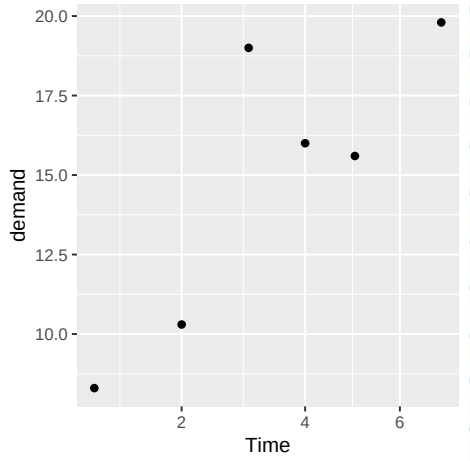
```
> p<-ggplot(data=BOD)
```

- layers (geoms)

```
> p<-p + geom_point(aes(y=demand, x=Time))
```

- scales

```
> p <- p + scale_x_sqrt(name="Time")
> p
```



# Section 2

## Layers

# Layers

- layers of data driven objects
  - geometric objects to represent data
  - statistical methods to summarize the data
  - mapping of aethetics
  - position control

# geom_ and stat_

- coupled together
- engage either
- stat_identity

# geom_

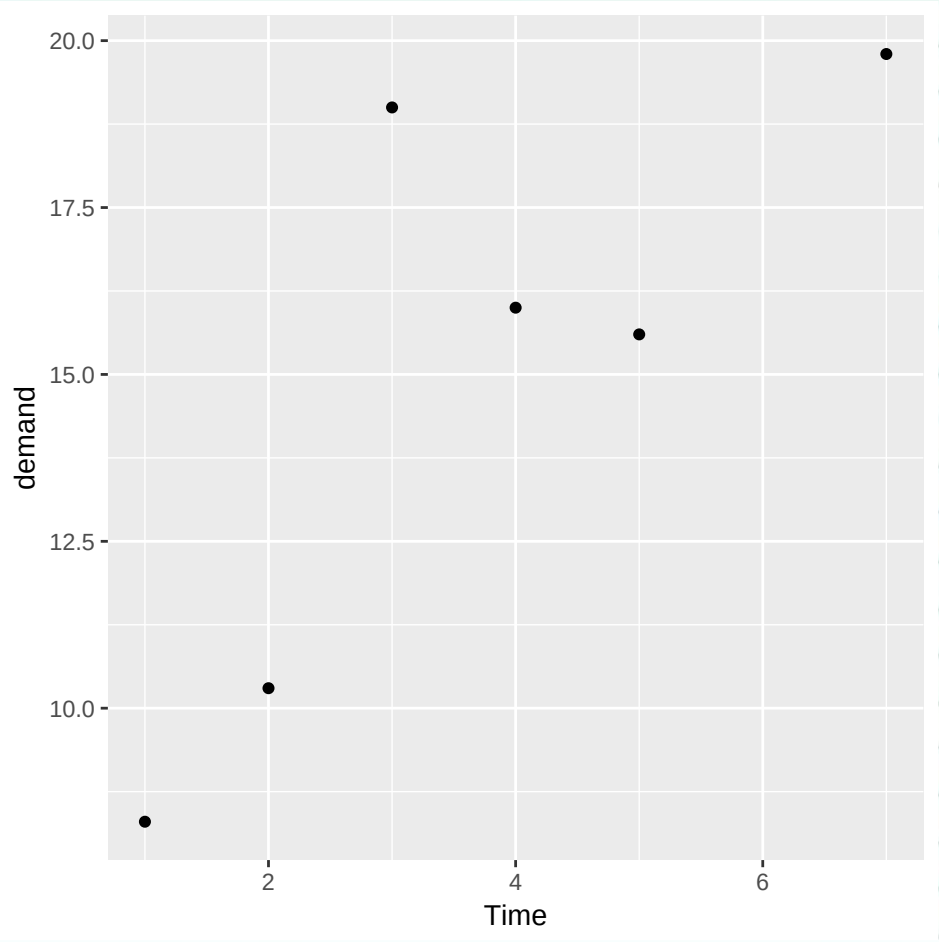
- data - obvious
- mapping - aesthetics

If omitted, inherited from `ggplot()`

- stat - the `stat_` function
- position - overlapping geoms

# geom_

```
> ggplot(data=BOD, aes(y=demand, x=Time)) + geom_point()
> #OR
> ggplot(data=BOD) + geom_point(aes(y=demand, x=Time))
```



# Optional mapping

- alpha - transparency
- colour - colour of the geometric features
- fill - colour of the geometric features
- linetype - fill colour of geometric features
- size - size of geometric features such as points or text
- shape - shape of geometric features such as points
- weight - weightings of values

# geom_point

```
> head(CO2)
```

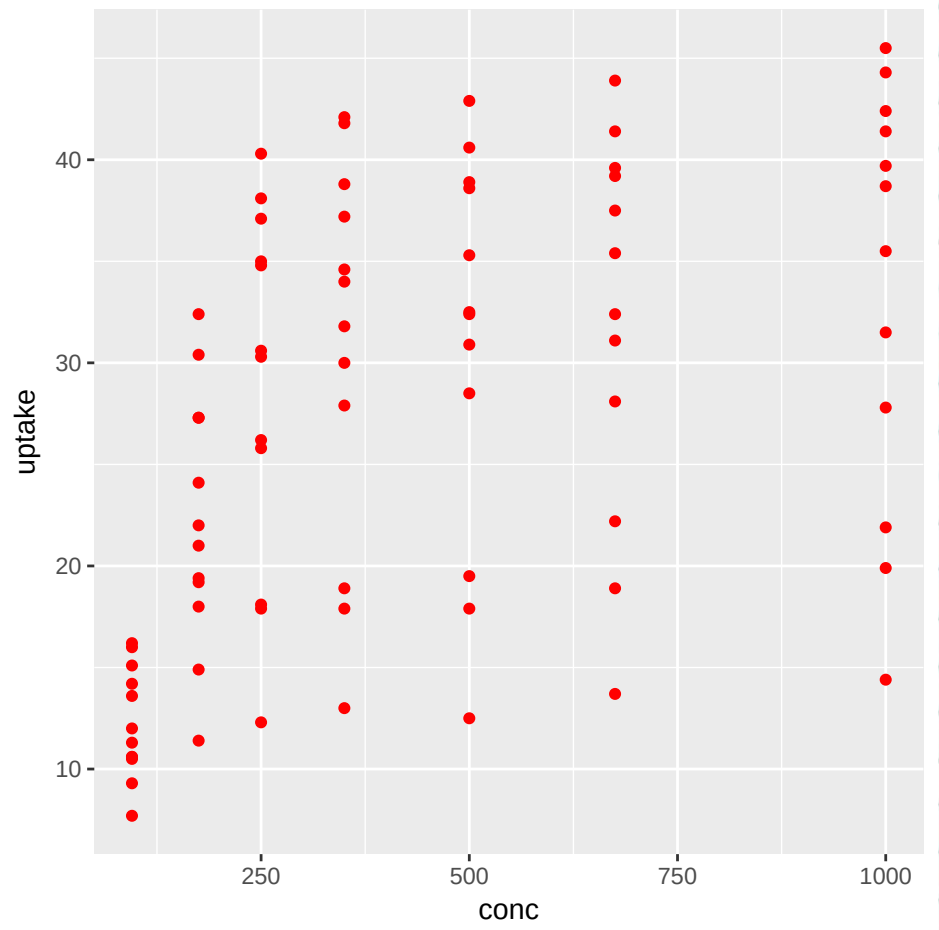
```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
4   Qn1 Quebec nonchilled  350   37.2
5   Qn1 Quebec nonchilled  500   35.3
6   Qn1 Quebec nonchilled  675   39.2
```

```
> summary(CO2)
```

```
     Plant                Type         Treatment       conc          uptake      
 Qn1    : 7   Quebec      :42   nonchilled:42   Min.   :  95   Min.   : 7.70  
 Qn2    : 7   Mississippi:42   chilled   :42   1st Qu.: 175   1st Qu.:17.90  
 Qn3    : 7                                    Median : 350   Median :28.30  
 Qc1    : 7                                    Mean   : 435   Mean   :27.21  
 Qc3    : 7                                    3rd Qu.: 675   3rd Qu.:37.12  
 Qc2    : 7                                    Max.   :1000   Max.   :45.50  
 (Other):42                                                                  
```

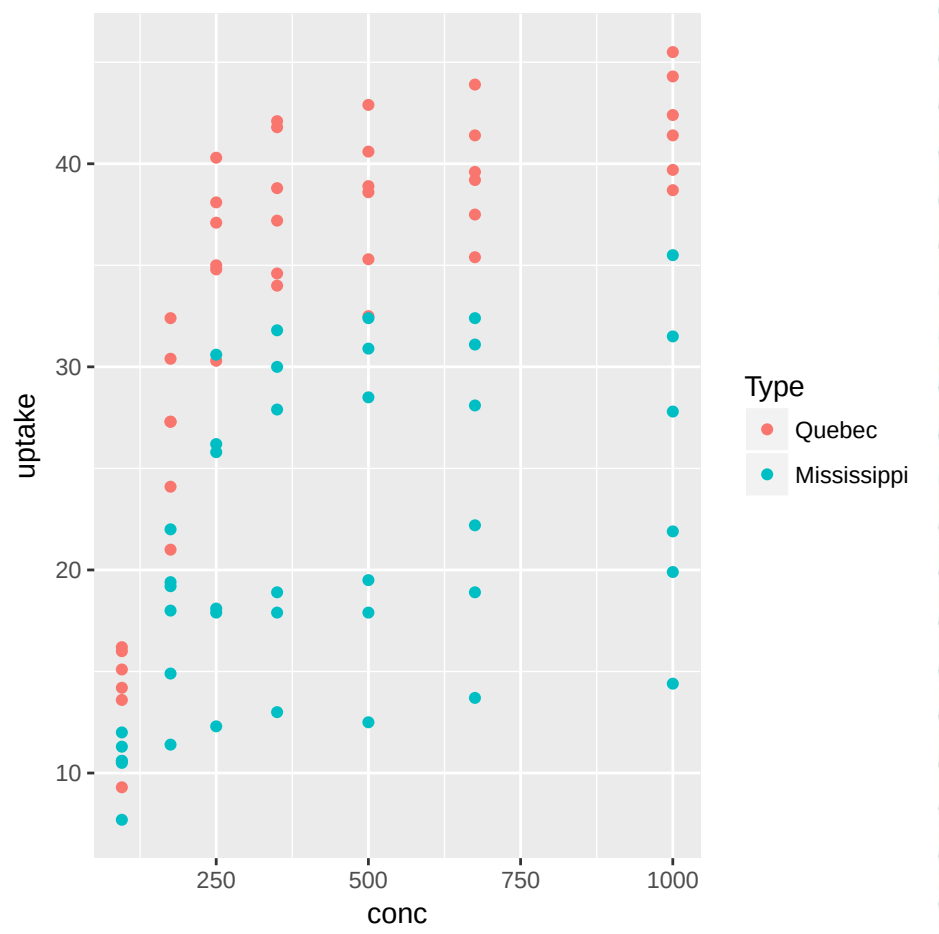
# geom_point

```
> ggplot(CO2)+geom_point(aes(x=conc,y=uptake), colour="red")
```



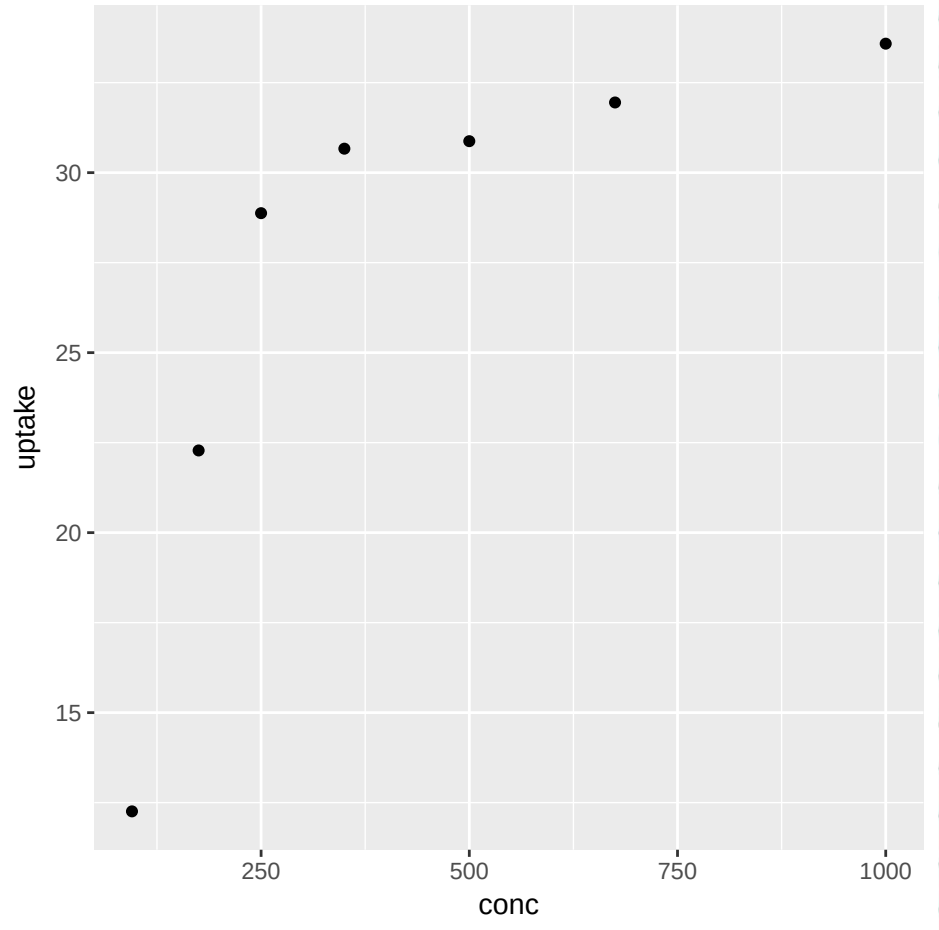
# geom_point

```
> ggplot(CO2)+geom_point(aes(x=conc,y=uptake, colour=Type))
```



# geom_point

```
> ggplot(CO2)+geom_point(aes(x=conc,y=uptake),
+  stat="summary",fun.y=mean)
```



# Example data sets

```
> head(diamonds)
```

```
# A tibble: 6 x 10
  carat       cut color clarity depth table price     x     y     z
  <dbl>     <ord> <ord>   <ord> <dbl> <dbl> <int> <dbl> <dbl> <dbl>
1  0.23     Ideal     E     SI2  61.5    55   326  3.95  3.98  2.43
2  0.21   Premium     E     SI1  59.8    61   326  3.89  3.84  2.31
3  0.23      Good     E     VS1  56.9    65   327  4.05  4.07  2.31
4  0.29   Premium     I     VS2  62.4    58   334  4.20  4.23  2.63
5  0.31      Good     J     SI2  63.3    58   335  4.34  4.35  2.75
6  0.24 Very Good     J    VVS2  62.8    57   336  3.94  3.96  2.48
```

```
> summary(diamonds)
```

```
     carat               cut        color        clarity          depth            table
 Min.   :0.2000   Fair      : 1610   D: 6775   SI1     :13065   Min.   :43.00   Min.   :43
 1st Qu.:0.4000   Good      : 4906   E: 9797   VS2     :12258   1st Qu.:61.00   1st Qu.:5
 Median :0.7000   Very Good:12082   F: 9542   SI2     : 9194   Median :61.80   Median
 Mean   :0.7979   Premium   :13791   G:11292   VS1     : 8171   Mean   :61.75   Mean   :5
 3rd Qu.:1.0400   Ideal     :21551   H: 8304   VVS2    : 5066   3rd Qu.:62.50   3rd Qu.:
 Max.   :5.0100                     I: 5422   VVS1    : 3655   Max.   :79.00   Max.   :95.00
                                    J: 2808   (Other): 2531
     price             x                y                z
 Min.   :  326   Min.   : 0.000   Min.   : 0.000   Min.   : 0.000
```

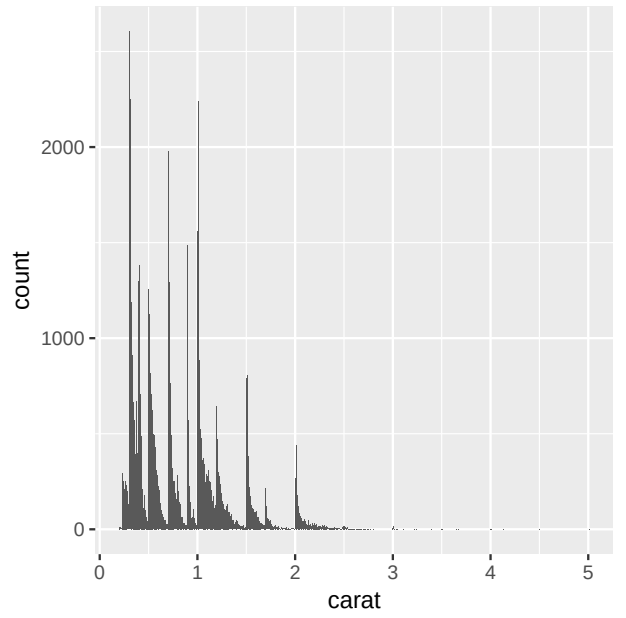
# Section 3

# Primary geometric objects

# geom_bar

| Feature | geom | stat | position |
|---|---|---|---|
| Histogram | _bar | _bin | stack |

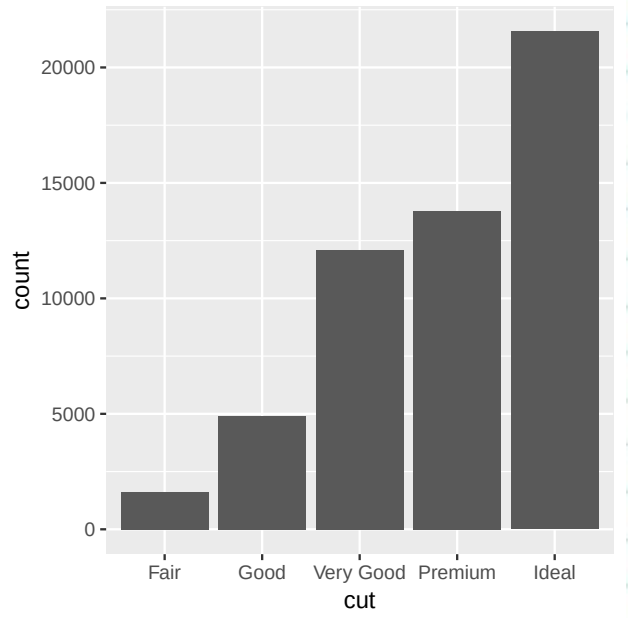
```
> ggplot(diamonds) + geom_bar(aes(x = carat))
```



# geom_bar

| Feature | geom | stat | position |
|---|---|---|---|
| Barchart | _bar | _bin | stack |

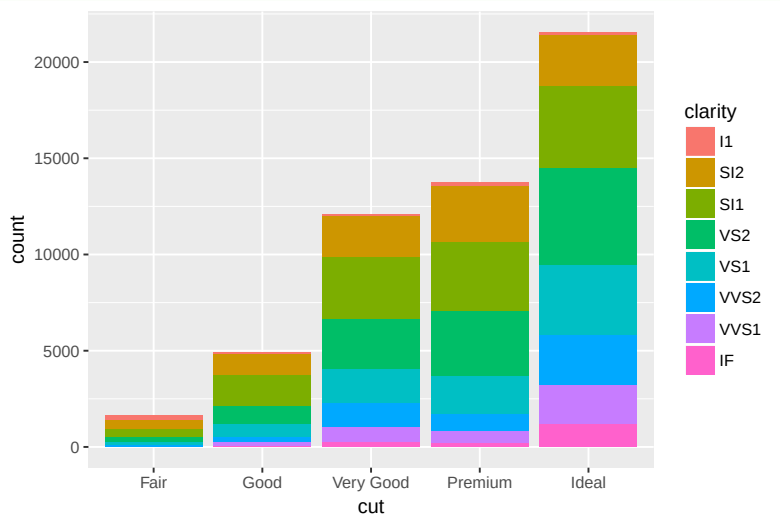
```
> ggplot(diamonds) + geom_bar(aes(x = cut))
```



# geom_bar

| Feature | geom | stat | position |
|---|---|---|---|
| barchart | _bar | _bin | stack |

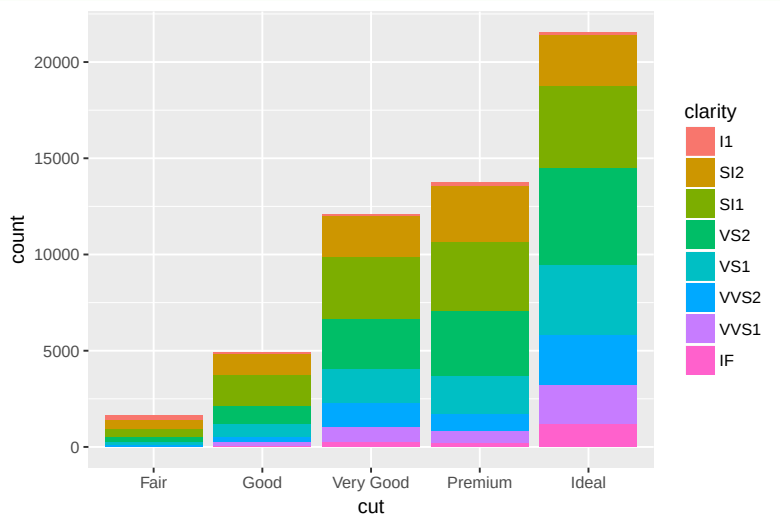
```
> ggplot(diamonds) + geom_bar(aes(x = cut, fill = clarity))
```



# geom_bar

| Feature | geom | stat | position |
|---|---|---|---|
| barchart | _bar | _bin | stack |

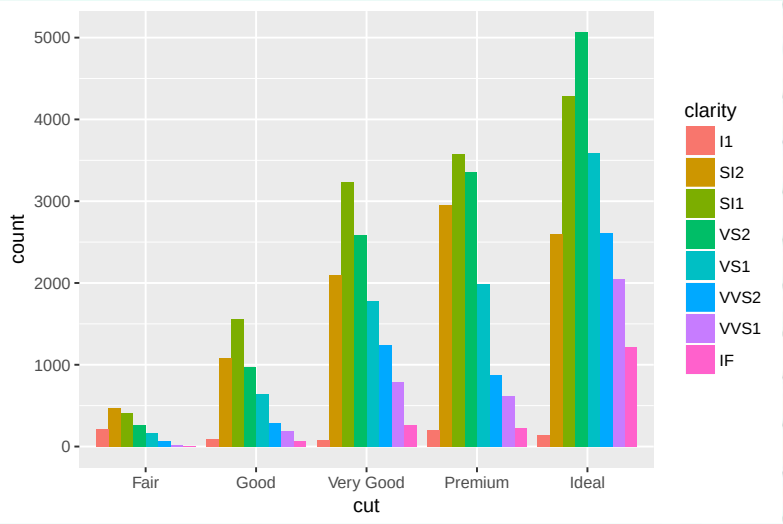
```
> ggplot(diamonds) + geom_bar(aes(x = cut, fill = clarity))
```



# geom_bar

| Feature | geom | stat | position |
|---|---|---|---|
| barchart | _bar | _bin | dodge |

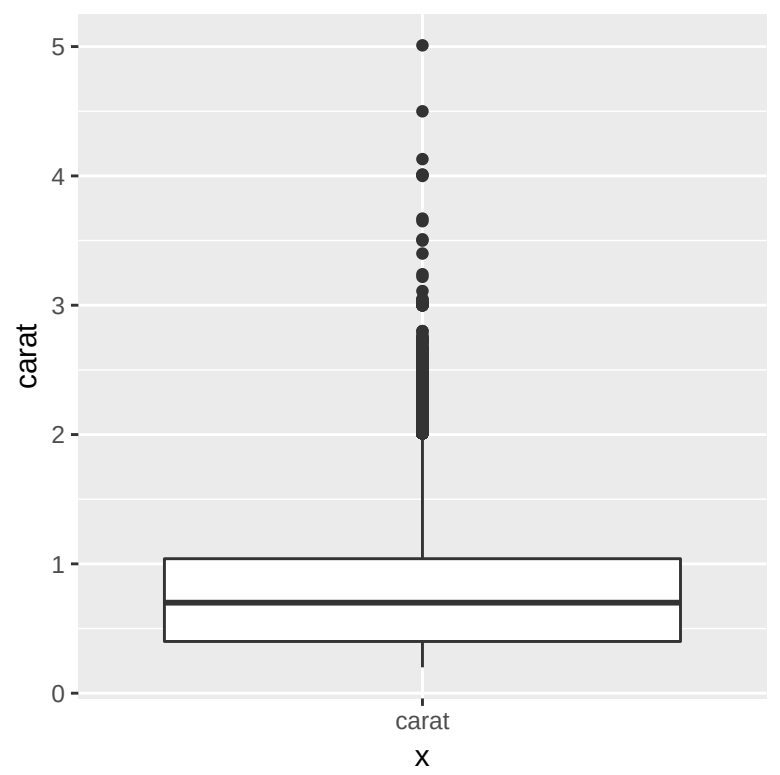
```
> ggplot(diamonds) + geom_bar(aes(x = cut, fill = clarity),
+   position='dodge')
```



# geom_boxplot

| Feature | geom | stat | position |
|---|---|---|---|
| boxplot | _boxplot | _boxplot | dodge |

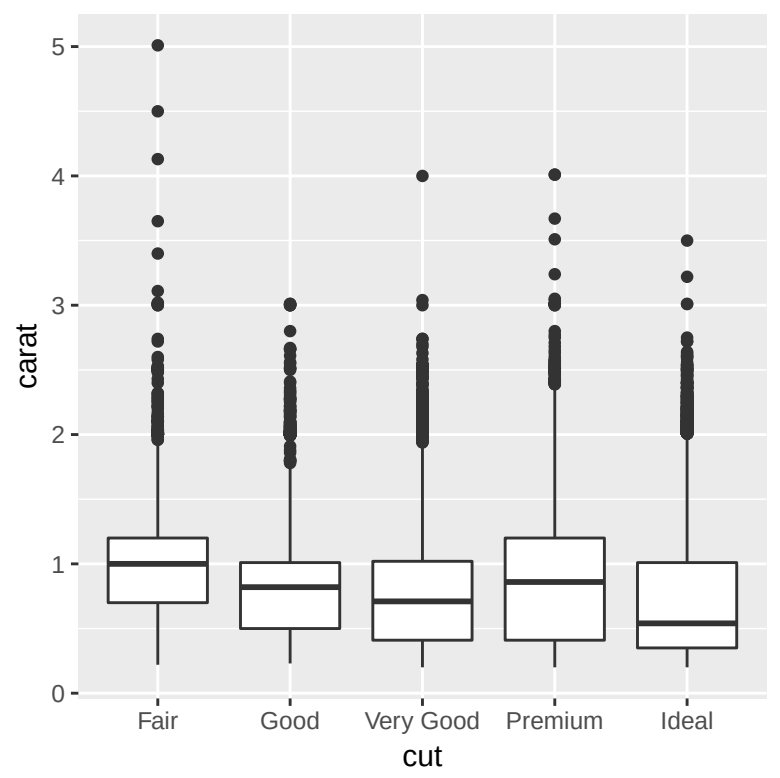
```
> ggplot(diamonds) + geom_boxplot(aes(x = "carat", y = carat))
```



# geom_boxplot

| Feature | geom | stat | position |
|---|---|---|---|
| boxplot | _boxplot | _boxplot | dodge |

```
> ggplot(diamonds) + geom_boxplot(aes(x = cut, y = carat))
```



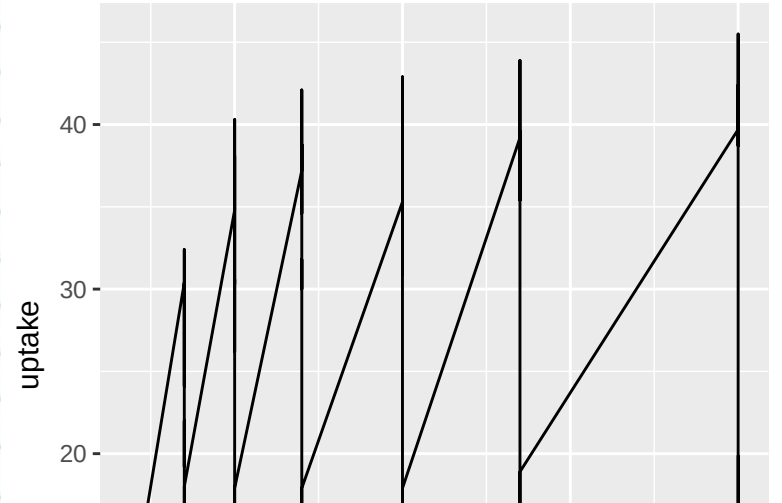
# geom_line

| Feature | geom | stat | position |
|---|---|---|---|
| line | _line | _identity | identity |

```
> head(CO2, 3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2) + geom_line(aes(x = conc, y = uptake))
```



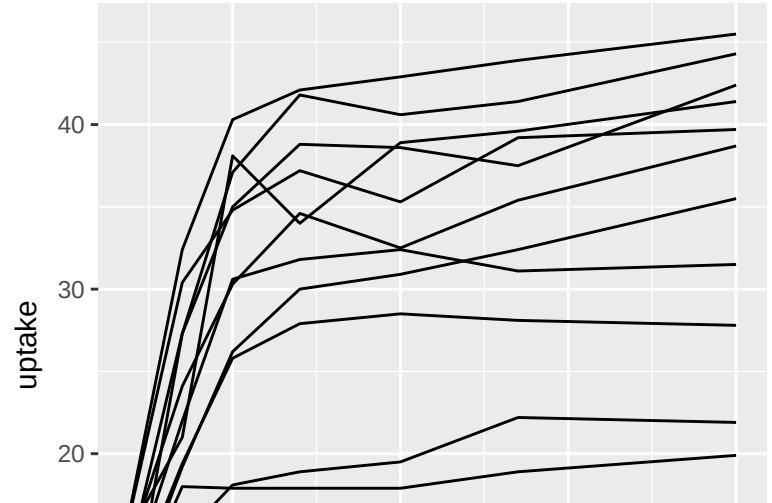
# geom_line

| Feature | geom | stat | position |
|---|---|---|---|
| line | _line | _identity | identity |

```
> head(CO2, 3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2) + geom_line(aes(x = conc, y = uptake, group=Plant))
```



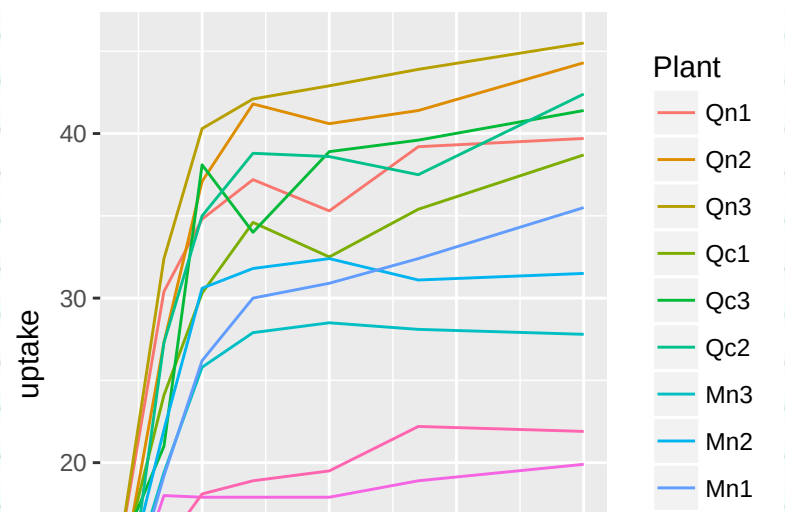
# geom_line

| Feature | geom | stat | position |
|---|---|---|---|
| line | _line | _identity | identity |

```
> head(CO2, 3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2) + geom_line(aes(x = conc, y = uptake, color=Plant))
```



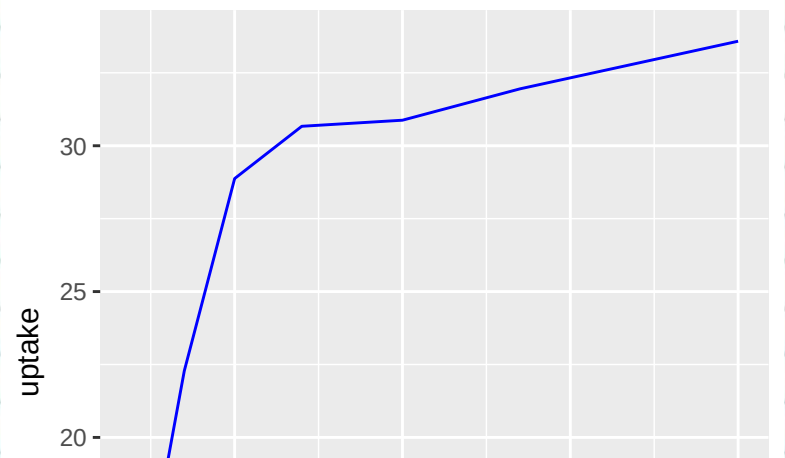
# geom_line

| Feature | geom | stat | position |
|---|---|---|---|
| line | _line | _summary | identity |

```
> head(CO2, 3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2) + geom_line(aes(x = conc, y = uptake),
+     stat = "summary", fun.y = mean, color='blue')
```



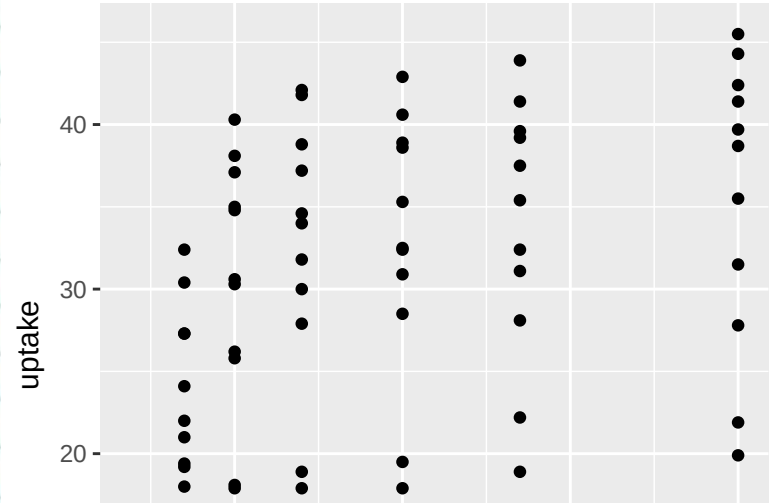
# geom_point

| Feature | geom | stat | position |
|---|---|---|---|
| point | _point | _identity | identity |

```
> head(CO2, 3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2) + geom_point(aes(x = conc, y = uptake))
```



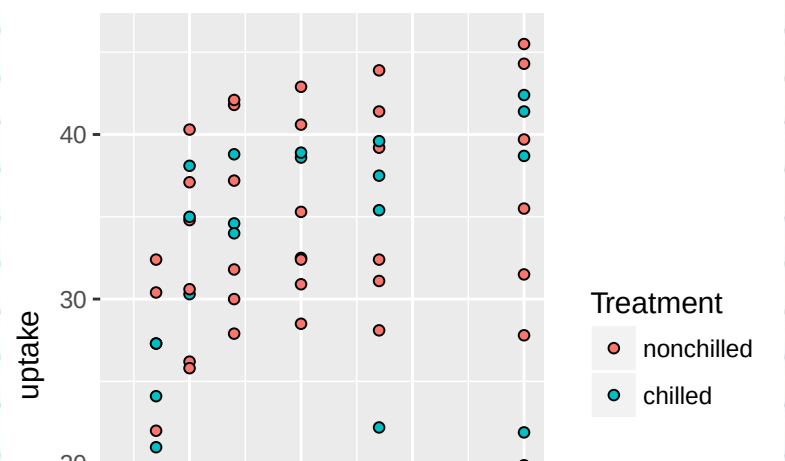
# geom_point

| Feature | geom | stat | position |
|---|---|---|---|
| point | _point | _identity | identity |

```
> head(CO2, 3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2) + geom_point(aes(x = conc, y = uptake, fill=Treatment),
+   shape=21)
```



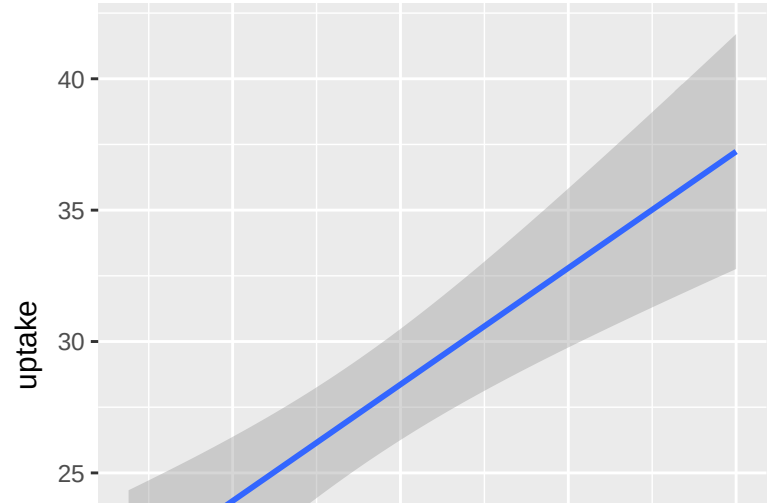
# geom_smooth

| Feature | geom | stat | position |
|---|---|---|---|
| smoother | _smooth | _smooth | identity |

```
> head(CO2, 3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2) + geom_smooth(aes(x = conc, y = uptake), method='lm')
```



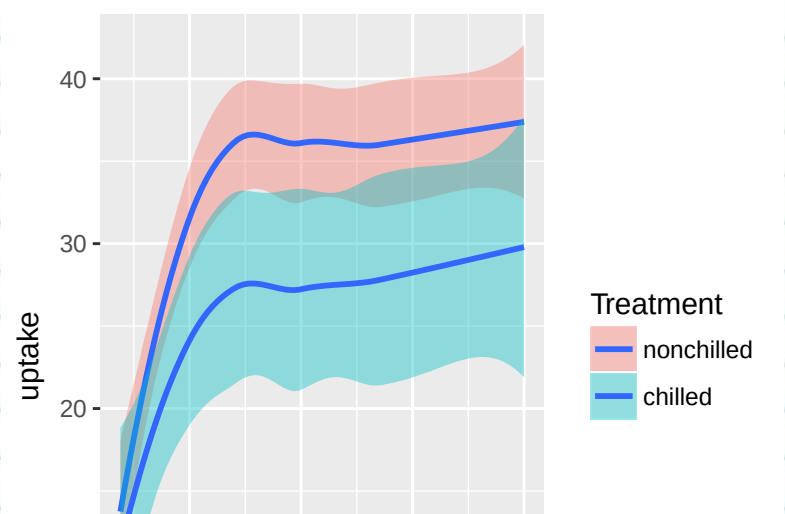
# geom_smooth

| Feature | geom | stat | position |
|---|---|---|---|
| smoother | _smooth | _smooth | identity |

```
> head(CO2, 3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2) + geom_smooth(aes(x = conc, y = uptake, fill=Treatment))
```



# geom_polygon

| Feature | geom | stat | position |
|---|---|---|---|
| polygon | _polygon | _identity | identity |

```
> library(maps)
> library(mapdata)
> aus <- map_data("worldHires", region="Australia")
> head(aus,3)
```

```
      long       lat group order    region              subregion
1 142.1461 -10.74943     1     1 Australia Prince of Wales Island
2 142.1430 -10.74525     1     2 Australia Prince of Wales Island
3 142.1406 -10.74113     1     3 Australia Prince of Wales Island
```

```
> ggplot(aus, aes(x=long, y=lat, group=group)) +
+     geom_polygon()
```

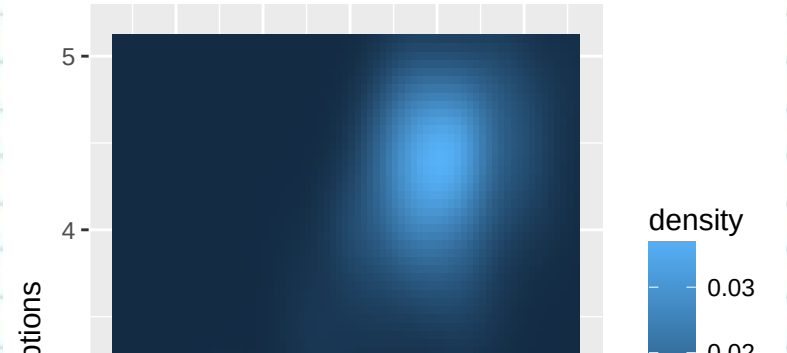
# geom_tile

| Feature | geom | stat | position |
|---|---|---|---|
| tile | _tile | _identity | identity |

```
> head(faithfuld,3)
```

```
# A tibble: 3 x 3
  eruptions waiting     density
      <dbl>   <dbl>       <dbl>
1  1.600000      43 0.003216159
2  1.647297      43 0.003835375
3  1.694595      43 0.004435548
```

```
> ggplot(faithfuld, aes(waiting, eruptions)) +
+       geom_tile(aes(fill = density))
```



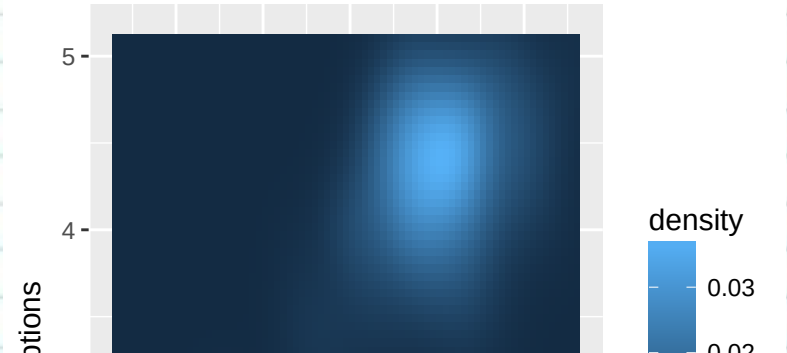
# geom_raster

| Feature | geom | stat | position |
|---|---|---|---|
| raster | _raster | _identity | identity |

```
> head(faithfuld,3)
```

```
# A tibble: 3 x 3
  eruptions waiting     density
      <dbl>   <dbl>       <dbl>
1  1.600000      43 0.003216159
2  1.647297      43 0.003835375
3  1.694595      43 0.004435548
```

```
> ggplot(faithfuld, aes(waiting, eruptions)) +
+       geom_raster(aes(fill = density))
```



# Section 4

# Secondary geometric objects

# Example data set

```
> head(warpbreaks)
```

```
  breaks wool tension
1     26    A       L
2     30    A       L
3     54    A       L
4     25    A       L
5     70    A       L
6     52    A       L
```

```
> summary(warpbreaks)
```

```
     breaks       wool   tension
 Min.   :10.00   A:27   L:18
 1st Qu.:18.25   B:27   M:18
 Median :26.00          H:18
 Mean   :28.15
 3rd Qu.:34.00
 Max.   :70.00
```

# geom_errorbar

| Feature | geom | stat | position |
|---|---|---|---|
| errorbar | _identity | _identity | identity |

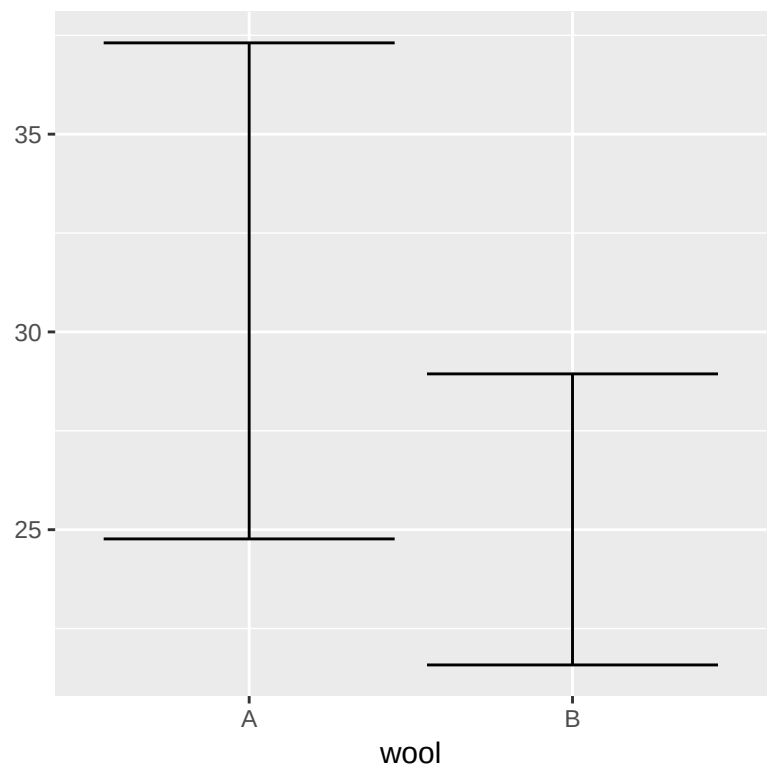
```
> library(dplyr)
> library(gmodels)
> warpbreaks.sum <- warpbreaks %>% group_by(wool) %>%
+     summarise(Mean=mean(breaks), Lower=ci(breaks)[2], Upper=ci(breaks)[3]
> warpbreaks.sum
```

```
# A tibble: 2 x 4
    wool     Mean    Lower    Upper
  <fctr>    <dbl>    <dbl>    <dbl>
1      A 31.03704 24.76642 37.30765
2      B 25.25926 21.57994 28.93858
```

# geom_errorbar

| Feature | geom | stat | position |
|---|---|---|---|
| errorbar | _identity | _identity | identity |

```
> ggplot(warpbreaks.sum) +
+     geom_errorbar(aes(x = wool, ymin = Lower, ymax = Upper))
```



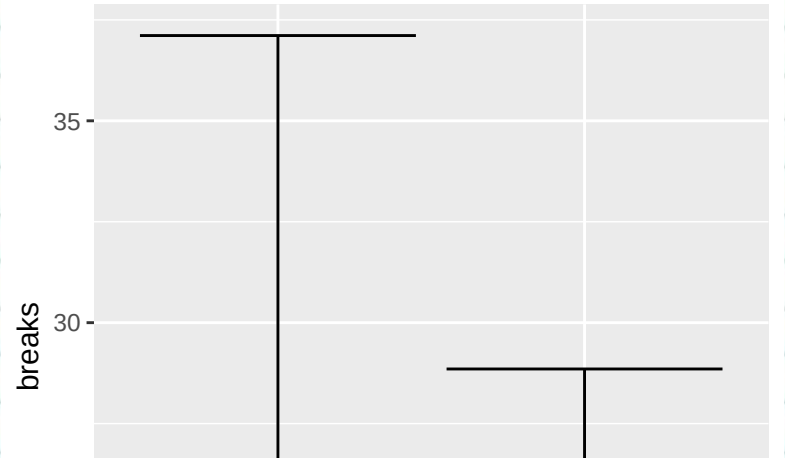
# geom_errorbar

| Feature | geom | stat | position |
|---|---|---|---|
| errorbar | _identity | _summary | identity |

```
> head(warpbreaks,3)
```

```
  breaks wool tension
1     26    A       L
2     30    A       L
3     54    A       L
```

```
> ggplot(warpbreaks) + geom_errorbar(aes(x = wool, y = breaks),
+     stat = "summary", fun.data = "mean_cl_boot")
```



# Section 5

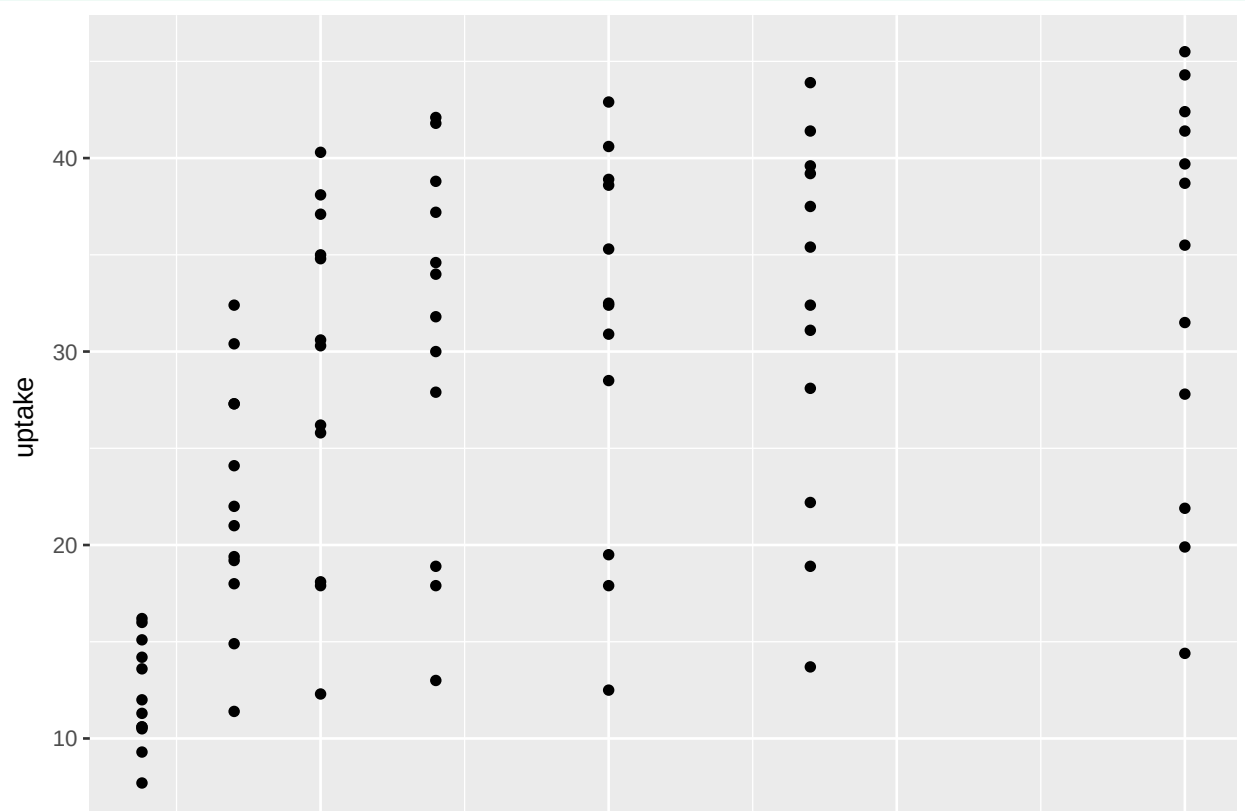
# Coordinate systems

# Coordinate systems

```
> head(CO2,3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2)+geom_point(aes(x=conc,y=uptake))+
+   coord_cartesian() #default
```

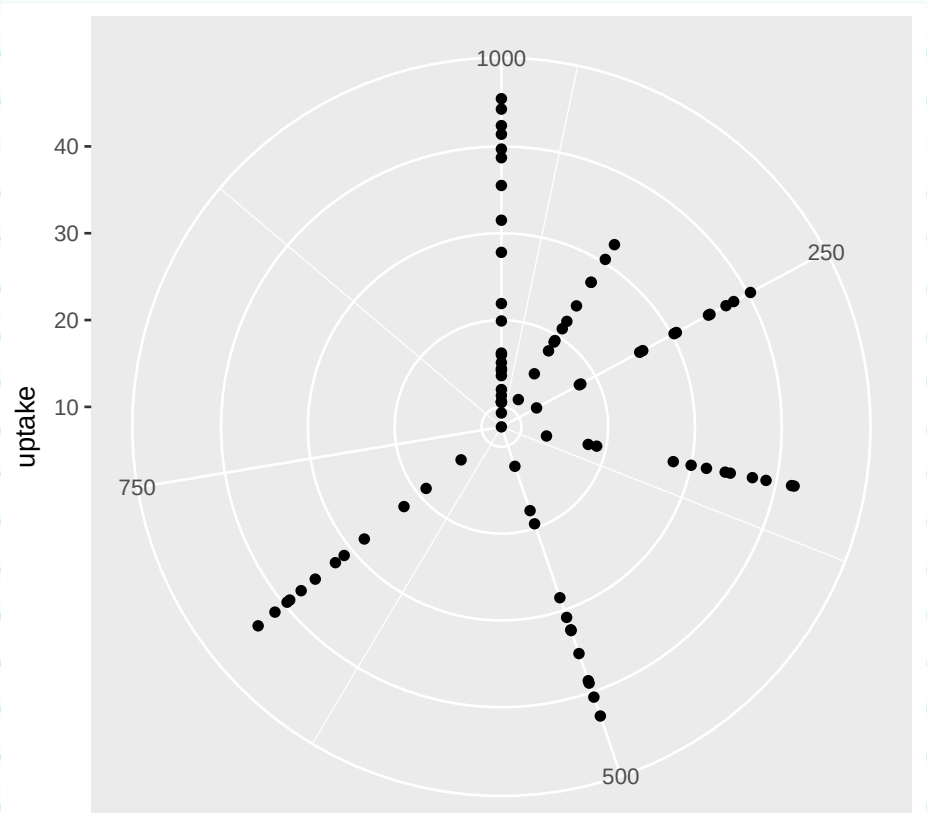


# Coordinate systems

```
> head(CO2,3)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2)+geom_point(aes(x=conc,y=uptake))+
+   coord_polar()
```

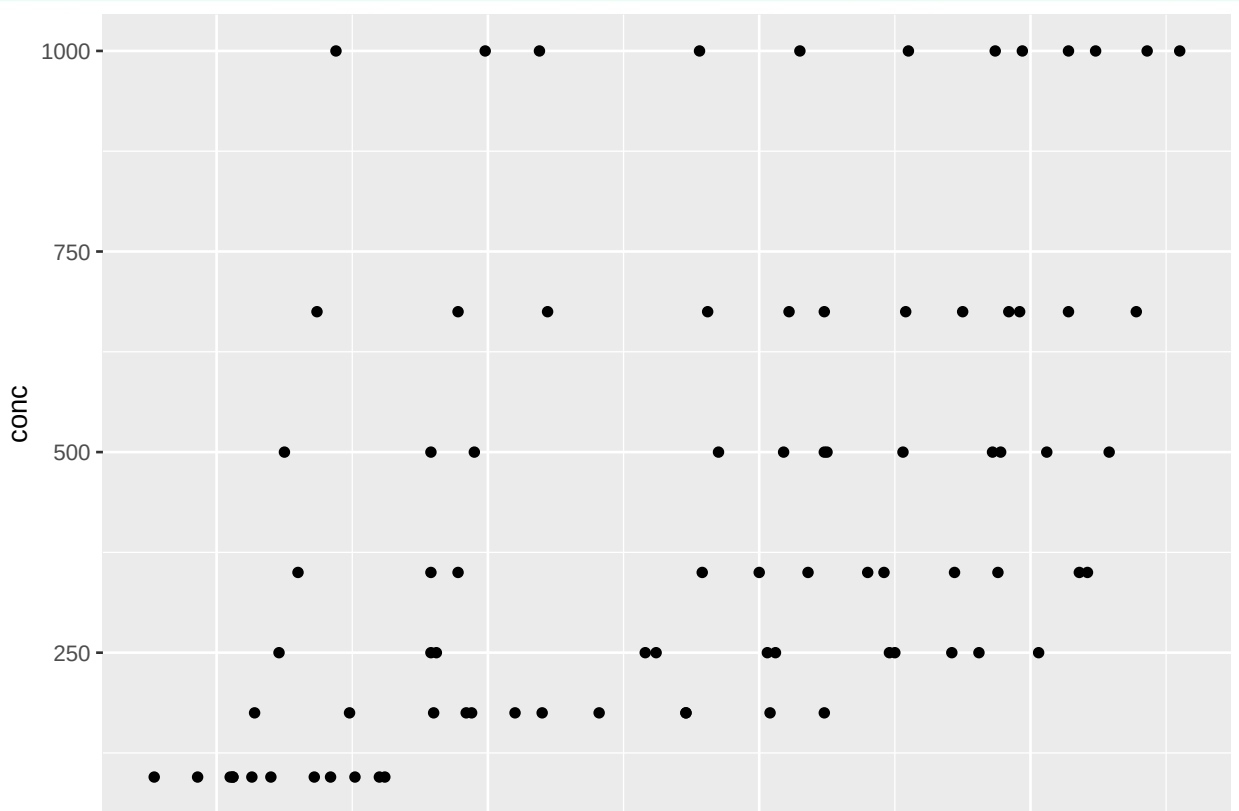


# Coordinate systems

```
> head(CO2,3)
```

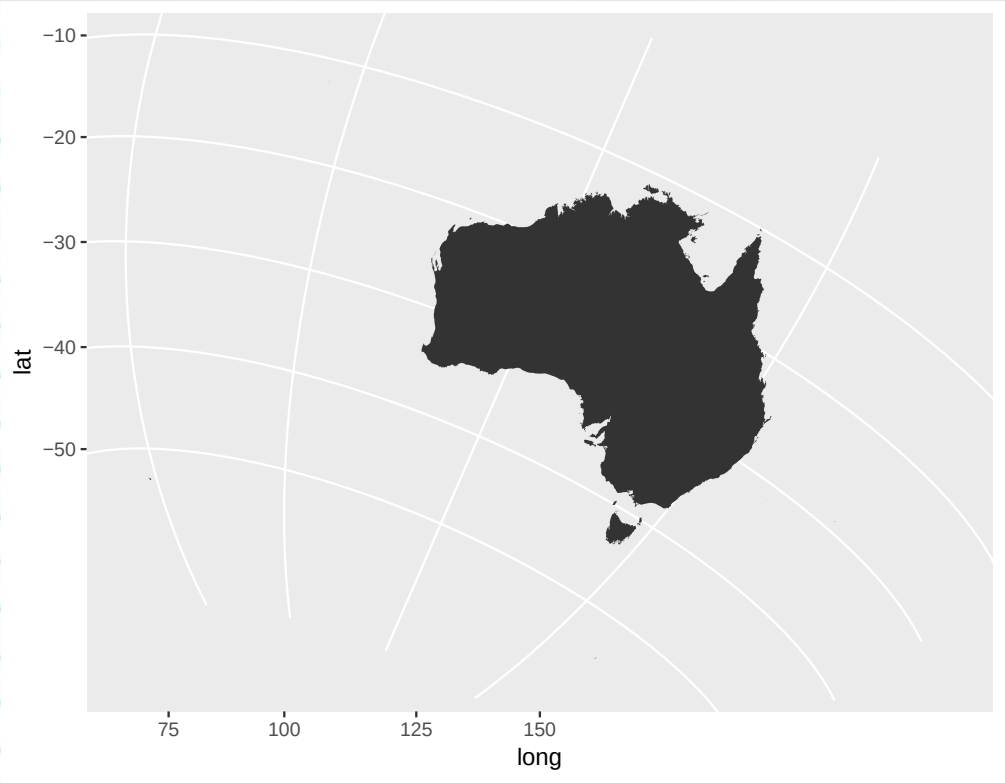
```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
3   Qn1 Quebec nonchilled  250   34.8
```

```
> ggplot(CO2)+geom_point(aes(x=conc,y=uptake))+
+  coord_flip()
```



# Coordinate systems

```
> #Orthographic coordinates
> library(maps)
> library(mapdata)
> aus <- map_data("worldHires", region="Australia")
> ggplot(aus, aes(x=long, y=lat, group=group)) +
+   coord_map("ortho", orientation=c(-20,125,23.5))+
+   geom_polygon()
```



# Section 6

# Scales

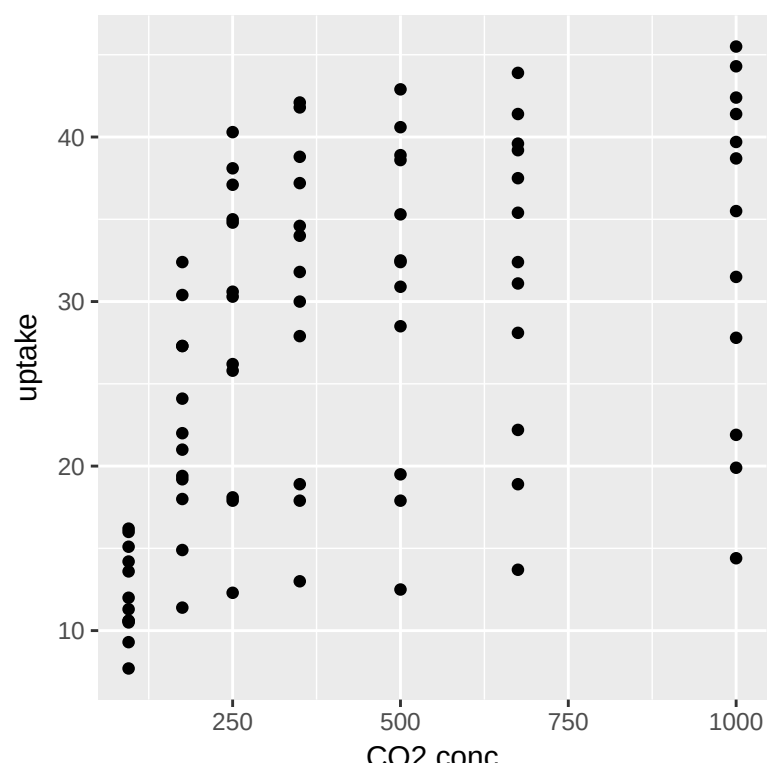
# scale_x_ and scale_y_

## Axis titles

```
> head(CO2,2)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
```

```
> ggplot(CO2, aes(y=uptake,x=conc)) + geom_point()+
+   scale_x_continuous(name="CO2 conc")
```



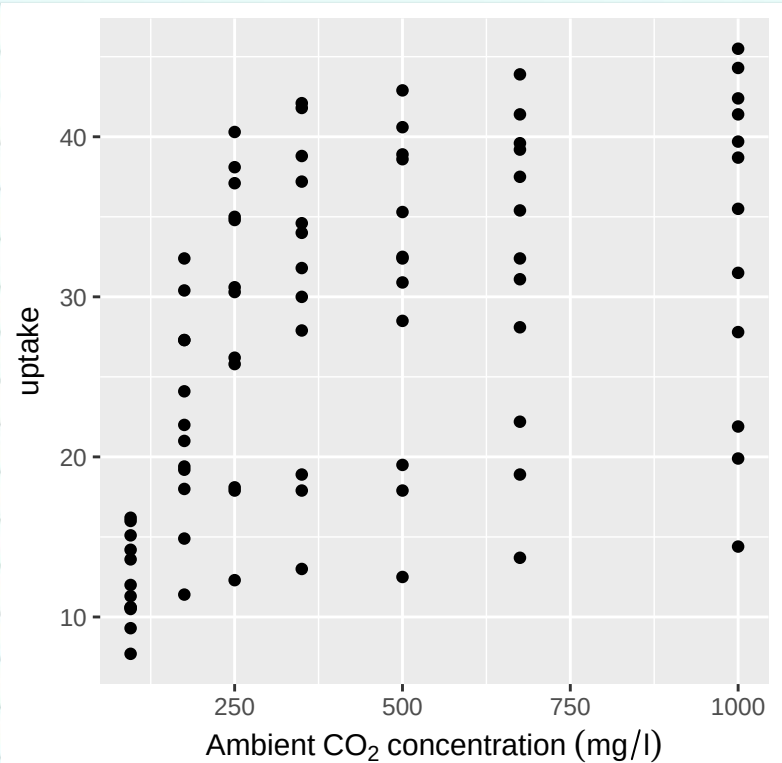
# scale_x_ and scale_y_

Axis titles with math

```
> head(CO2,2)
```

```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
```

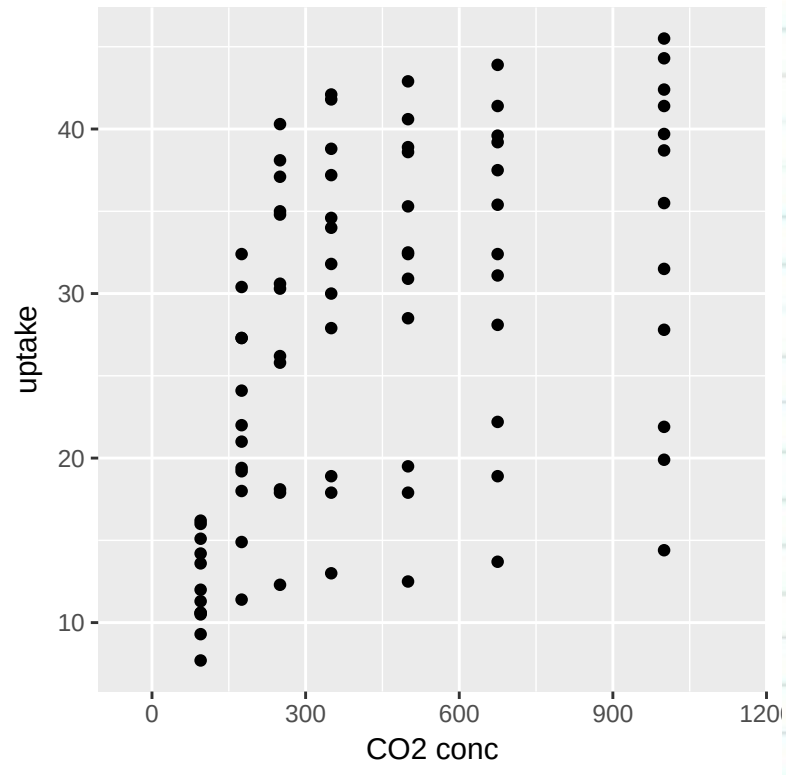
```
> ggplot(CO2, aes(y=uptake,x=conc)) + geom_point()+
+   scale_x_continuous(name=expression(Ambient~CO[2]~concentration~(mg/l)))
```



# scale_x_ and scale_y_

Axis more padding

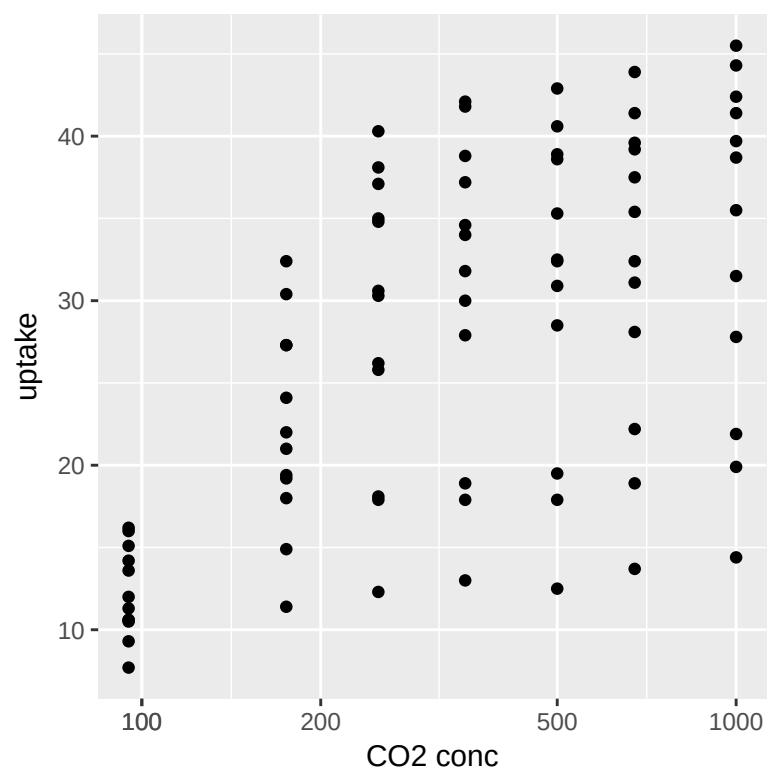
```
> ggplot(CO2, aes(y=uptake,x=conc)) + geom_point()+
+   scale_x_continuous(name="CO2 conc", expand=c(0,200))
```



# scale_x_ and scale_y_

Axis on a log scale

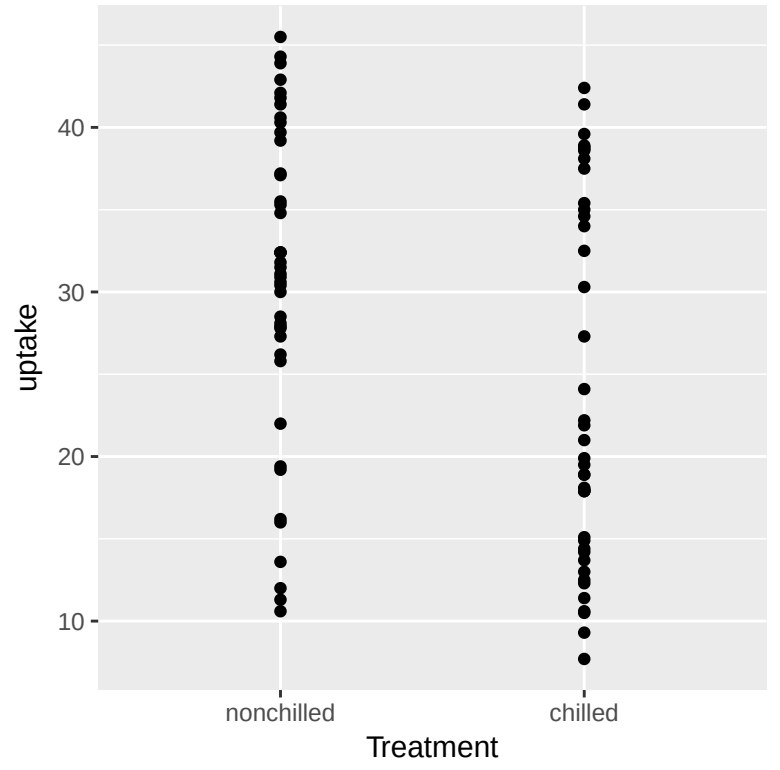
```
> ggplot(CO2, aes(y=uptake,x=conc)) + geom_point()+
+   scale_x_log10(name="CO2 conc",
+     breaks=as.vector(c(1,2,5,10) %o% 10^(-1:2)))
```



# scale_x_ and scale_y_

Axis representing categorical data

```
> ggplot(CO2, aes(y=uptake,x=Treatment)) + geom_point()+
+   scale_x_discrete(name="Treatment")
```



# Other scales

- size of points (thickness of lines)
- shape of points
- linetype of lines
- color of lines or points
- fill of shapes

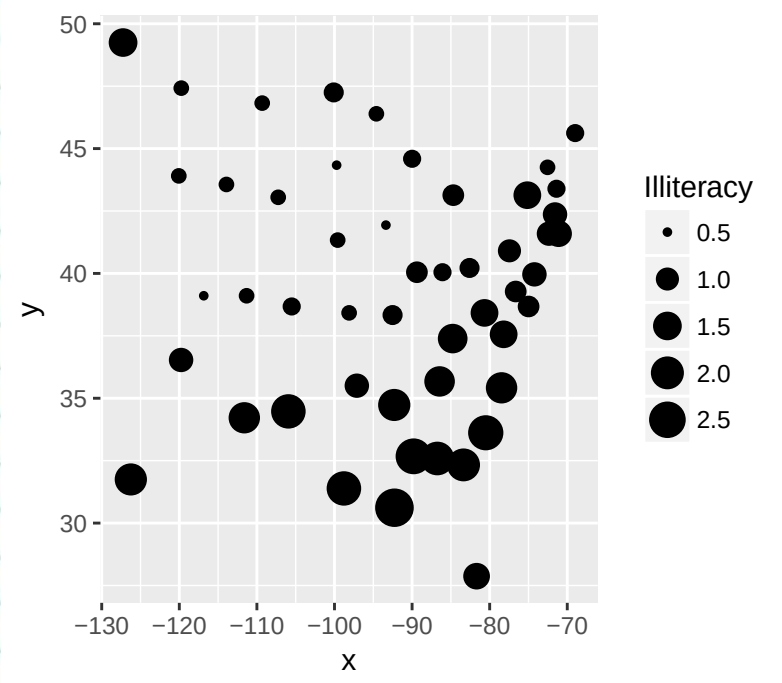
# scale_size

Size according to continuous variable

```
> state=data.frame(state.x77,state.region, state.division,state.center) %>%
+     select(Illiteracy,state.region,x,y)
> head(state,2)
```

```
        Illiteracy state.region         x       y
Alabama        2.1        South  -86.7509 32.5901
Alaska         1.5         West -127.2500 49.2500
```

```
> ggplot(state, aes(y=y,x=x)) + geom_point(aes(size=Illiteracy))
```



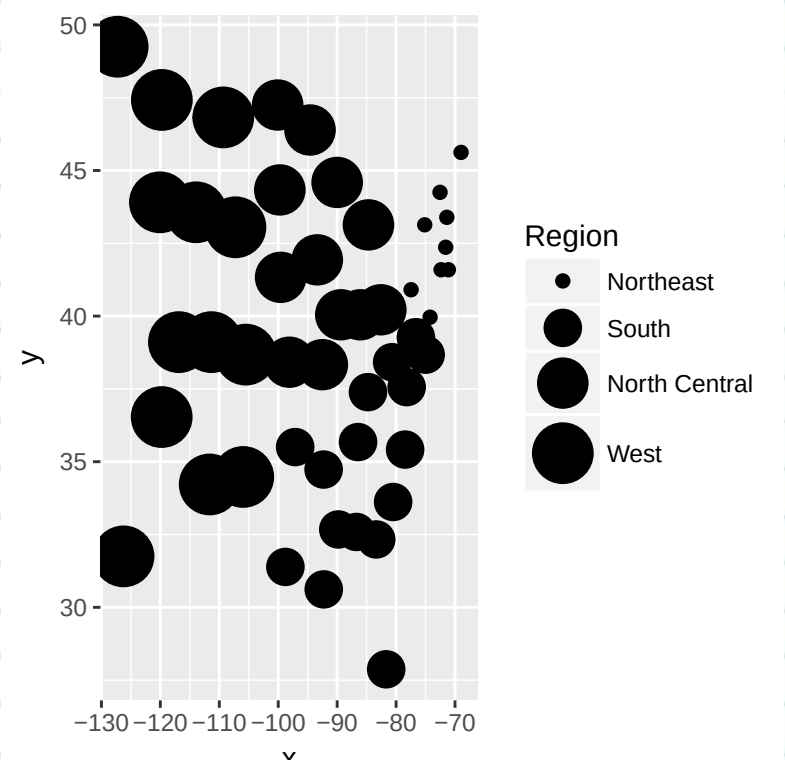
# scale_size

Discrete sizes ranging in size from 2 to 4

```
> head(state,2)
```

```
        Illiteracy state.region         x       y
Alabama        2.1        South  -86.7509 32.5901
Alaska         1.5         West -127.2500 49.2500
```

```
> ggplot(state, aes(y=y,x=x)) + geom_point(aes(size=state.region))+
+   scale_size_discrete(name="Region", range=c(2,10))
```



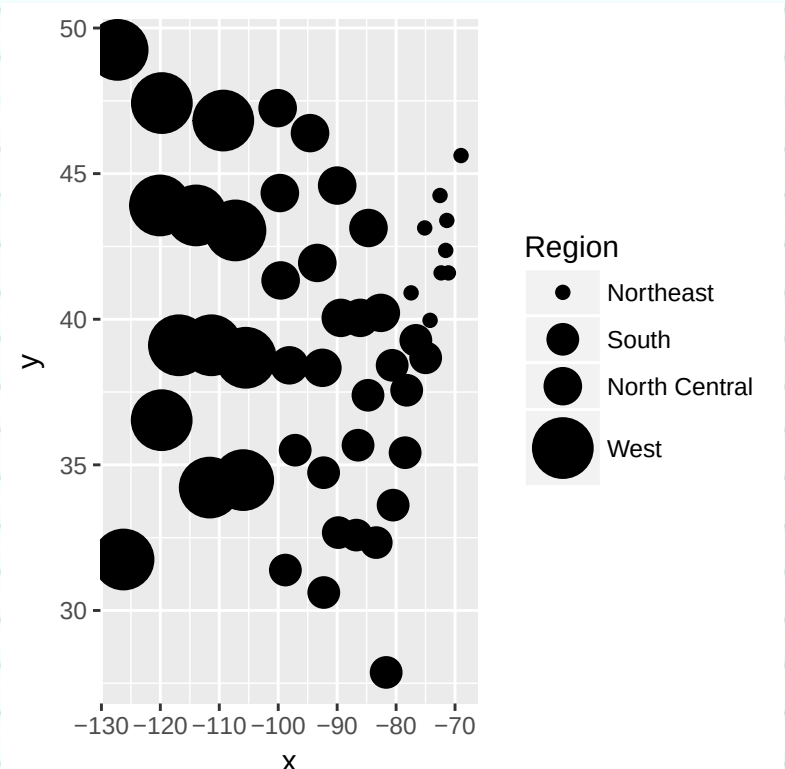
# scale_size

Manual sizes (2 and 4)

```
> head(state,2)
```

```
        Illiteracy state.region         x       y
Alabama        2.1        South  -86.7509 32.5901
Alaska         1.5         West -127.2500 49.2500
```

```
> ggplot(state, aes(y=y,x=x)) + geom_point(aes(size=state.region))+
+     scale_size_manual(name="Region", values=c(2,5,6,10))
```

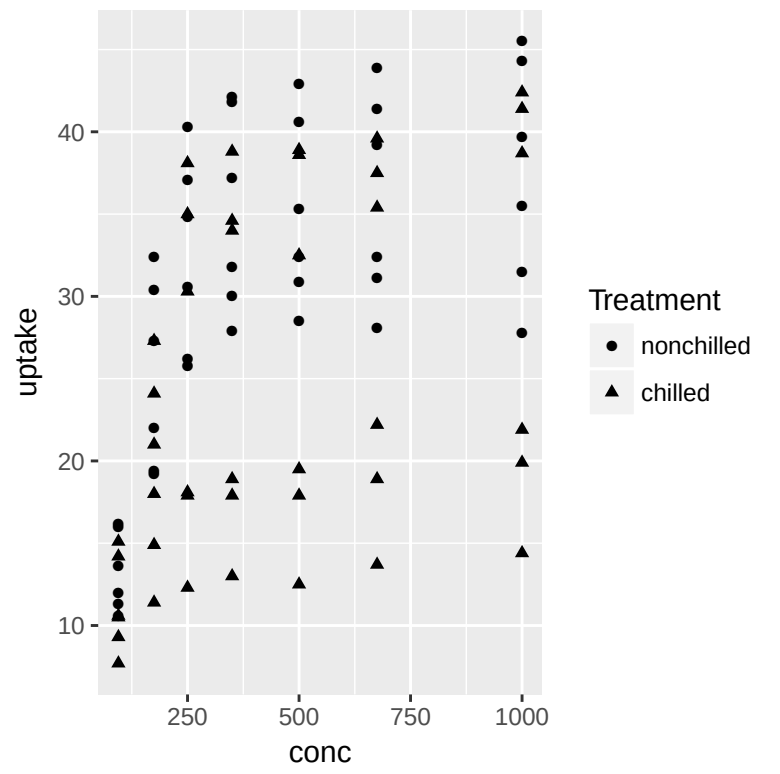


# scale_shape

```
> head(CO2,2)
```

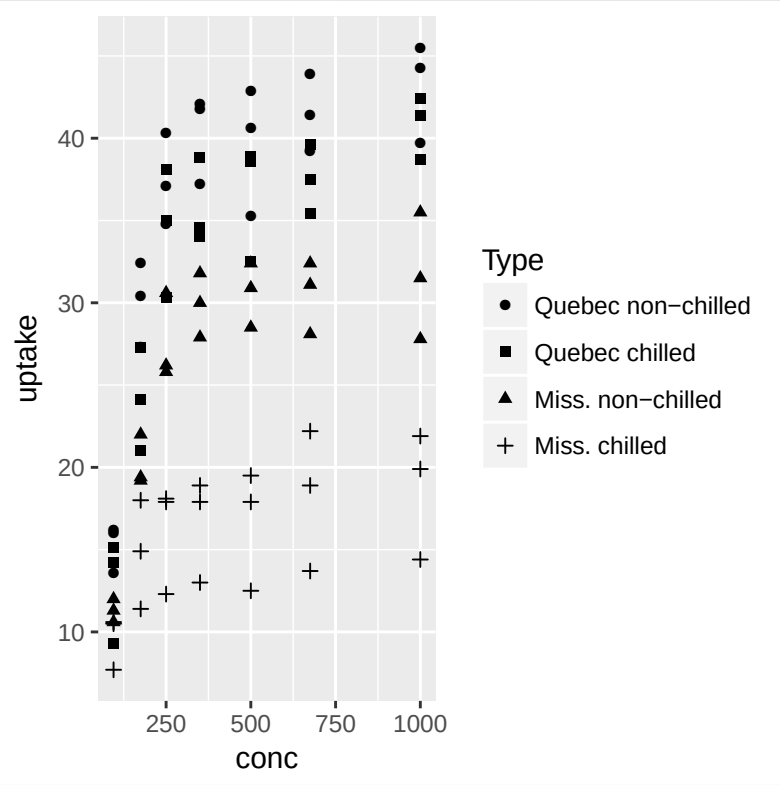
```
  Plant   Type  Treatment conc uptake
1   Qn1 Quebec nonchilled   95   16.0
2   Qn1 Quebec nonchilled  175   30.4
```

```
> ggplot(CO2, aes(y=uptake,x=conc)) + geom_point(aes(shape=Treatment))
```



# scale_shape

```
> CO2 = CO2 %>% mutate(Comb=interaction(Type, Treatment))
> ggplot(CO2, aes(y=uptake,x=conc)) + geom_point(aes(shape=Comb))+
+   scale_shape_discrete(name="Type",
+    breaks=c("Quebec.nonchilled","Quebec.chilled",
+             "Mississippi.nonchilled","Mississippi.chilled"),
+    labels=c("Quebec non-chilled","Quebec chilled",
+             "Miss. non-chilled","Miss. chilled"))
```

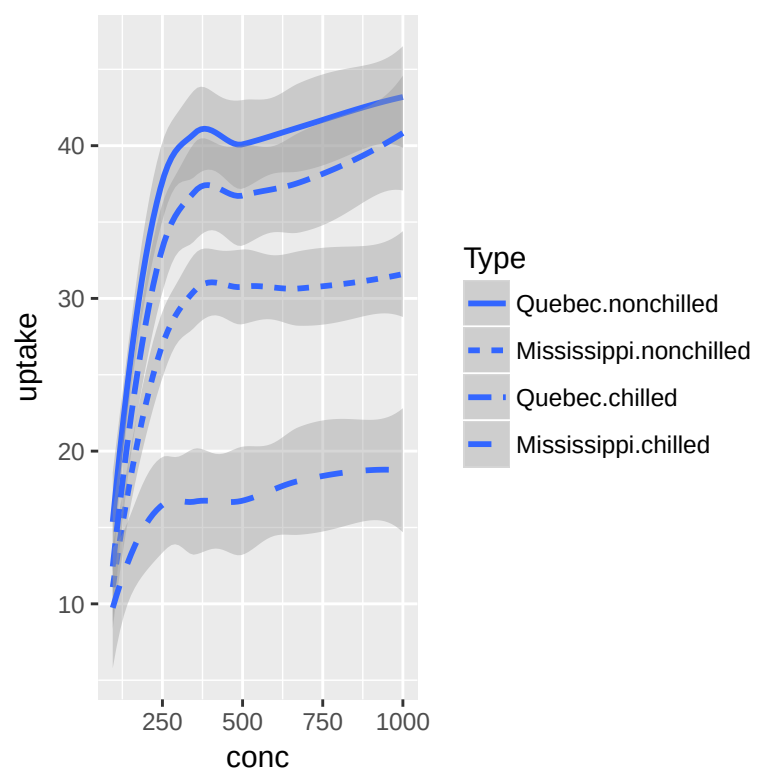


# scale linetype

```
> head(CO2,2)
```

```
  Plant   Type  Treatment conc uptake                Comb
1   Qn1 Quebec nonchilled   95   16.0 Quebec.nonchilled
2   Qn1 Quebec nonchilled  175   30.4 Quebec.nonchilled
```

```
> ggplot(CO2, aes(y=uptake,x=conc)) + geom_smooth(aes(linetype=Comb))+
+   scale_linetype_discrete(name="Type")
```

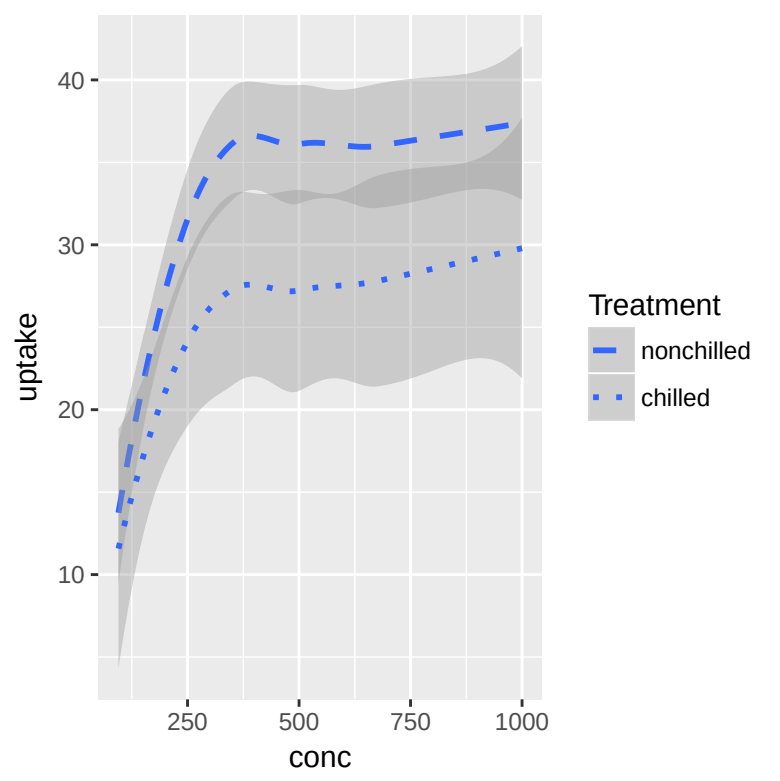


# scale linetype

```
> head(CO2,2)
```

```
  Plant   Type  Treatment conc uptake                Comb
1   Qn1 Quebec nonchilled   95   16.0 Quebec.nonchilled
2   Qn1 Quebec nonchilled  175   30.4 Quebec.nonchilled
```

```
> ggplot(CO2, aes(y=uptake,x=conc)) + geom_smooth(aes(linetype=Treatment))+
+   scale_linetype_manual(name="Treatment", values=c("dashed","dotted"))
```

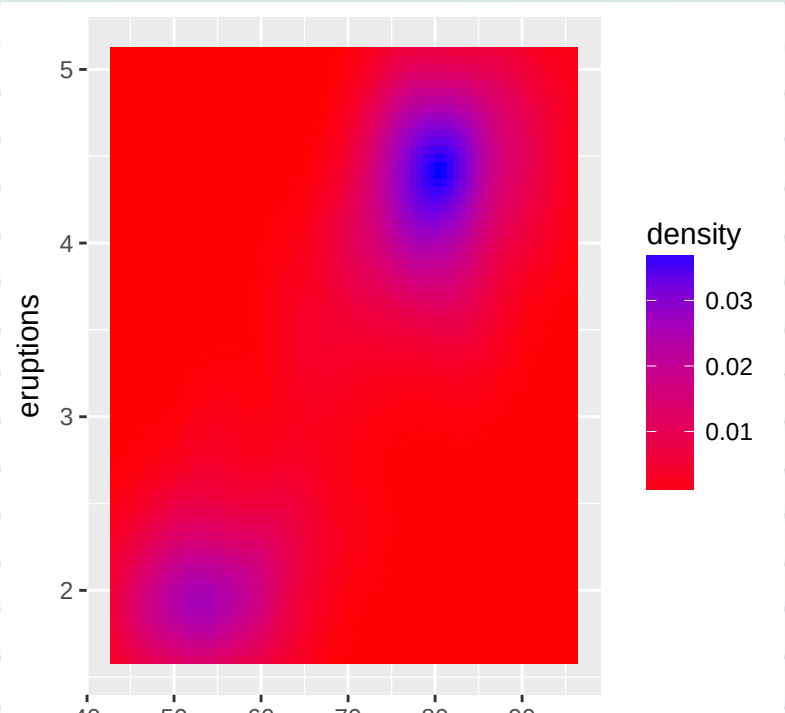


# scale fill and scale color

```
> head(faithfuld,2)
```

```
# A tibble: 2 x 3
  eruptions waiting     density
      <dbl>   <dbl>       <dbl>
1  1.600000      43 0.003216159
2  1.647297      43 0.003835375
```

```
> ggplot(faithfuld, aes(waiting, eruptions)) +
+     geom_raster(aes(fill = density)) +
+     scale_fill_continuous(low='red',high='blue')
```



# Section 7

## Facets

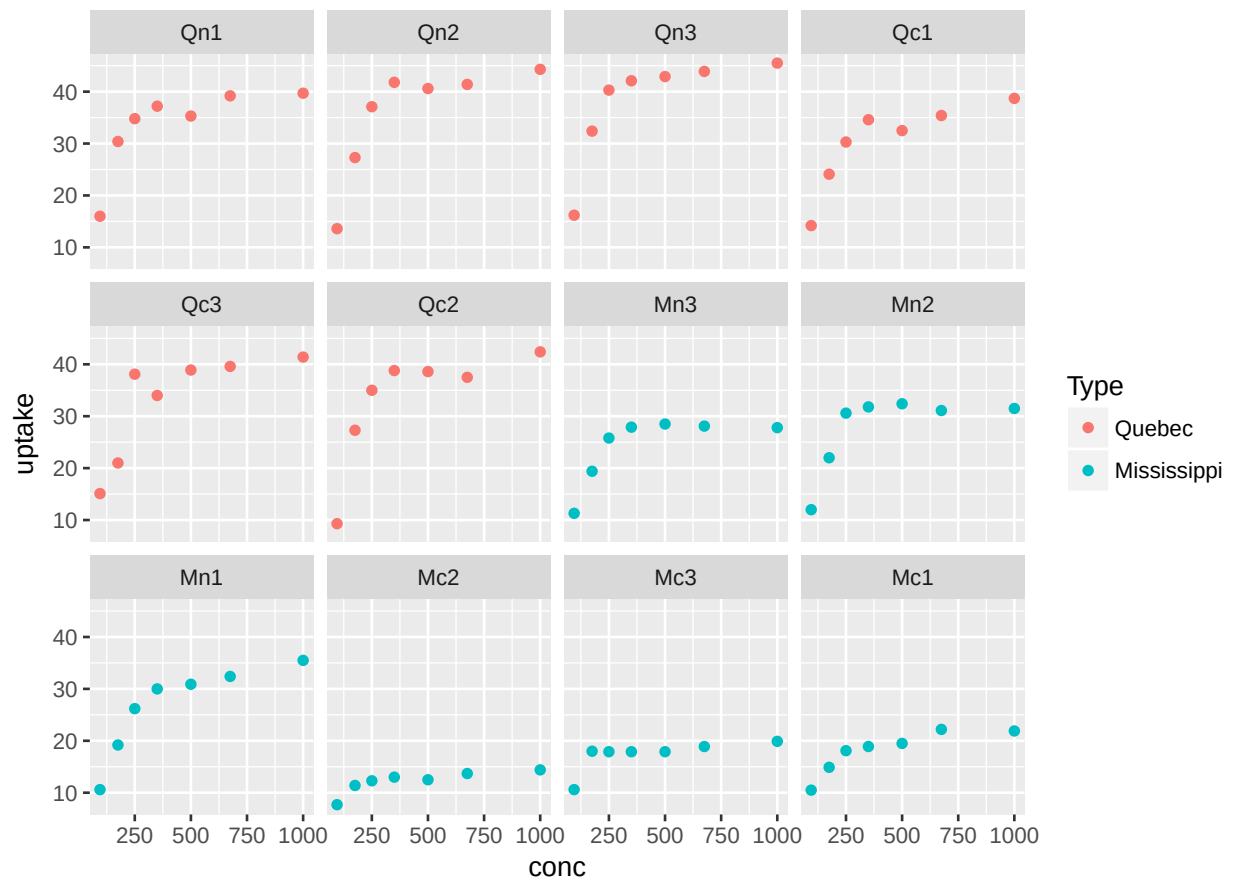
# Facets

Panels - matrices of plots

- `facet_wrap`
- `facet_grid`

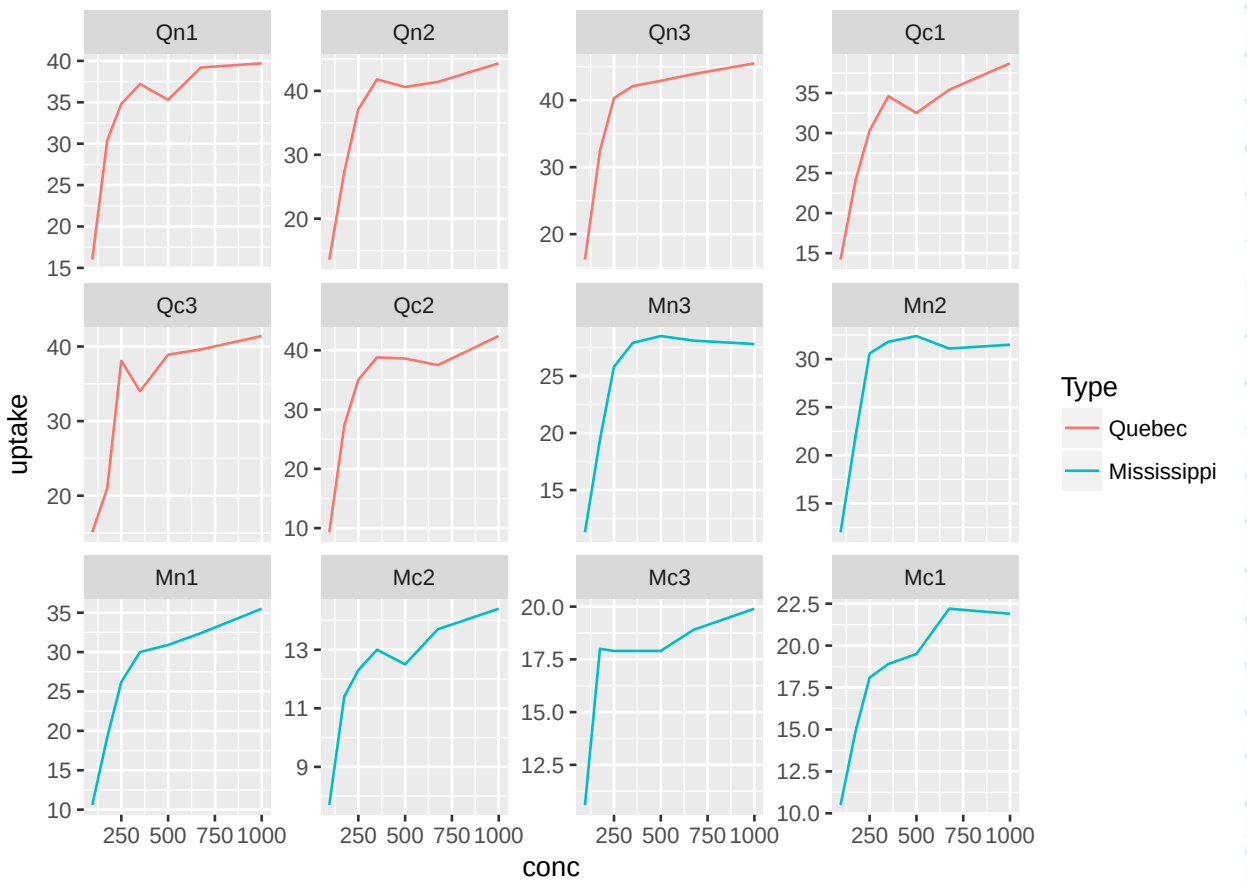
# Facets

```
> ggplot(CO2)+geom_point(aes(x=conc,y=uptake, colour=Type))+
+ facet_wrap(~Plant)
```



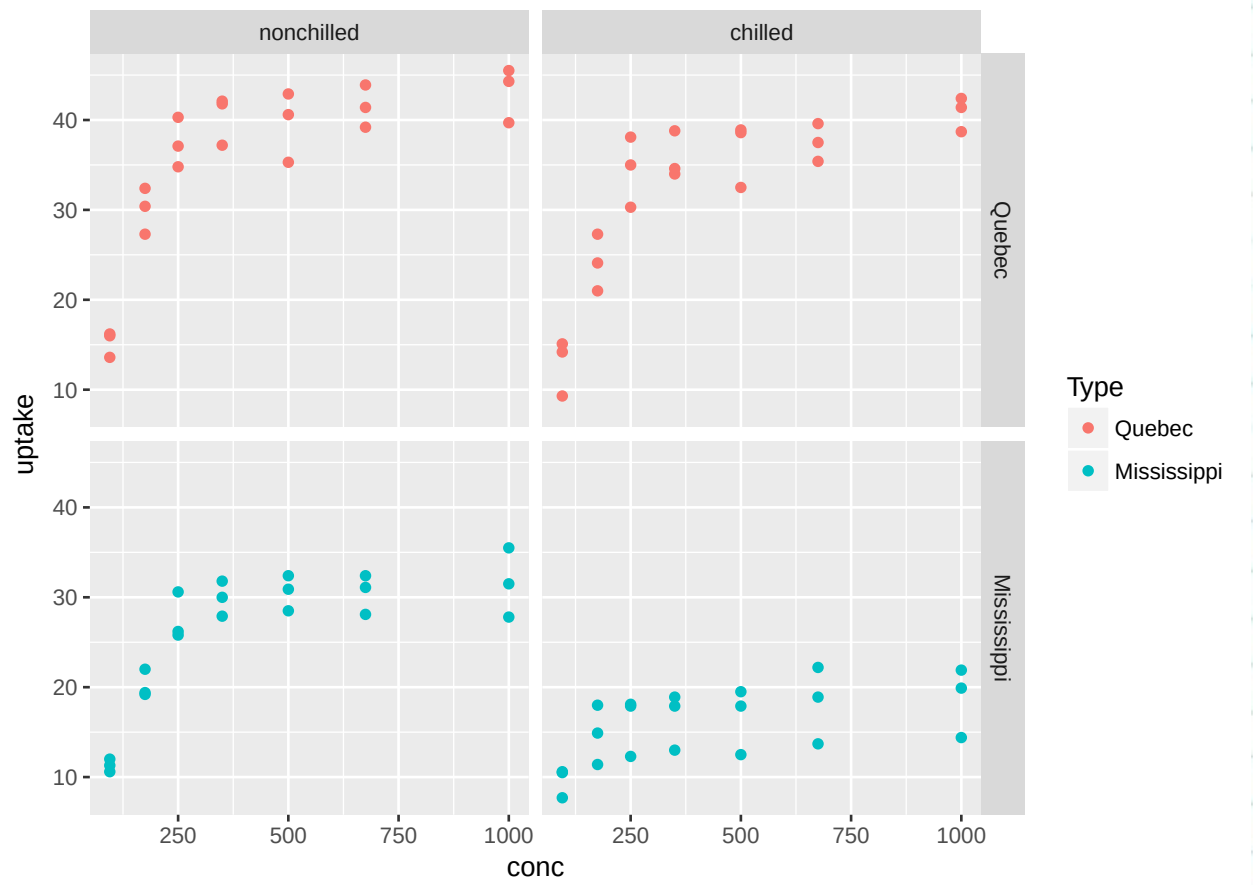
# Facets

```
> ggplot(CO2)+geom_line(aes(x=conc,y=uptake, colour=Type))+
+ facet_wrap(~Plant, scales='free_y')
```



# Facets

```
> ggplot(CO2)+geom_point(aes(x=conc,y=uptake, colour=Type))+
+ facet_grid(Type~Treatment)
```

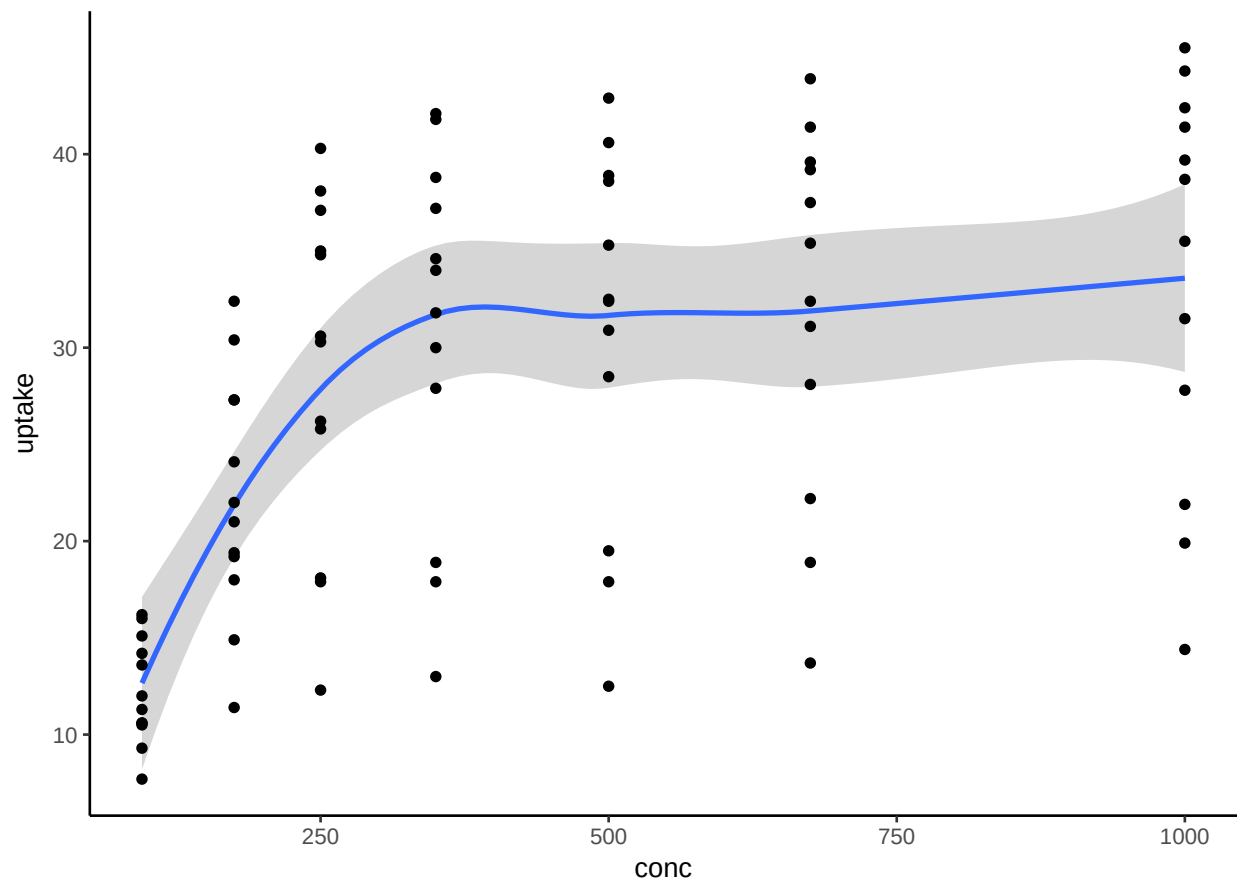


# Section 8

# Themes

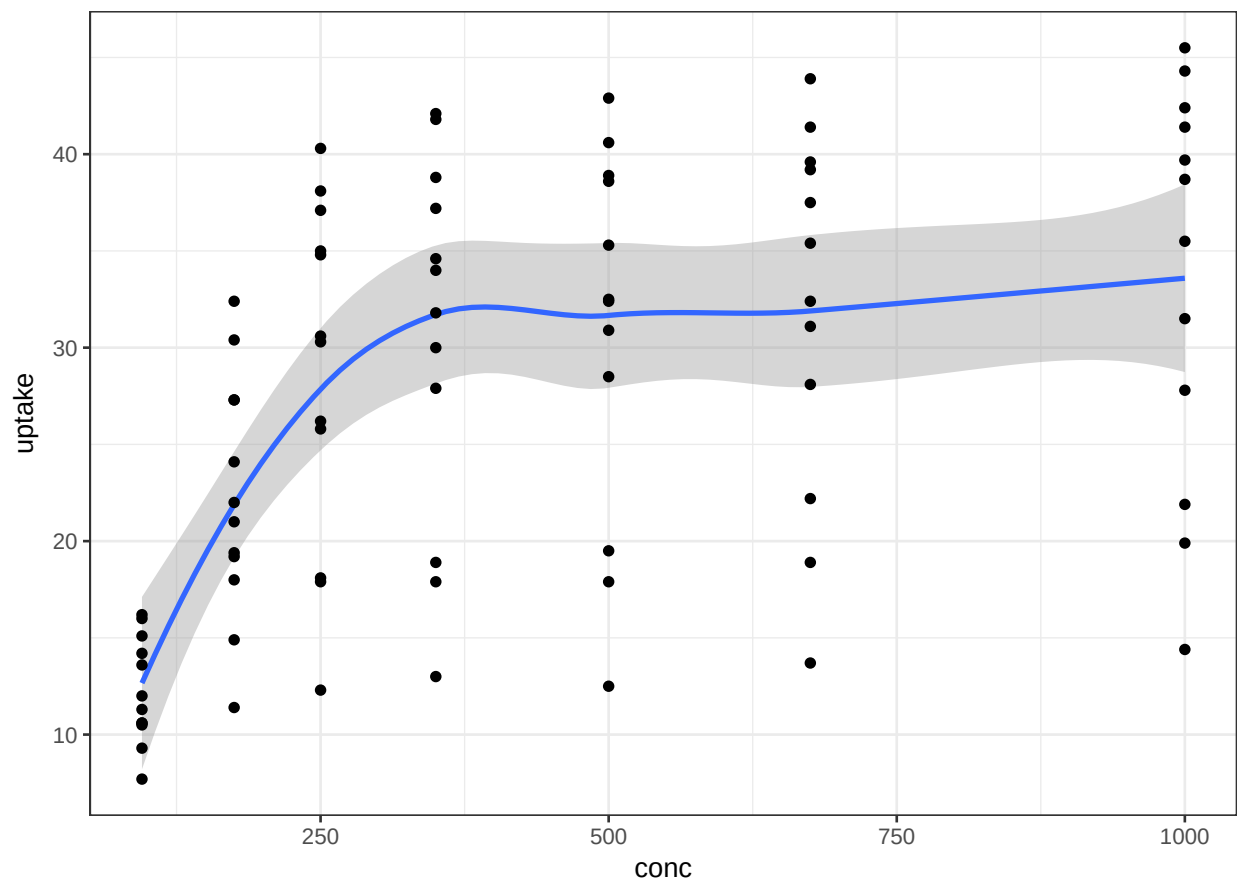
# theme_classic

```
> ggplot(CO2, aes(y = uptake, x = conc)) + geom_smooth() +
+     geom_point() + theme_classic()
```



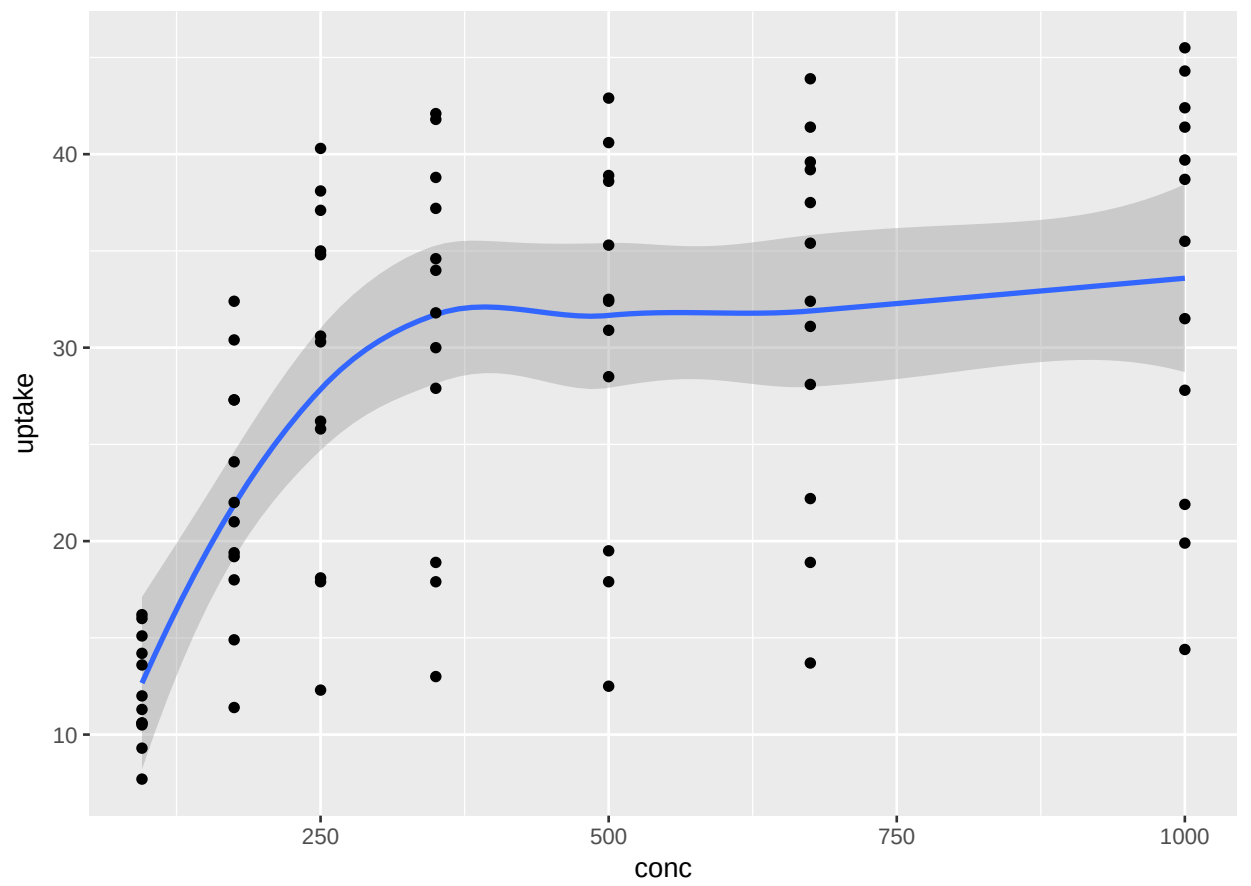
# theme_bw

```
> ggplot(CO2, aes(y = uptake, x = conc)) + geom_smooth() +
+     geom_point() + theme_bw()
```



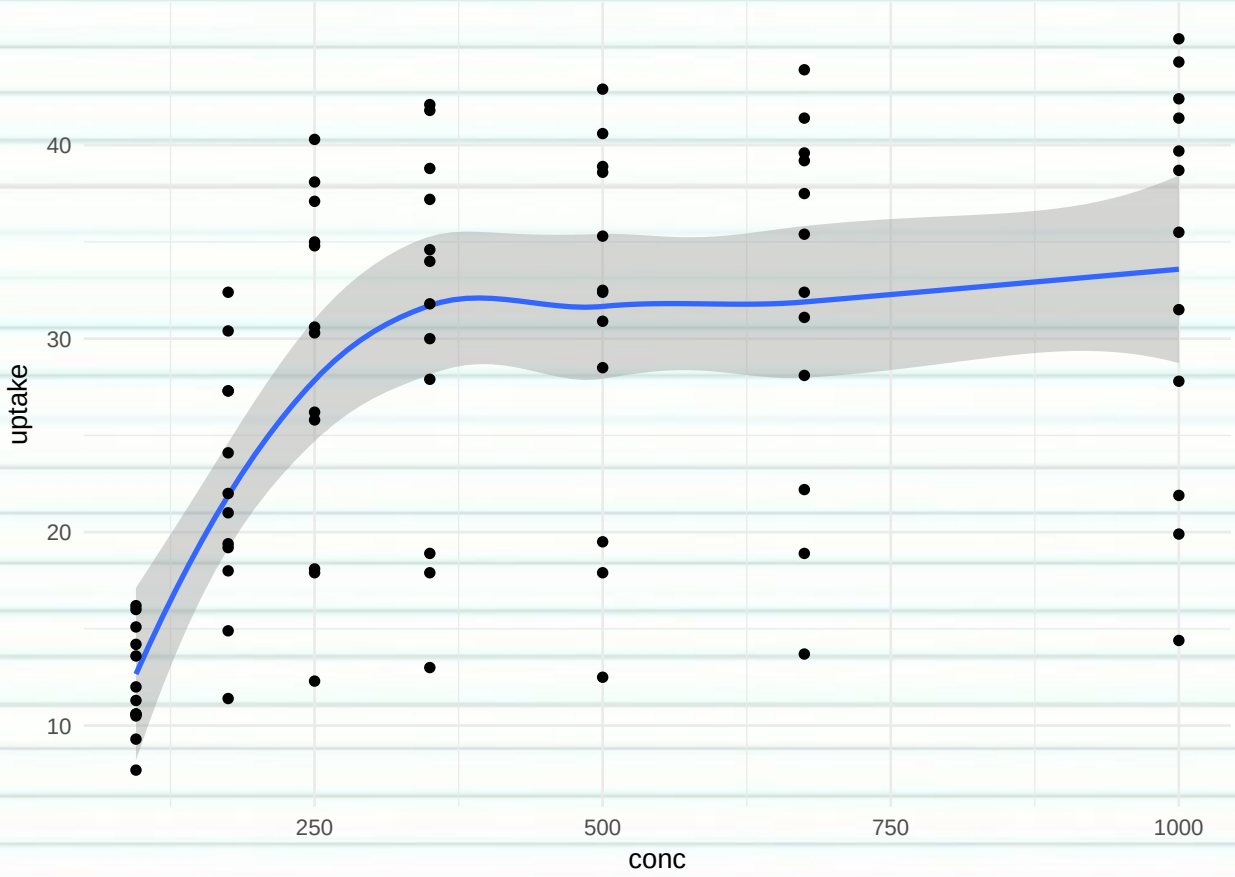
# theme_grey

```
> ggplot(CO2, aes(y = uptake, x = conc)) + geom_smooth() +
+     geom_point() + theme_grey()
```



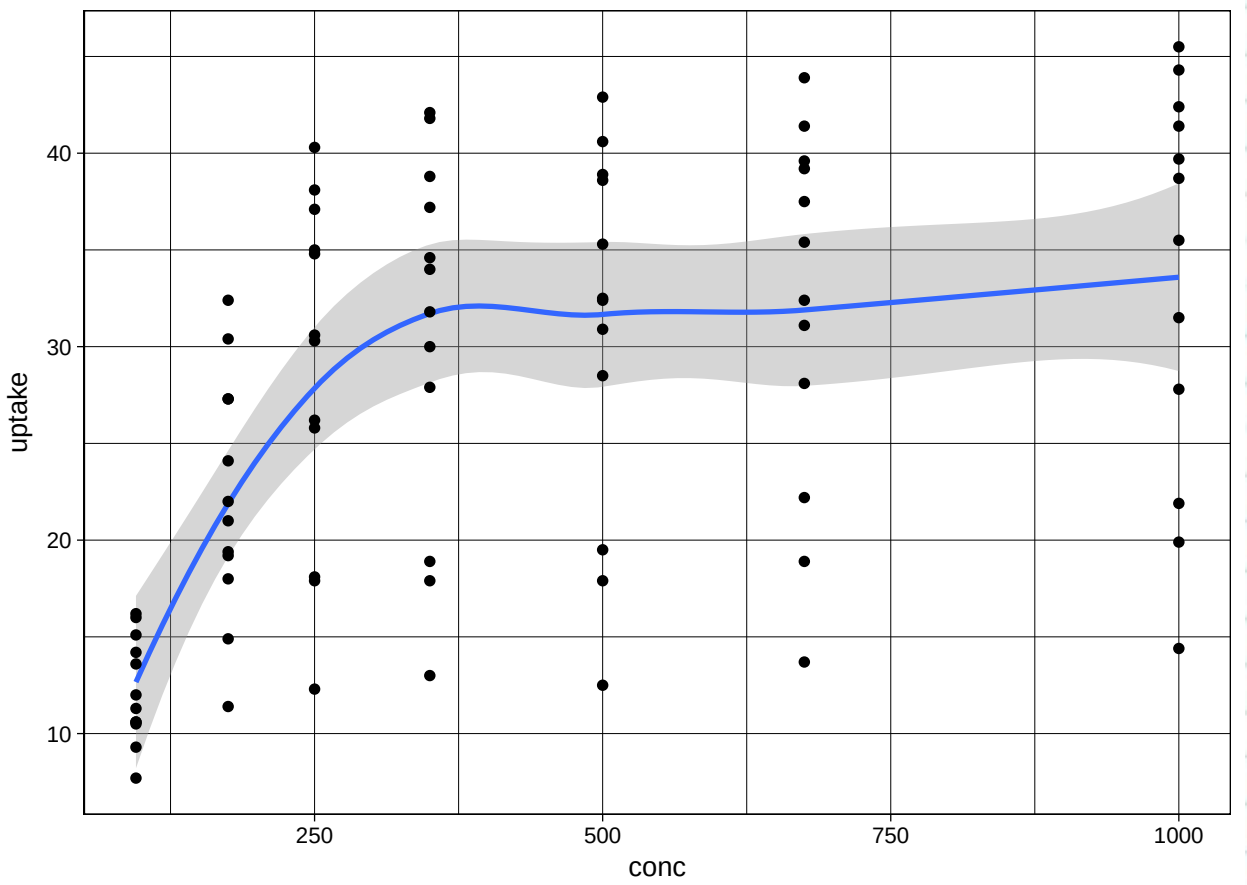
# theme_minimal

```
> ggplot(CO2, aes(y = uptake, x = conc)) + geom_smooth() +
+     geom_point() + theme_minimal()
```



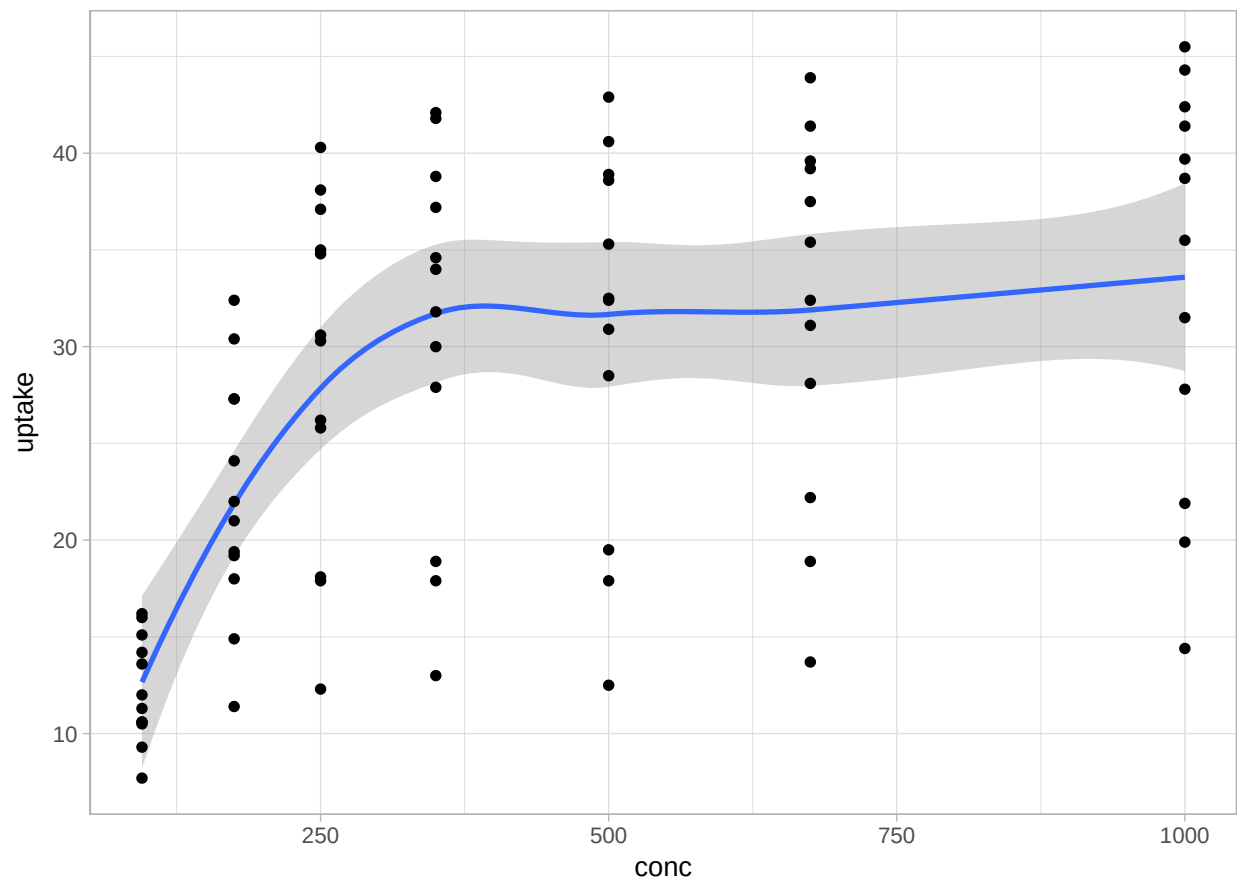
# theme_linedraw

```
> ggplot(CO2, aes(y = uptake, x = conc)) + geom_smooth() +
+     geom_point() + theme_linedraw()
```



# theme_light

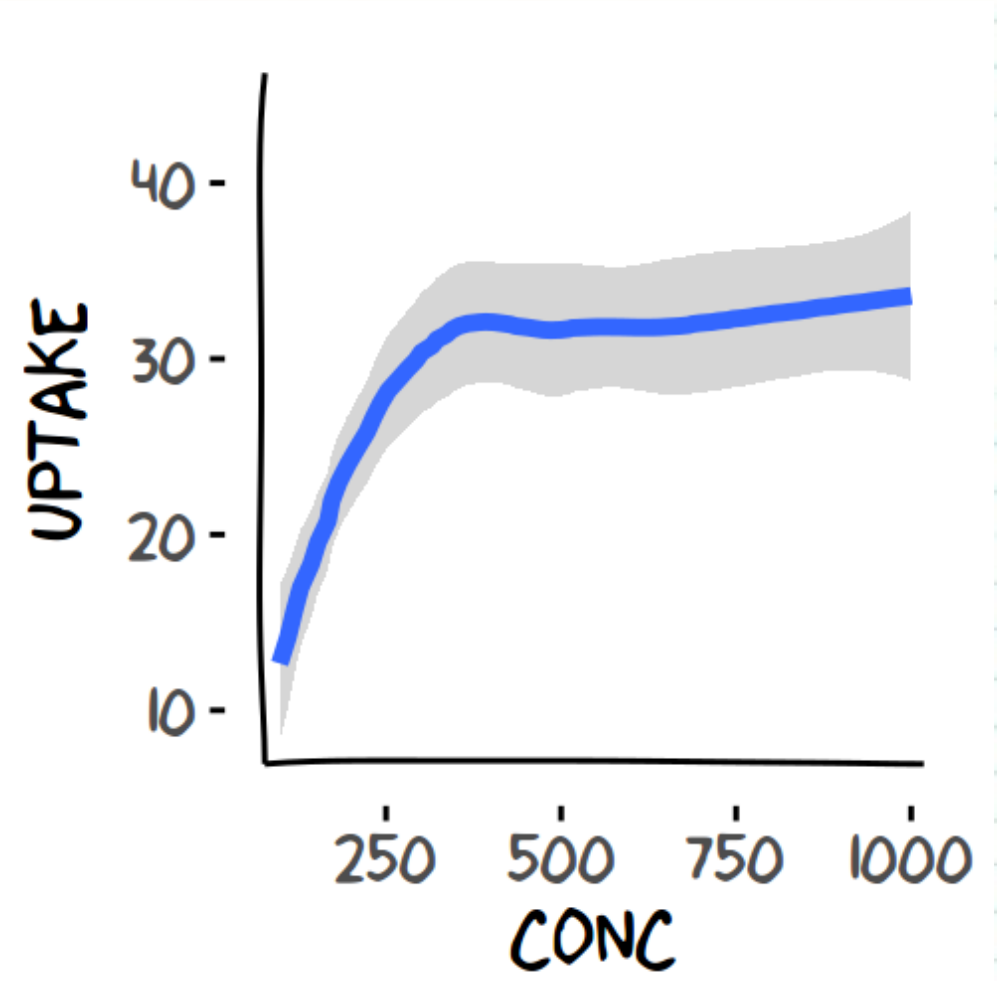
```
> ggplot(CO2, aes(y = uptake, x = conc)) + geom_smooth() +
+     geom_point() + theme_light()
```



# others

```
> png('images/xkcd.png', width=500, height=500, res=200)
> library(xkcd)
> library(sysfonts)
> #library(extrafont)
> #download.file("http://simonsoftware.se/other/xkcd.ttf", dest="xkcd.ttf")
> ##font_import(".")
> #loadfonts()
> xrange <- range(CO2$conc)
> yrange <- range(CO2$uptake)
> ggplot(CO2, aes(y = uptake, x = conc)) + geom_smooth(position='jitter', s
+     #geom_point() +
+         theme_minimal()+theme(text=element_text(size=16, family='xkcd'))+
+         xkcdaxis(xrange, yrange)
>
> dev.off()
```

# others



# Practice

```
> head(state)
```

```
           Illiteracy state.region         x       y
Alabama           2.1        South  -86.7509 32.5901
Alaska            1.5         West -127.2500 49.2500
Arizona           1.8         West -111.6250 34.2192
Arkansas          1.9        South  -92.2992 34.7336
California        1.1         West -119.7730 36.5341
Colorado          0.7         West -105.5130 38.6777
```

Calculate the mean and 95% confidence interval of Illiteracy per state.region and plot them. and plot them

# Practice

```
> head(state)
```

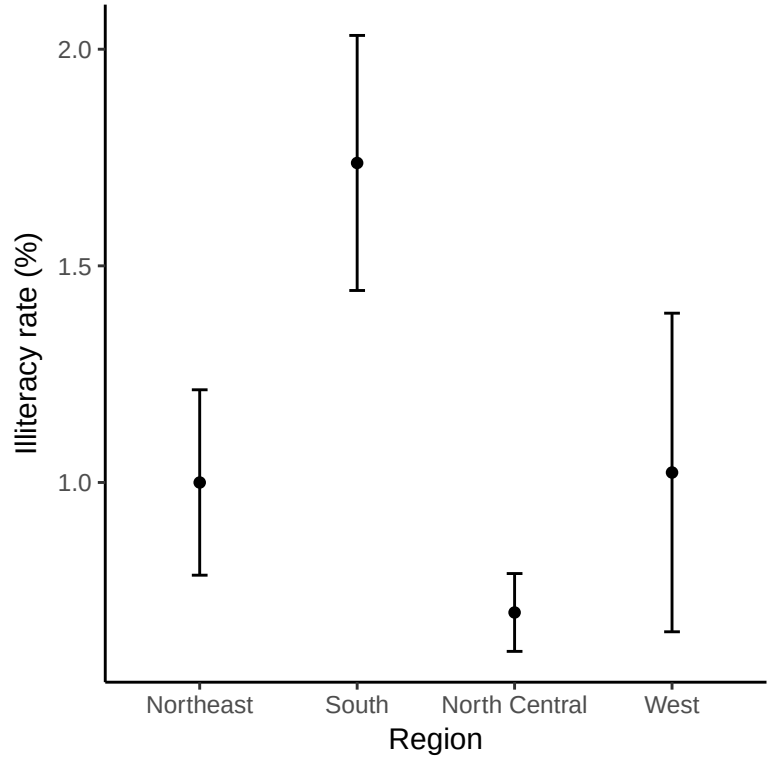
```
           Illiteracy state.region         x       y
Alabama           2.1        South  -86.7509 32.5901
Alaska            1.5         West -127.2500 49.2500
Arizona           1.8         West -111.6250 34.2192
Arkansas          1.9        South  -92.2992 34.7336
California        1.1         West -119.7730 36.5341
Colorado          0.7         West -105.5130 38.6777
```

```
> library(gmodels)
> state.sum = state %>% group_by(state.region) %>%
+     summarise(Mean=mean(Illiteracy), Lower=ci(Illiteracy)[2],
+                                      Upper=ci(Illiteracy)[3])
> state.sum
```

```
# A tibble: 4 x 4
   state.region     Mean     Lower     Upper
          <fctr>    <dbl>     <dbl>     <dbl>
1     Northeast 1.000000 0.7860119 1.2139881
2         South 1.737500 1.4431367 2.0318633
3 North Central 0.700000 0.6101452 0.7898548
4          West 1.023077 0.6553719 1.3907819
```

# Practice

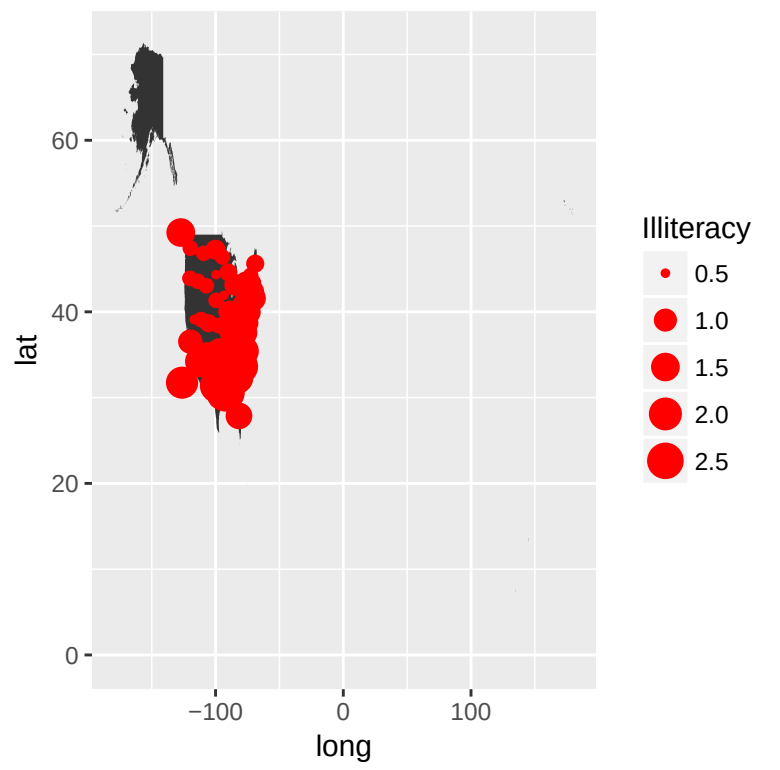
```
> ggplot(state.sum, aes(y=Mean, x=state.region)) + geom_point() +
+     geom_errorbar(aes(ymin=Lower, ymax=Upper), width=0.1) +
+         scale_x_discrete('Region') +
+         scale_y_continuous('Illiteracy rate (%)')+
+             theme_classic() +
+                 theme(axis.line.y=element_line(),axis.line.x=element_line
```



# Practice

Overlay illiteracy data onto map of US

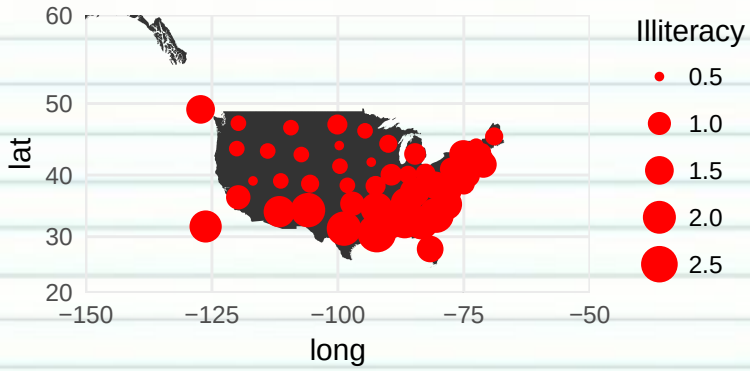
```
> library(mapdata)
> US <- map_data("worldHires", region="USA")
> ggplot(US) +
+     geom_polygon(aes(x=long, y=lat, group=group)) +
+         geom_point(data=state,aes(y=y,x=x, size=Illiteracy),color='red')
```



# Practice

Overlay illiteracy data onto map of US

```
> library(mapdata)
> US <- map_data("worldHires", region="USA")
> ggplot(US) +
+     geom_polygon(aes(x=long, y=lat, group=group)) +
+         geom_point(data=state,aes(y=y,x=x, size=Illiteracy),color='red')+
+             coord_map(xlim=c(-150,-50),ylim=c(20,60)) + theme_minimal()
```



# Practice

```
> MACNALLY <- read.csv('../data/macnally.csv',
+   header=T, row.names=1, strip.white=TRUE)
> head(MACNALLY)
```

```
                HABITAT GST EYR
Reedy Lake        Mixed 3.4 0.0
Pearcedale  Gipps.Manna 3.4 9.2
Warneet     Gipps.Manna 8.4 3.8
Cranbourne  Gipps.Manna 3.0 5.0
Lysterfield       Mixed 5.6 5.6
Red Hill          Mixed 8.1 4.1
```

Calculate the mean and standard error of GST and plot them

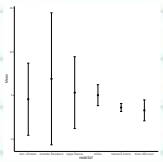
# Practice

Calculate the mean and standard error of GST and plot mean and confidence bars

```
> library(gmodels)
> ci(MACNALLY$GST)
```

```
  Estimate   CI lower   CI upper Std. Error
  4.878378   4.035292   5.721465   0.415704
```

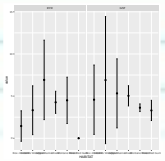
```
> MACNALLY.agg = MACNALLY %>% group_by(HABITAT) %>%
+   summarize(Mean=mean(GST), Lower=ci(GST)[2], Upper=ci(GST)[3])
> ggplot(MACNALLY.agg, aes(y=Mean, x=HABITAT)) +
+     geom_errorbar(aes(ymin=Lower, ymax=Upper), width=0.1)+
+     geom_point() + theme_classic()
```



# Practice

You can also use ggplot's summary

```
> library(tidyverse)
> MACNALLY.melt = MACNALLY %>% gather(key=variable, value=value,-HABITAT)
> ggplot(MACNALLY.melt, aes(y=value, x=HABITAT)) +
+     stat_summary(fun.y='mean', geom='point')+
+     stat_summary(fun.data='mean_cl_normal', geom='errorbar', width=0.1)+
+         facet_grid(~variable)
```



```
> #and bootstrapped means..
> ggplot(MACNALLY.melt, aes(y=value, x=HABITAT)) +
+     stat_summary(fun.y='mean', geom='point')+
+     stat_summary(fun.data='mean_cl_boot', geom='errorbar', width=0.1)+
+         facet_grid(~variable)
```