Sane's STATS Academy of Statistics

ggplot2

Enhanced Graphics Package

About ggplot2

- Package ggplot2 provides a method of creating innovative graphs based on graphical grammar
- There are four graphic systems in R currently.

Four Graphics Systems in R

1. The `base` Graphics System written by the Ross Ihaka included by default in every R installation
2. The `grid` graphics system written by Paul Murrell (2011)
3. The `lattice` graphics system written by Deepayan Sarkar (2008)
4. The `ggplot2` graphics system written by Hadley Wickham (2009)

Base Graphics

- We have already covered it in the previous sessions
- Composed of functions like plot(), boxplot(), barplot() etc.

Grid Graphics

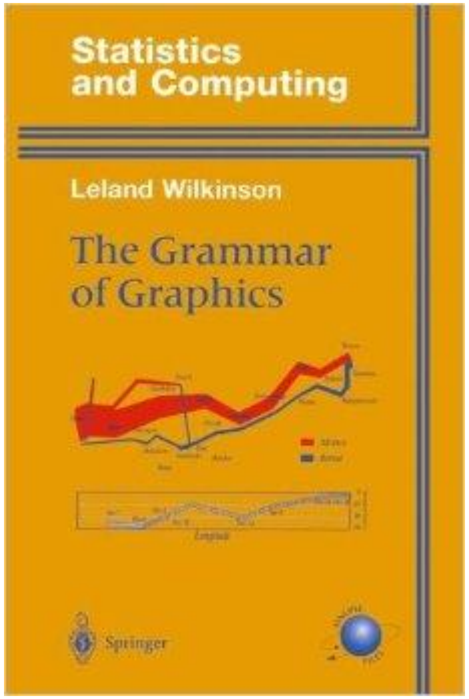
- Implemented by package `grid`
- Offers a low level alternative to the standard graphics system
- But the `grid` package doesn’t provide functions for producing statistical graphics or complete plots

Lattice Graphics

- Implements *`trellis`* graphs with package `lattice`
- Provides a comprehensive system for creating statistical graphics
- Built using package `grid`

Ggplot2 Graphics

- The package *ggplot2* has been written by Hadley Wickham
- Provides a system for creating graphs based on the grammar of graphics described by Wilkinson and expanded by Wickham



Function qplot

- Before we look into the ggplot function, let us first have a look at the function qplot() (Quick Plot), which is a basic plotting function in package ggplot2.
- The function qplot() hides what goes on underneath (inside)

Syntax : qplot(x , y , data , …)

Where

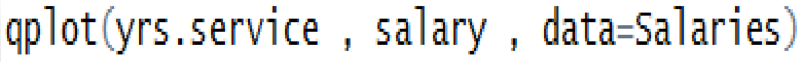
x : variable to be considered on X-axis

y : variable to be considered on Y-axis (If not specified scatter plot won’t be drawn)

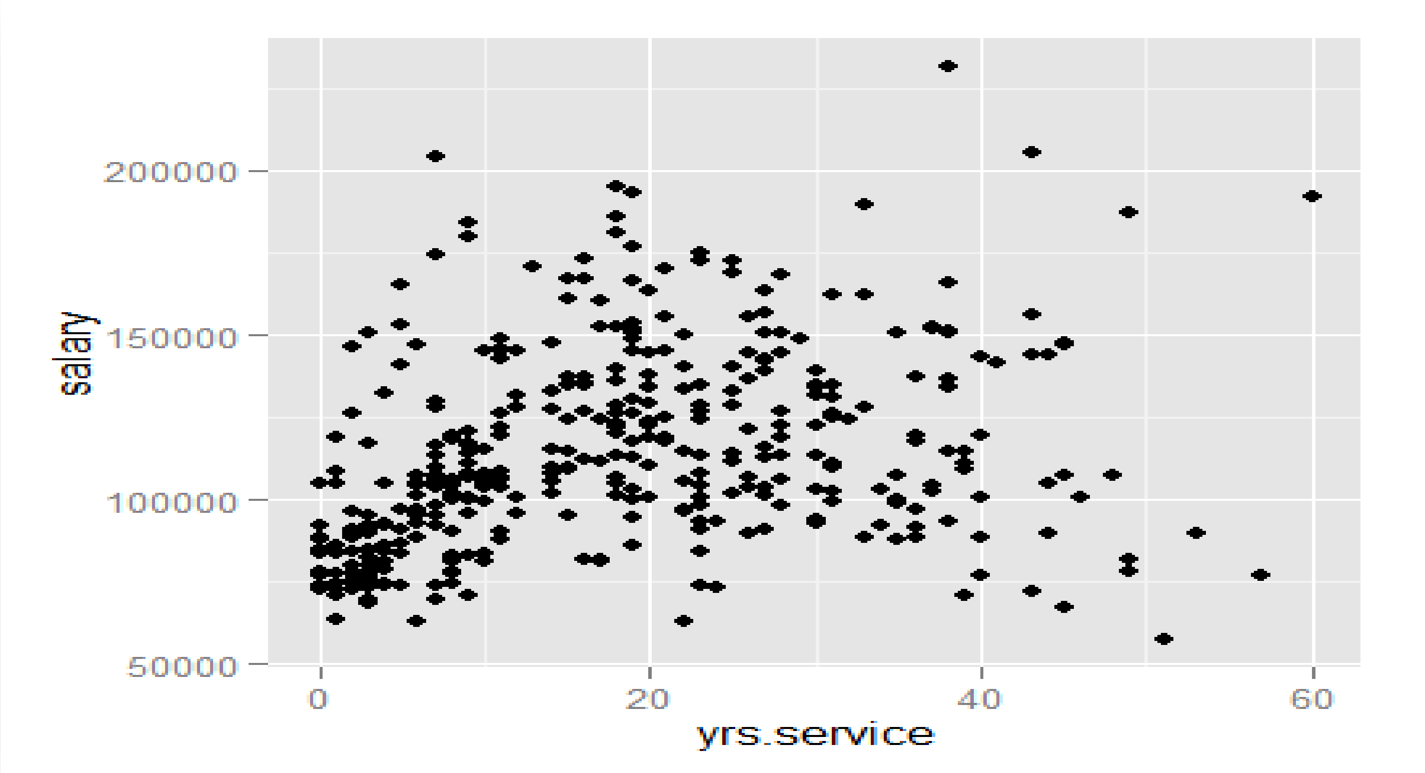
data : data frame object

Example

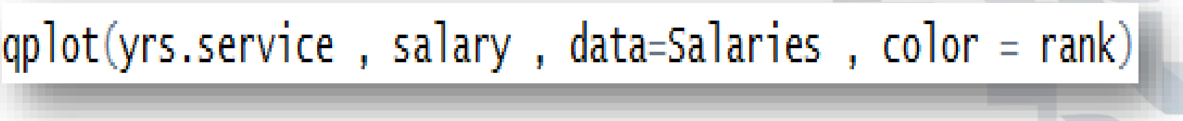
- We consider here the dataset Salaries in the package car.



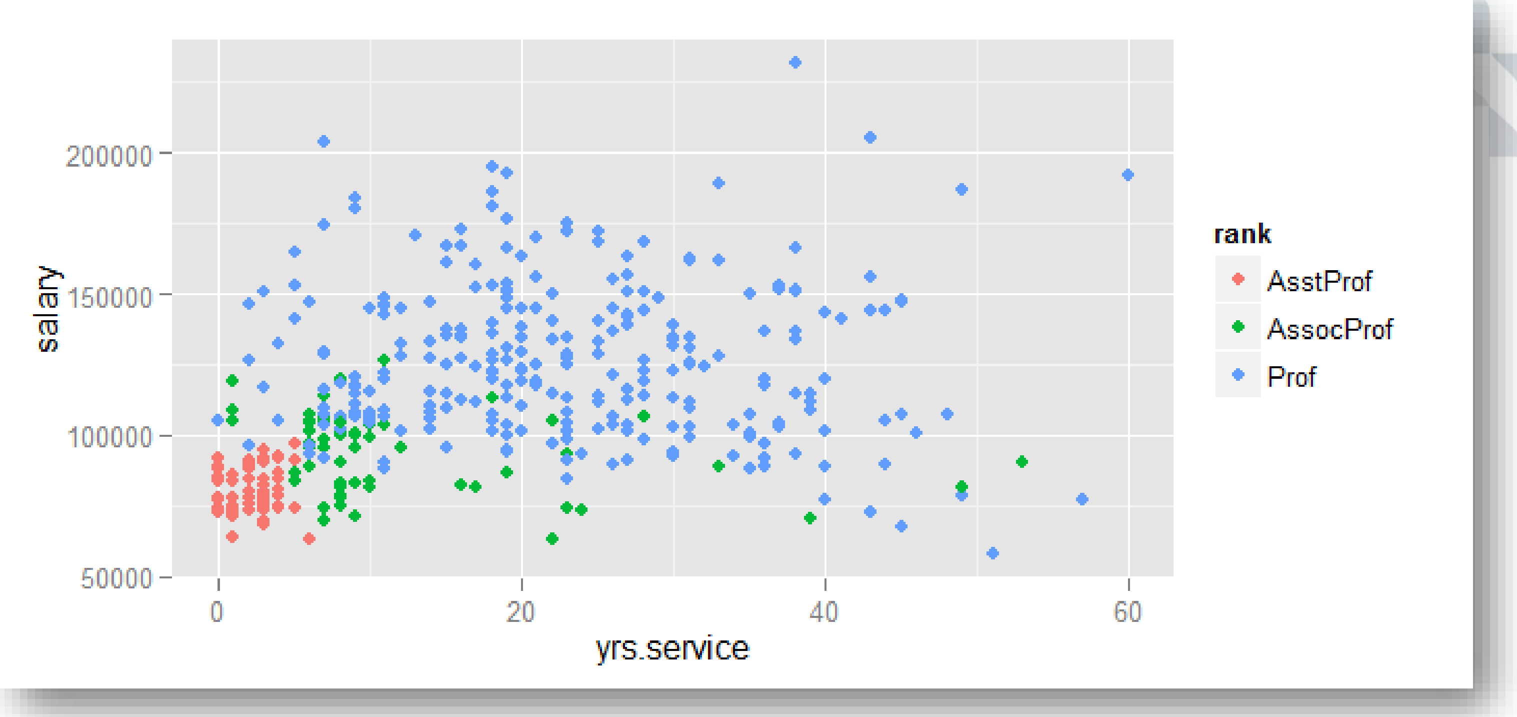
```
qplot(yrs.service , salary , data=Salaries)
```



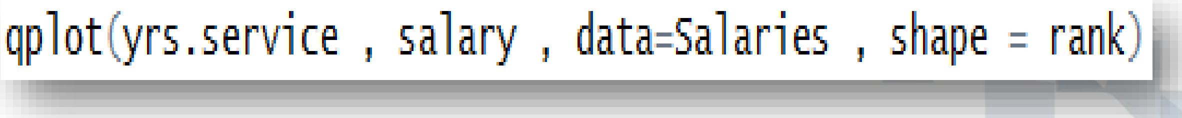
Rendering Colours : Categorical



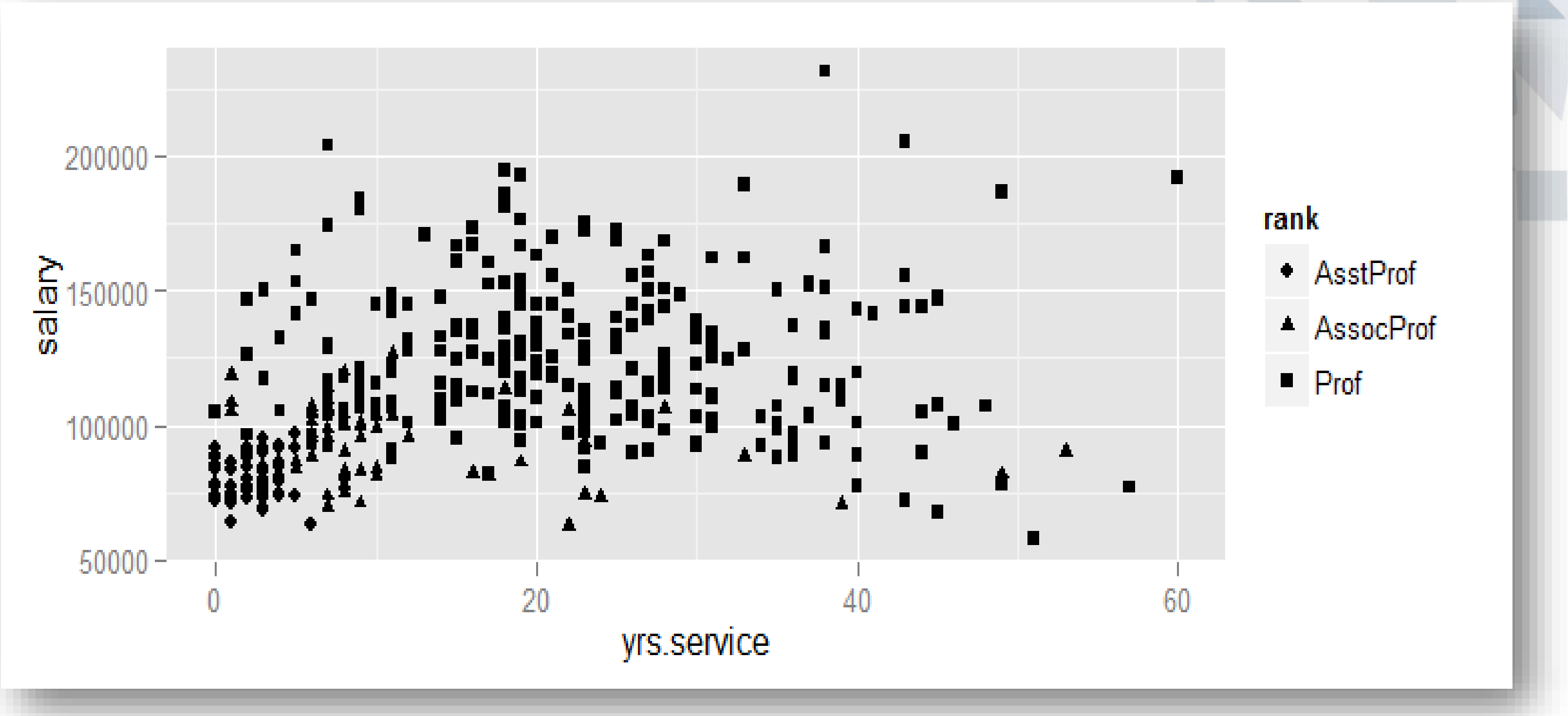
```
qplot(yrs.service , salary , data=Salaries , color = rank)
```



Rendering Shapes : Categorical

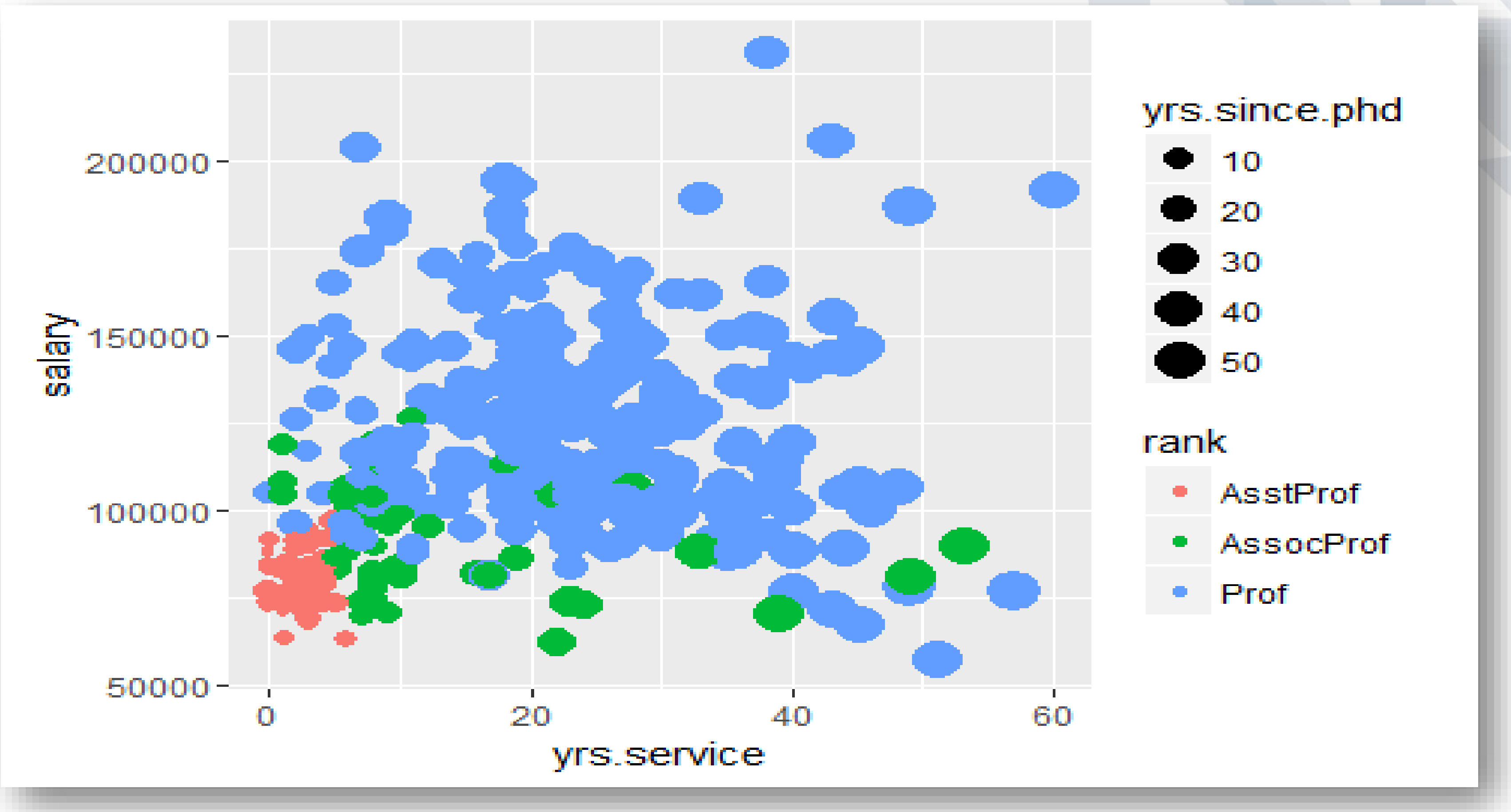


```
qplot(yrs.service , salary , data=Salaries , shape = rank)
```

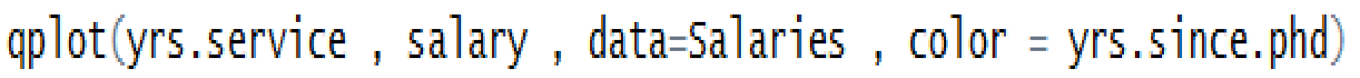


Bubble Plot

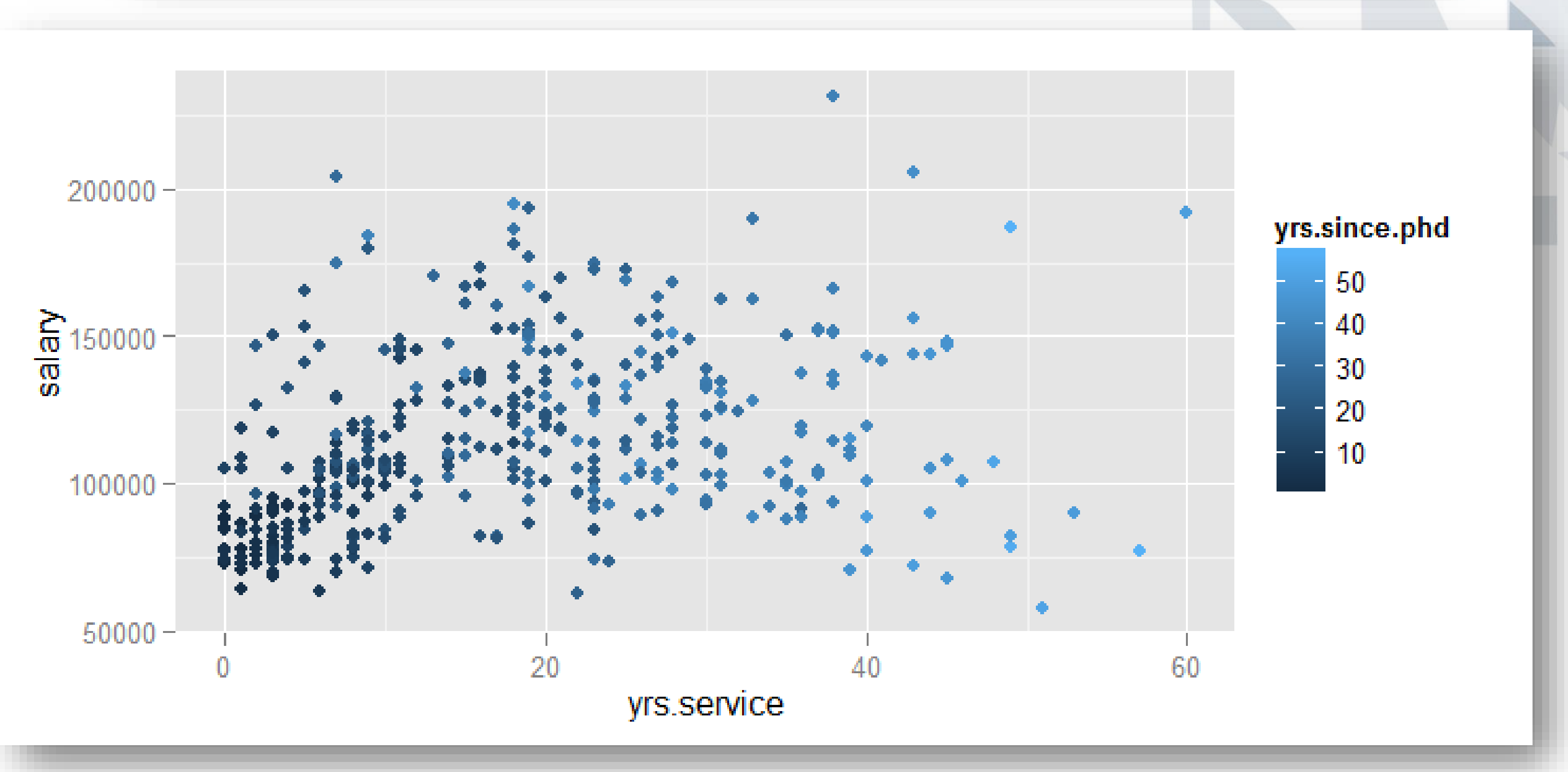
```
qplot(yrs.service , salary , data=Salaries ,
      size = yrs.since.phd, color = rank)
```



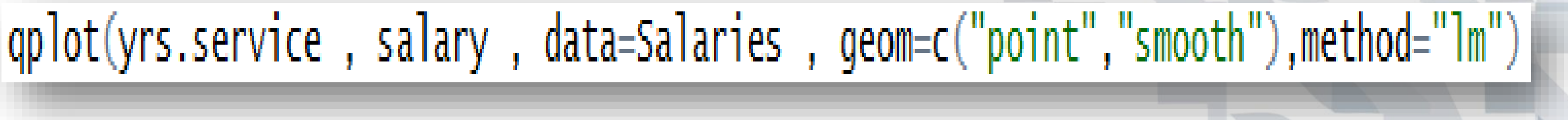
Rendering Colours : Continuous



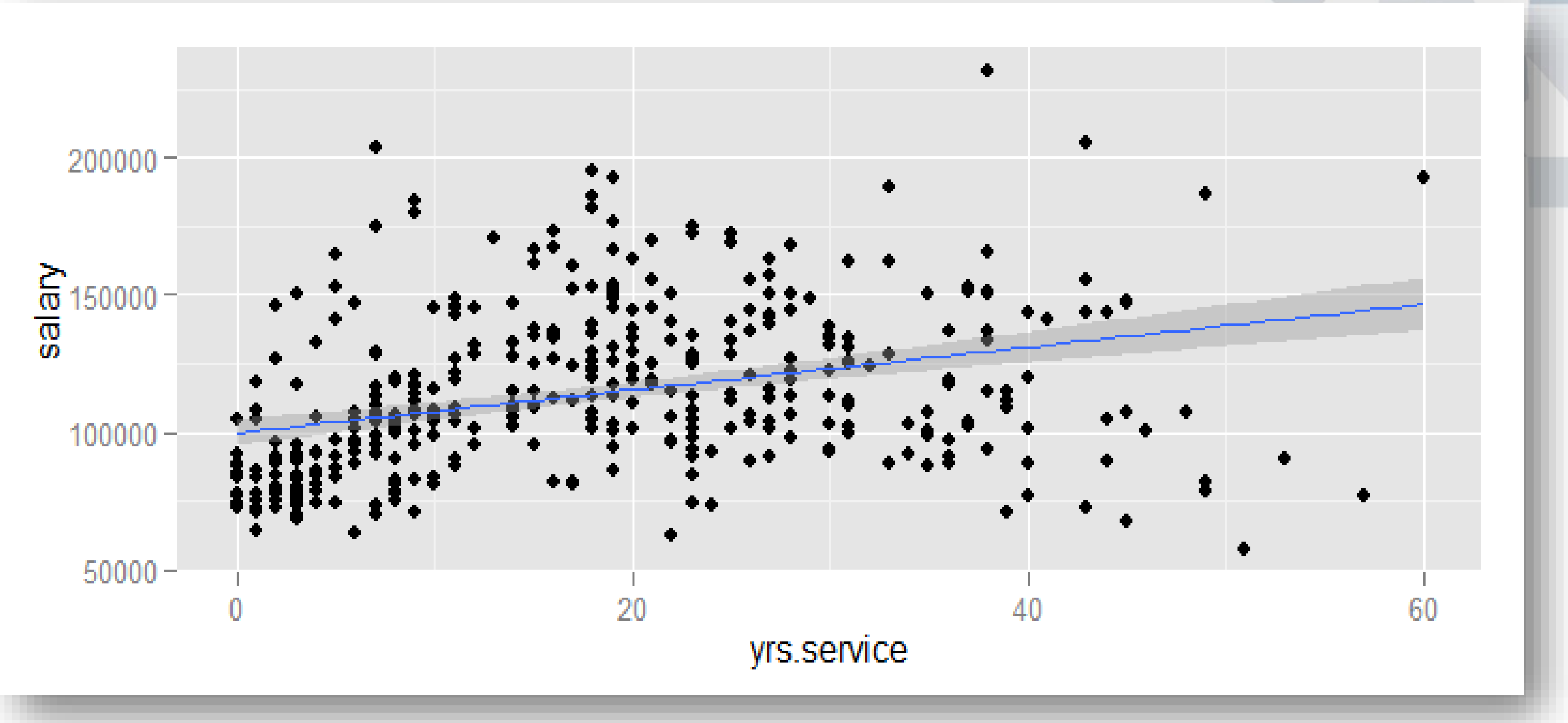
```
qplot(yrs.service , salary , data=Salaries , color = yrs.since.phd)
```



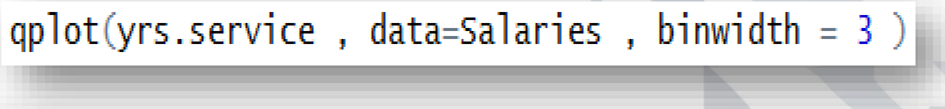
Adding Smoothened Line



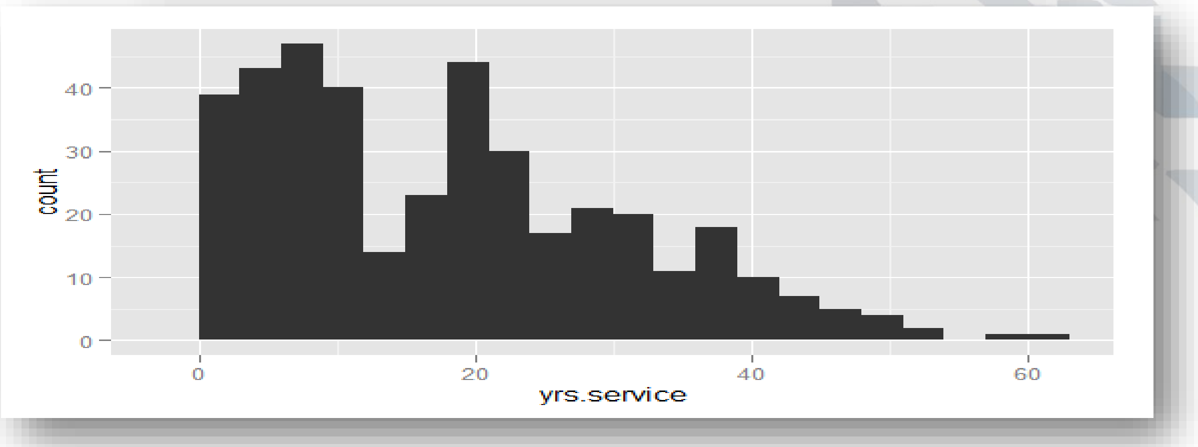
```
qplot(yrs.service , salary , data=Salaries , geom=c("point","smooth"),method="lm")
```

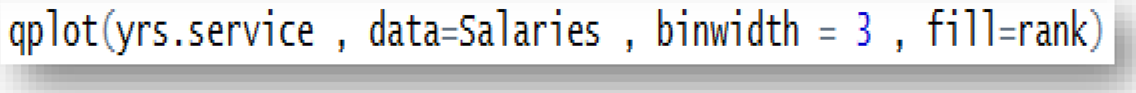


Histogram with qplot()

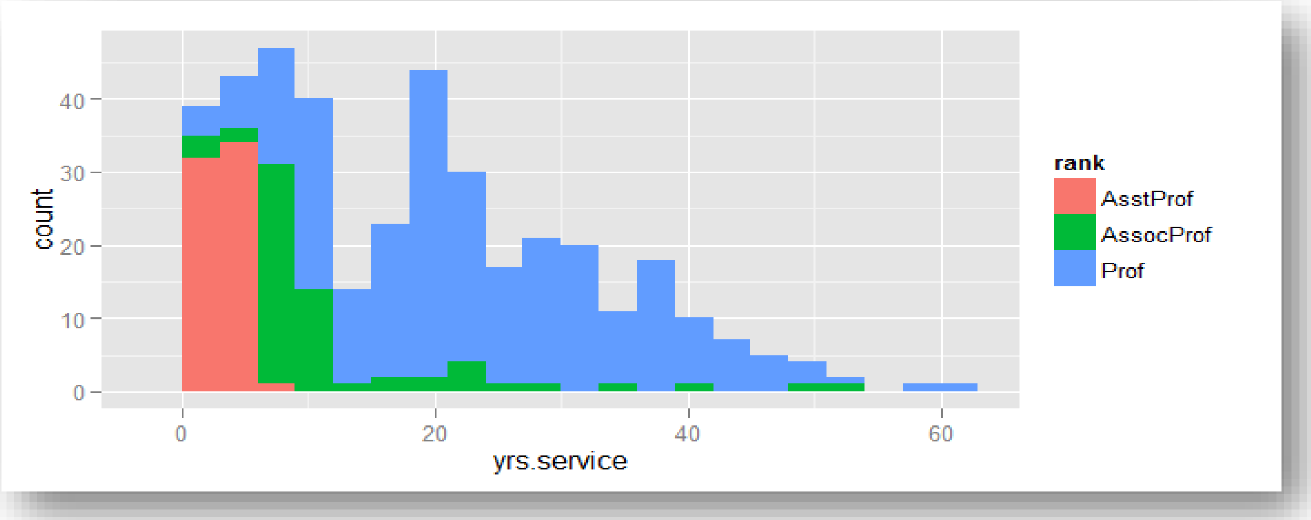


```
qplot(yrs.service , data=Salaries , binwidth = 3 )
```



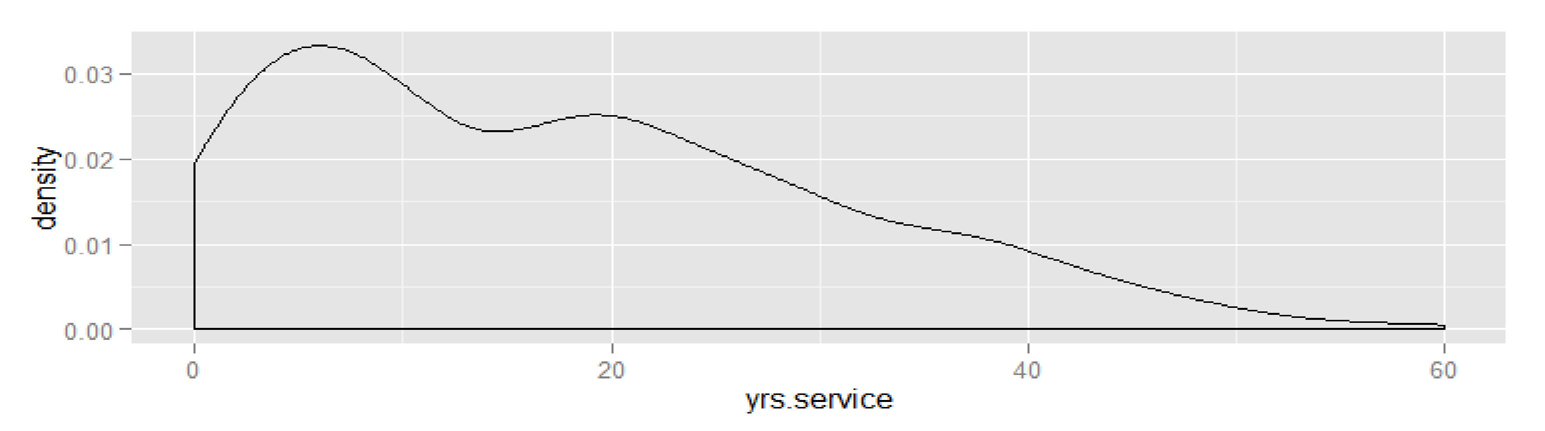


```
qplot(yrs.service , data=Salaries , binwidth = 3 , fill=rank)
```

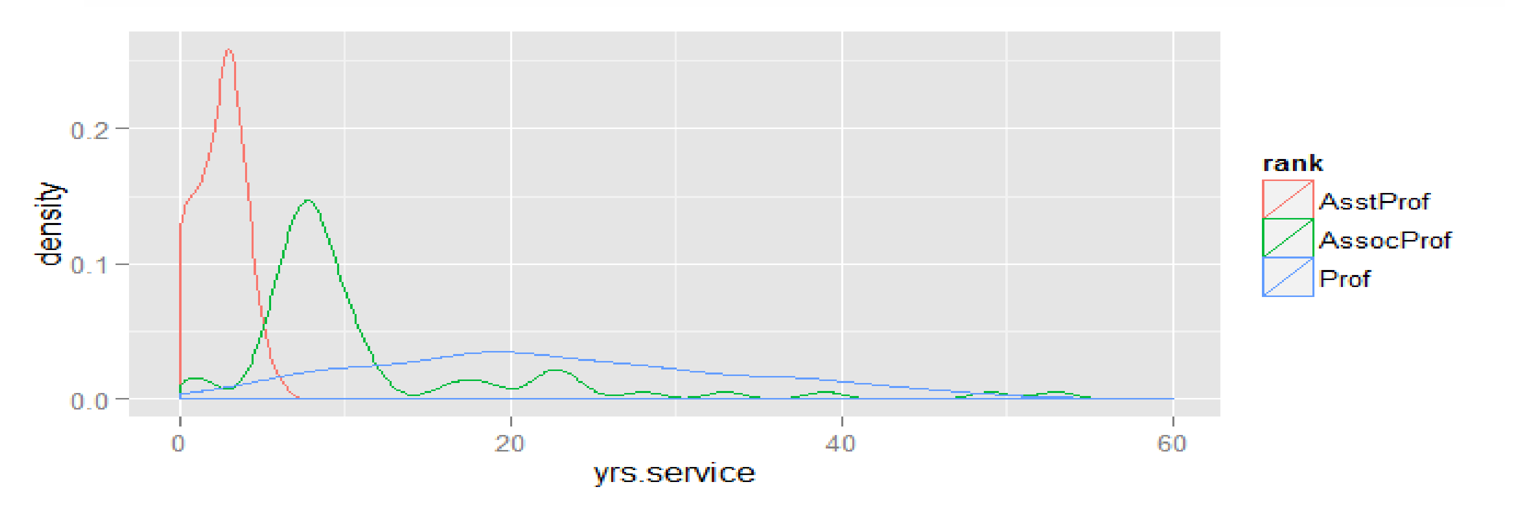


Density Plots

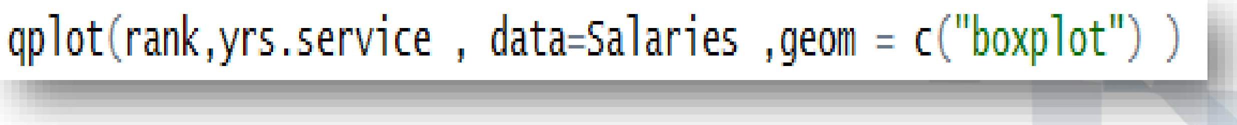
```
qplot(yrs.service , data=Salaries ,geom = "density" )
```



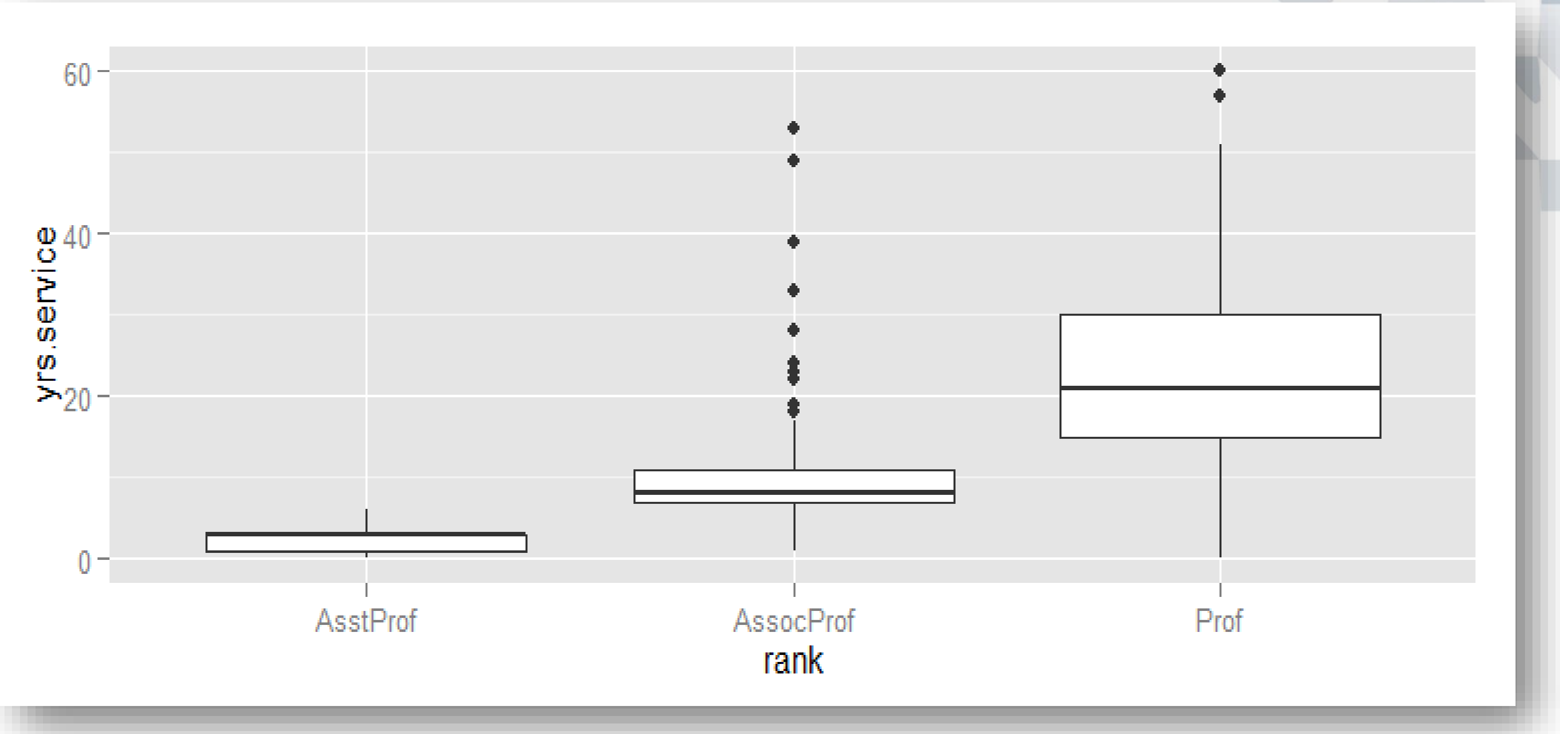
```
qplot(yrs.service , data=Salaries ,geom = "density" , color=rank)
```



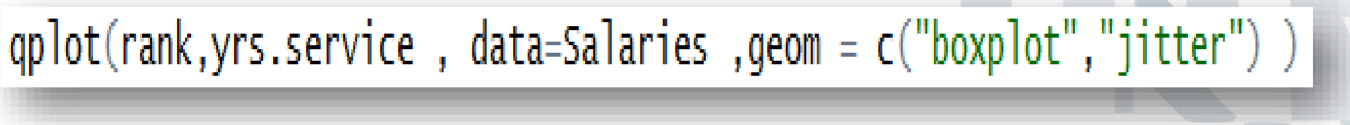
Boxplot



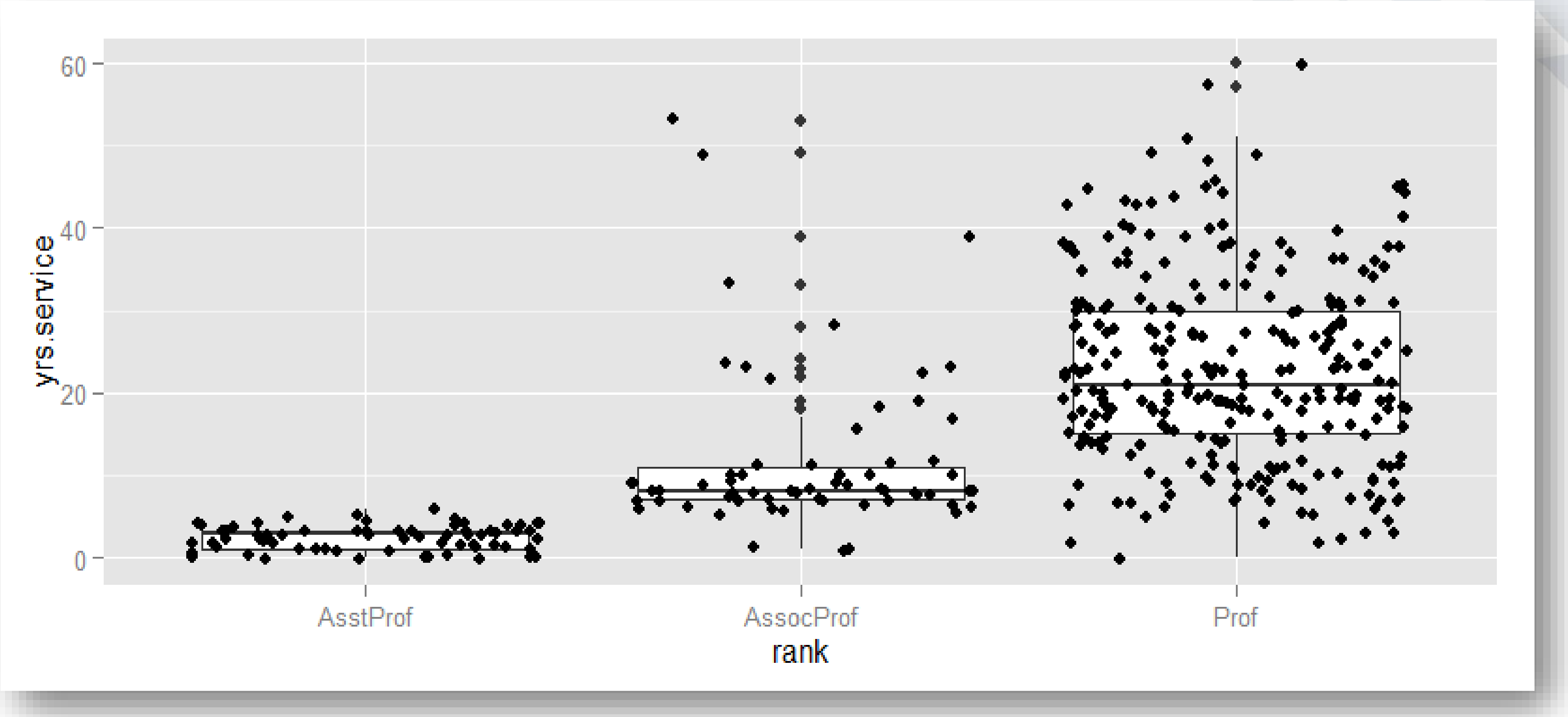
```
qplot(rank,yrs.service , data=Salaries ,geom = c("boxplot") )
```



Boxplot with Jittering



```
qplot(rank,yrs.service , data=Salaries ,geom = c("boxplot","jitter") )
```

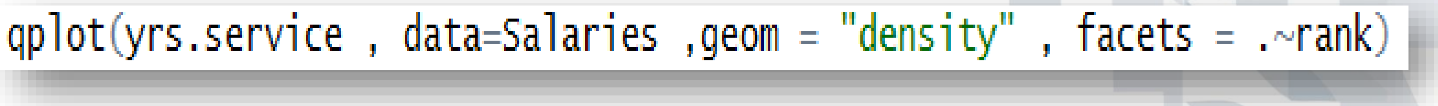


Facets

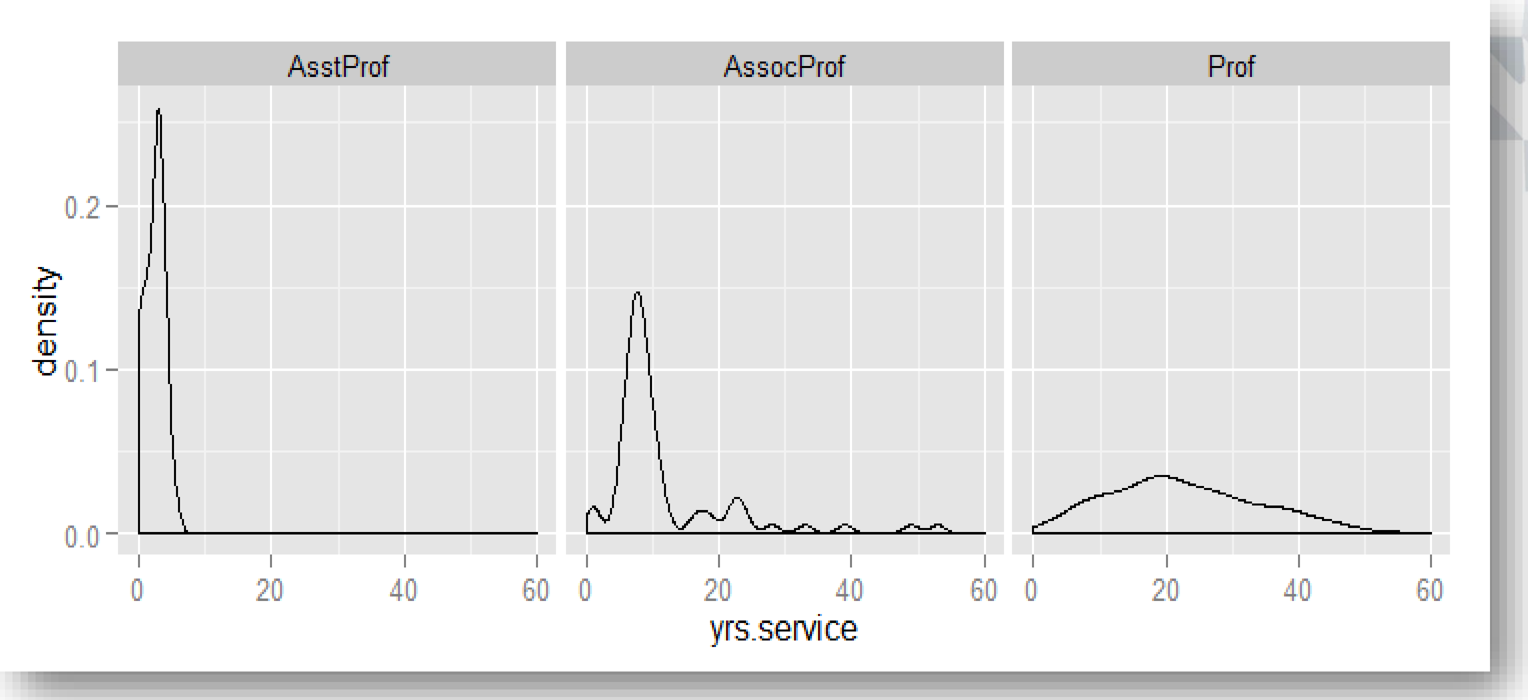
- Sometimes, the relationship become clearer if the graphs are shown side by side
- These are also called trellis graphs

Syntax	Effect
facets = . ~ var	Separate plots for each level of var into n columns
facets = var ~ .	Separate plots for each level of var into n rows
facets = var1 ~ var2	Separate plots for each combination with var1 in rows and var2 in columns

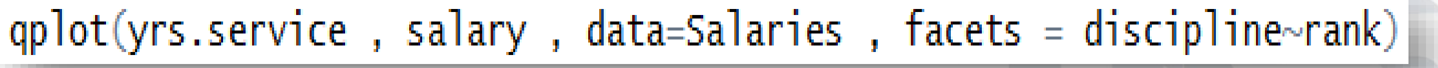
Facets Example



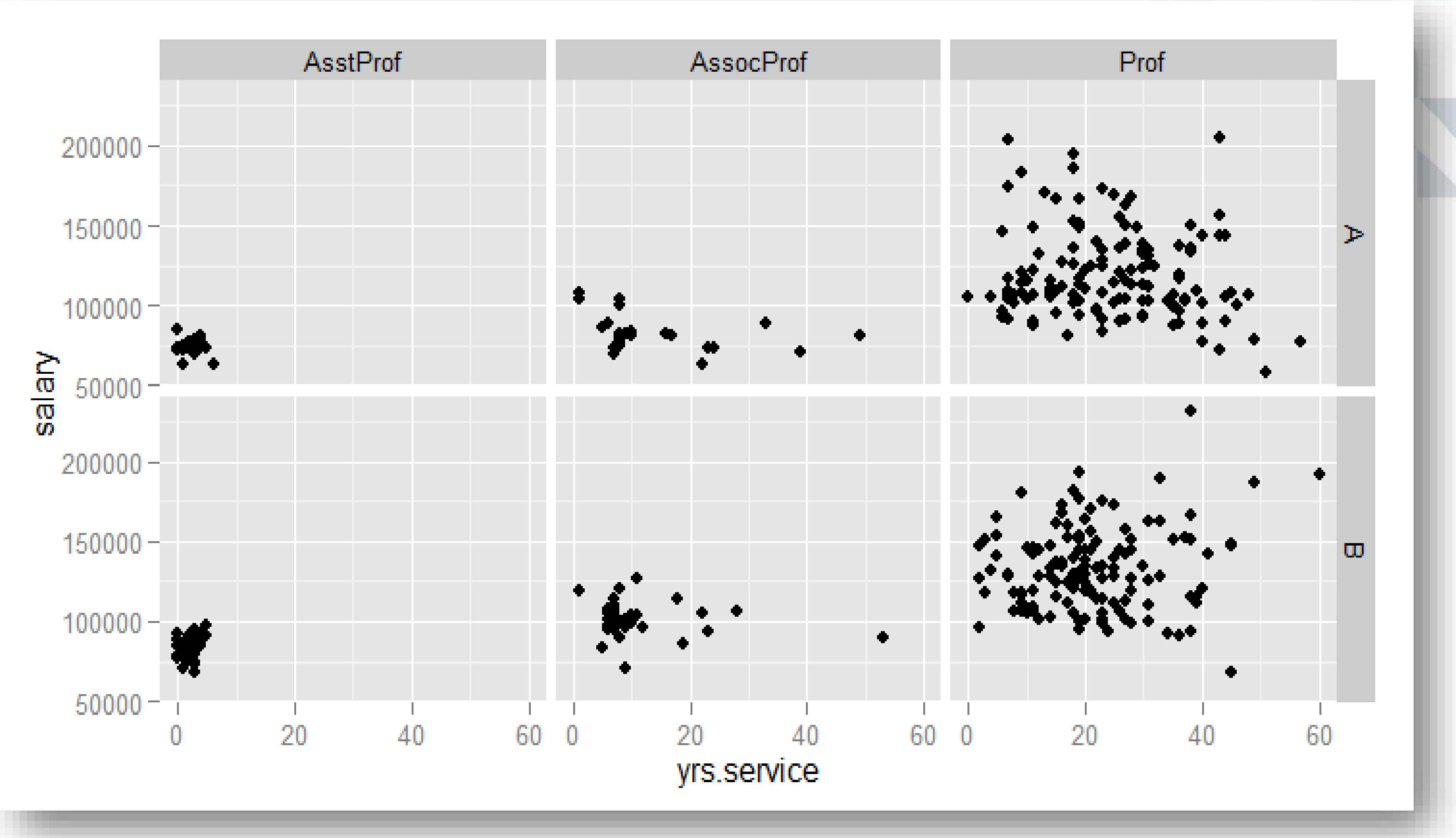
```
qplot(yrs.service , data=Salaries ,geom = "density" , facets = .~rank)
```



Facets Example



```
qplot(yrs.service , salary , data=Salaries , facets = discipline~rank)
```



Function *ggplot*

- With ggplot function, the plots are created by putting together functions in a chain-like manner using plus (+) sign

Syntax :

ggplot(data,aes(x=,y=,…)) + geom function(s)

Where

data : data frame object

aes() : a function for specifying the role of variables

Basic Components of ggplot()

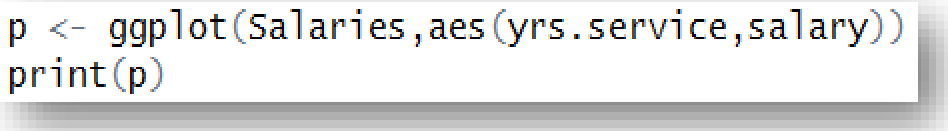
- **Data Frame**
- **Aesthetic mappings**: data mapping by color, shape etc.
- **Geoms**: Geometric object like points, shapes etc.
- **Facets** : Trellis plotting
- **Stats**: Statistical Transforms
- **Scales** : scale used by aesthetic map
- **Coordinate System**

Building Plots in ggplot()

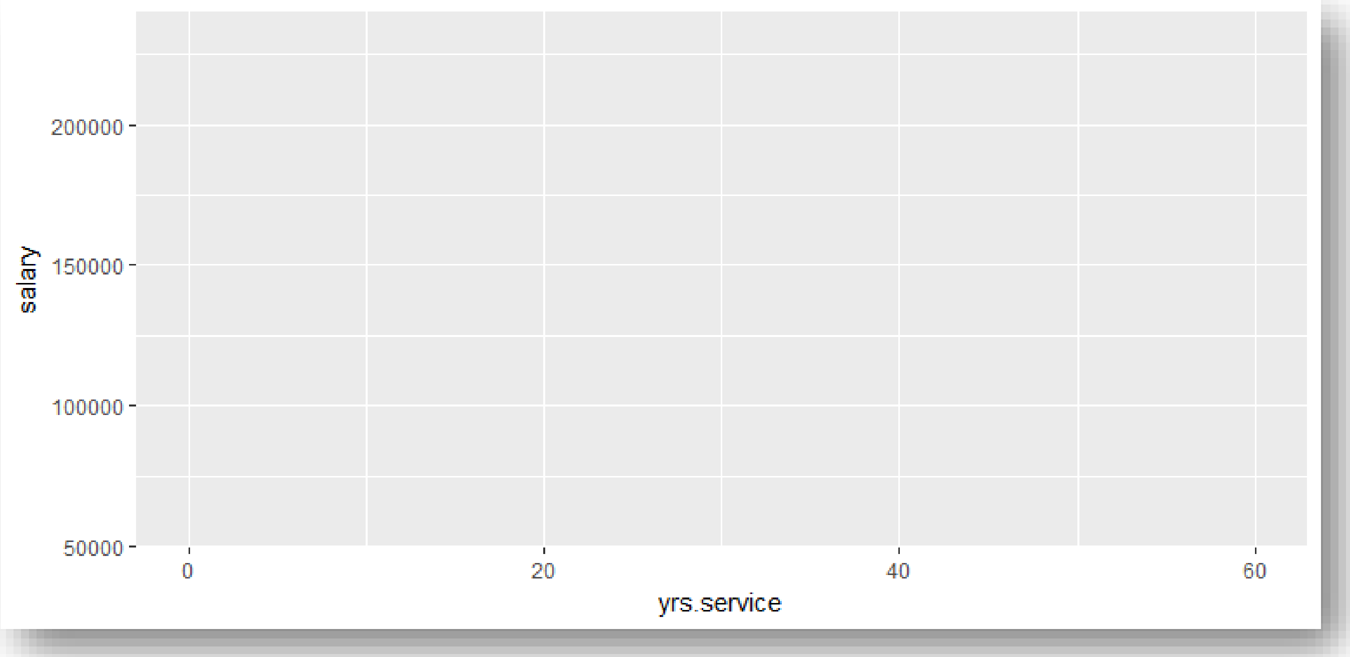
- Plots are built up in layers
  - Plotting the data
  - Overlaying the summary
  - Annotating the graph
- Let us have a simple example of displaying the scatter plot with *yrs.service* as X-axis and *salary* as Y-axis

Plotting by ggplot()

- We will find here that just specifying the dataset and the axes is not sufficient for generating graph.



```
p <- ggplot(Salaries,aes(yrs.service,salary))
print(p)
```

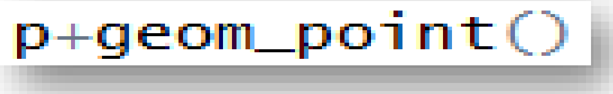


geom_*() functions

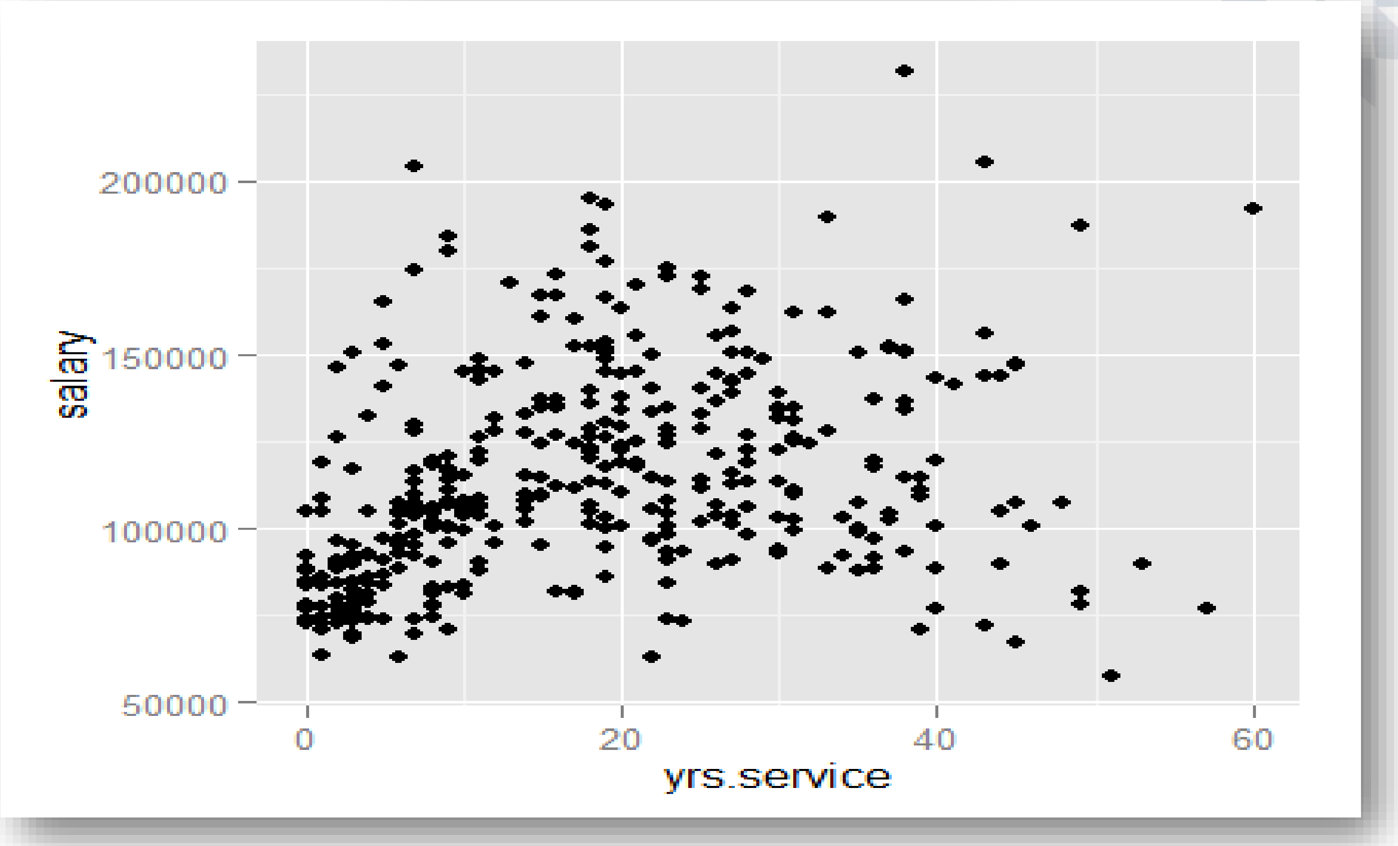
Geom	Graph Type
geom_point()	Scatter Plot
geom_line()	Line Graph
geom_histogram()	Histogram
geom_density()	Density Plot
geom_smooth()	Regression Line
geom_boxplot()	Boxplot
geom_bar()	Bar PLot

Scatter Plot

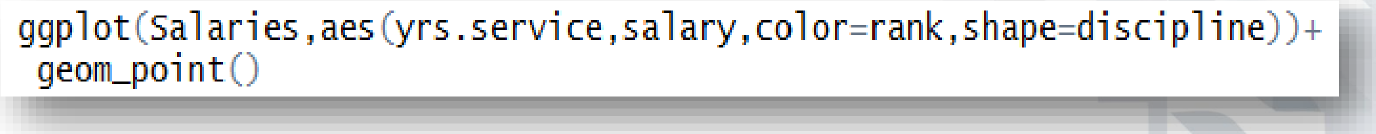
- Scatter plot can be generated with geom_point() function



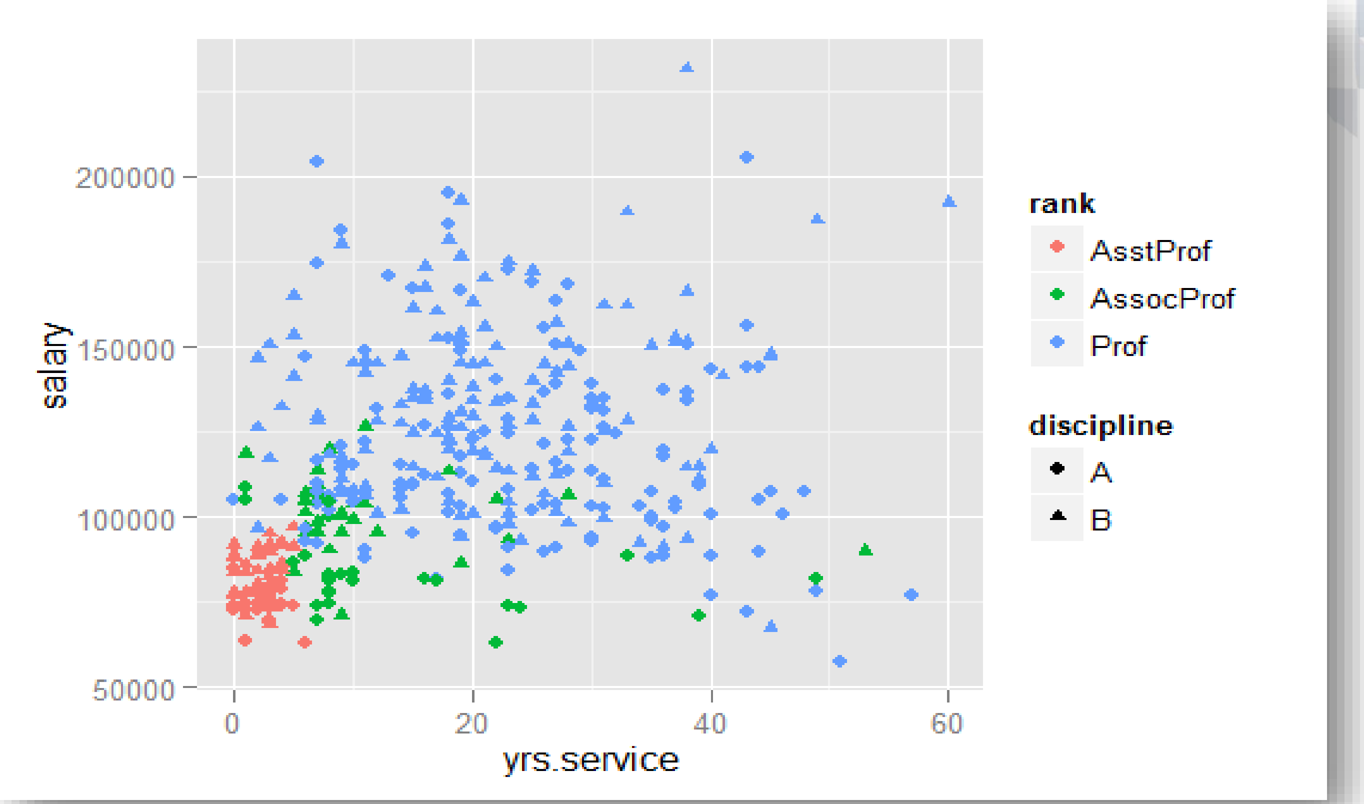
```
p+geom_point()
```



Grouping in Scatter Plot

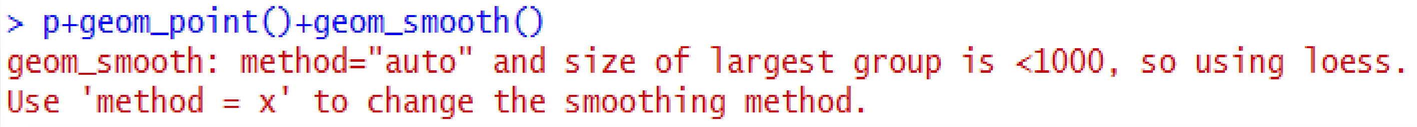


```
ggplot(Salaries,aes(yrs.service,salary,color=rank,shape=discipline))+
 geom_point()
```

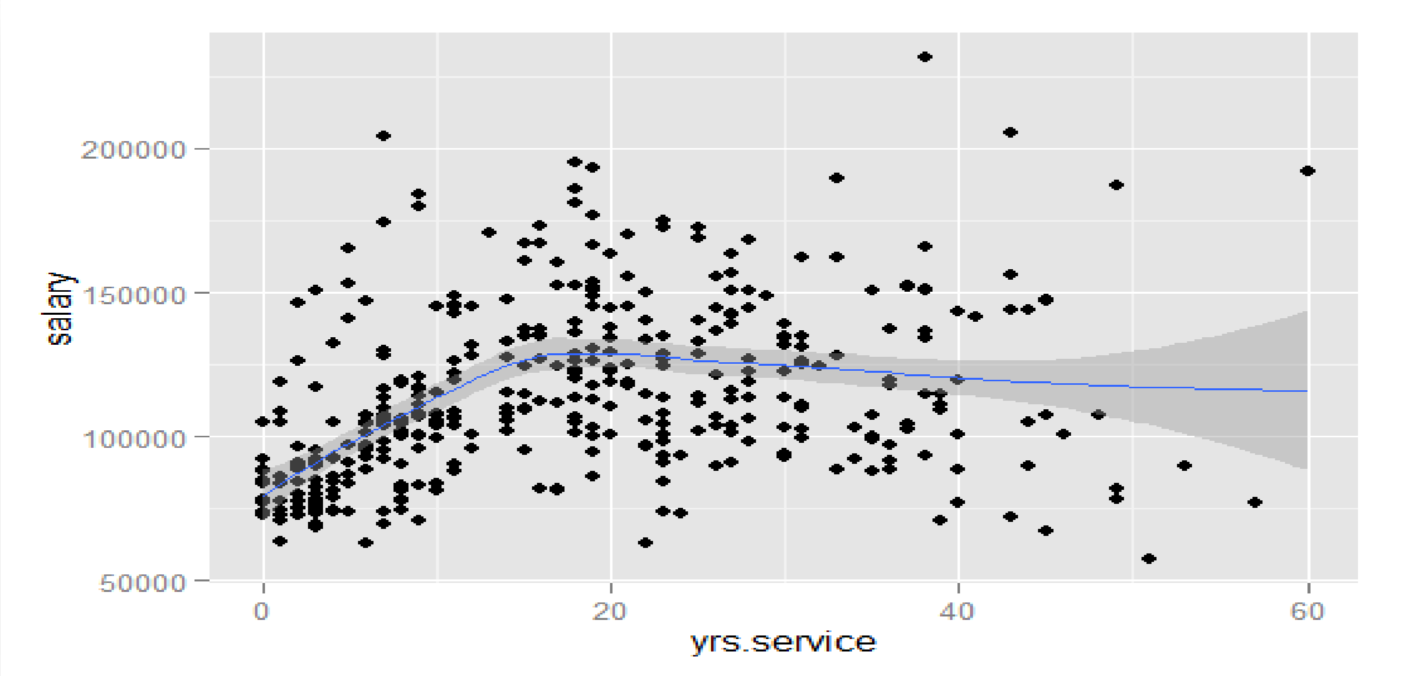


Smoothening

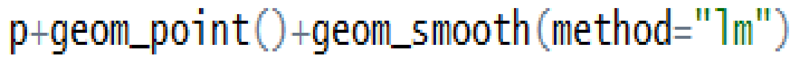
- By default, the smoothening happens with loess method.
- We need to specify lm method if we want linear regression line



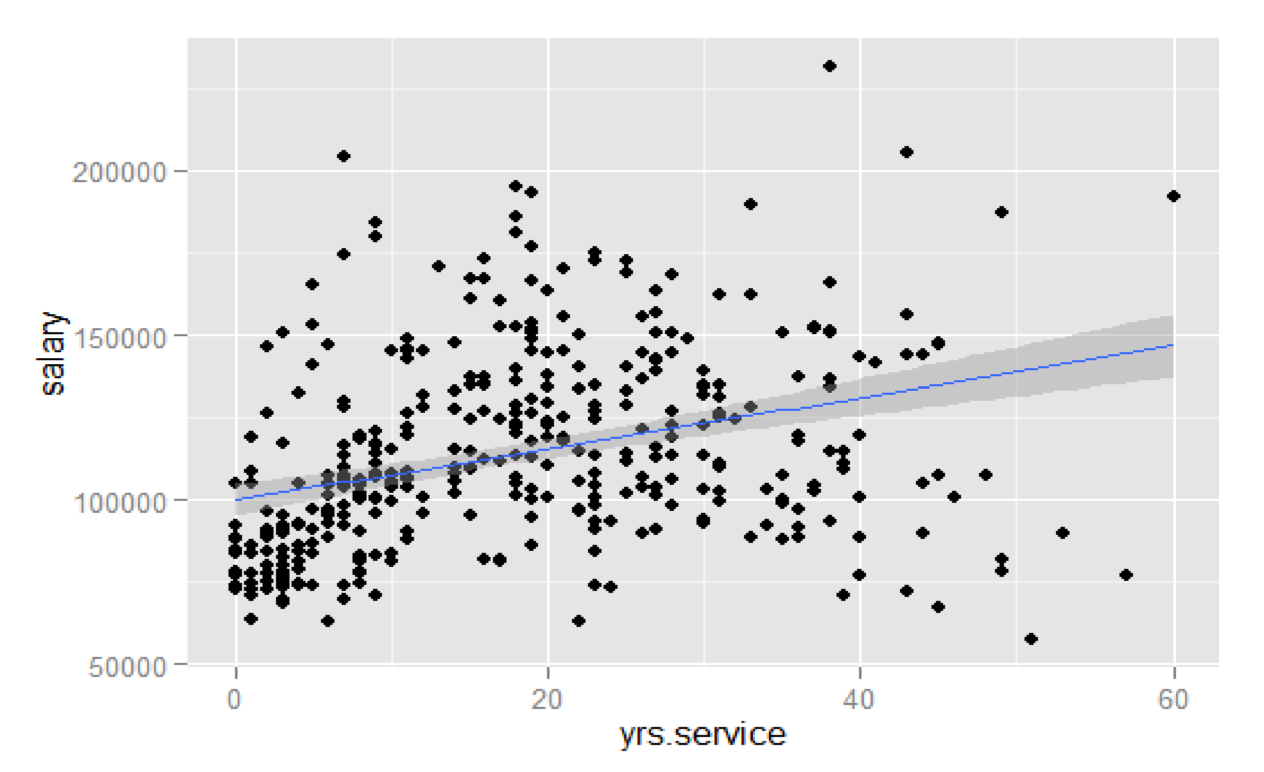
```
> p+geom_point()+geom_smooth()
geom_smooth: method="auto" and size of largest group is <1000, so using loess.
Use 'method = x' to change the smoothing method.
```



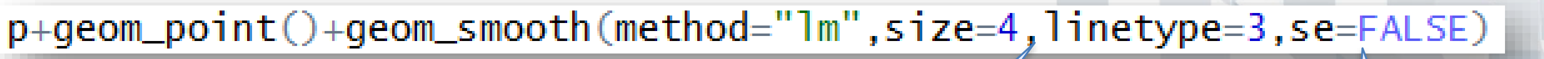
Smoothening



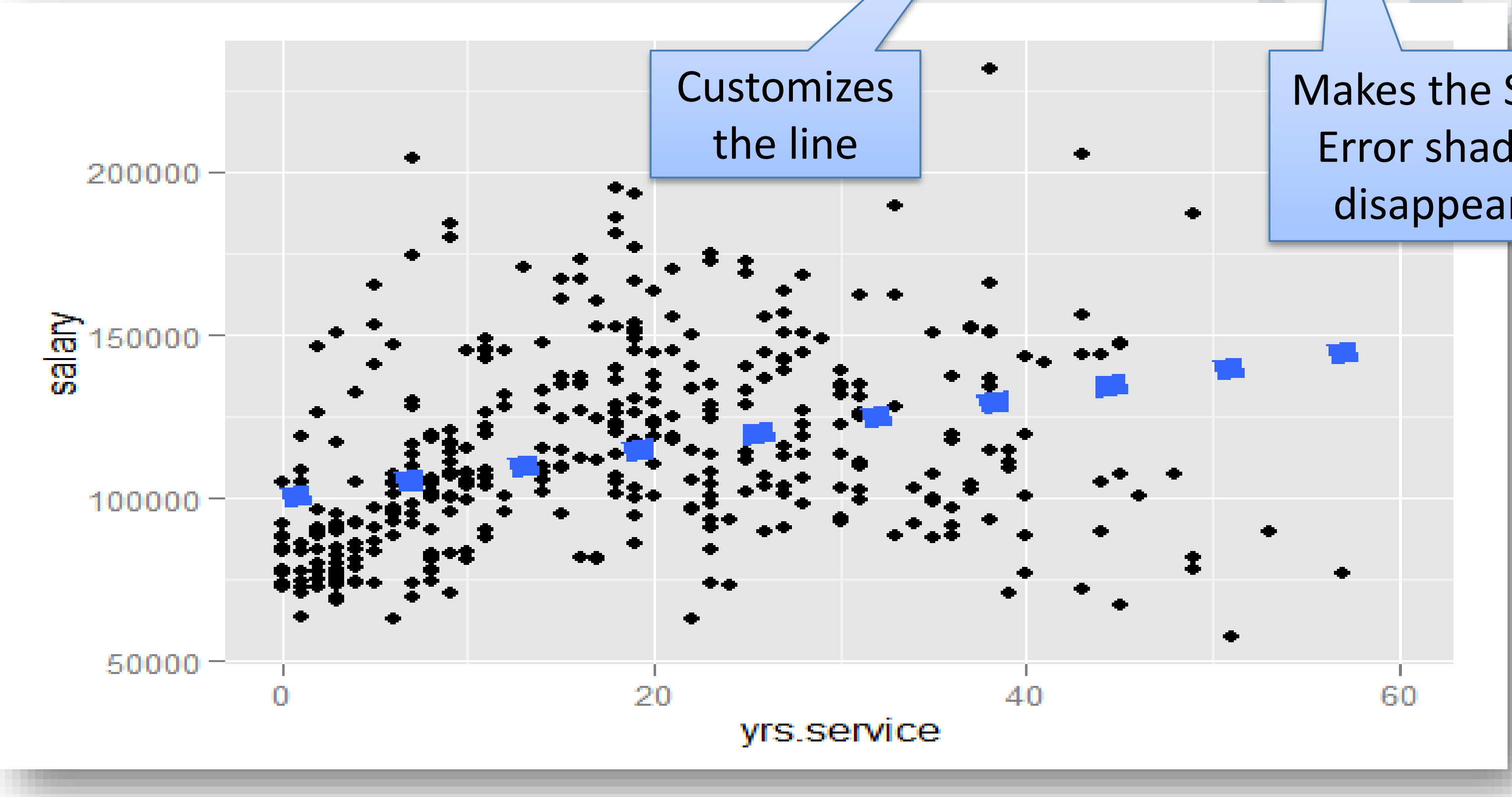
```
p+geom_point()+geom_smooth(method="lm")
```



Customizing the smooth



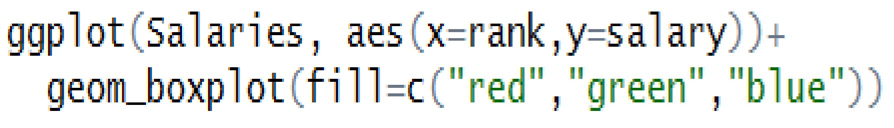
```
p+geom_point()+geom_smooth(method="lm",size=4,linetype=3,se=FALSE)
```



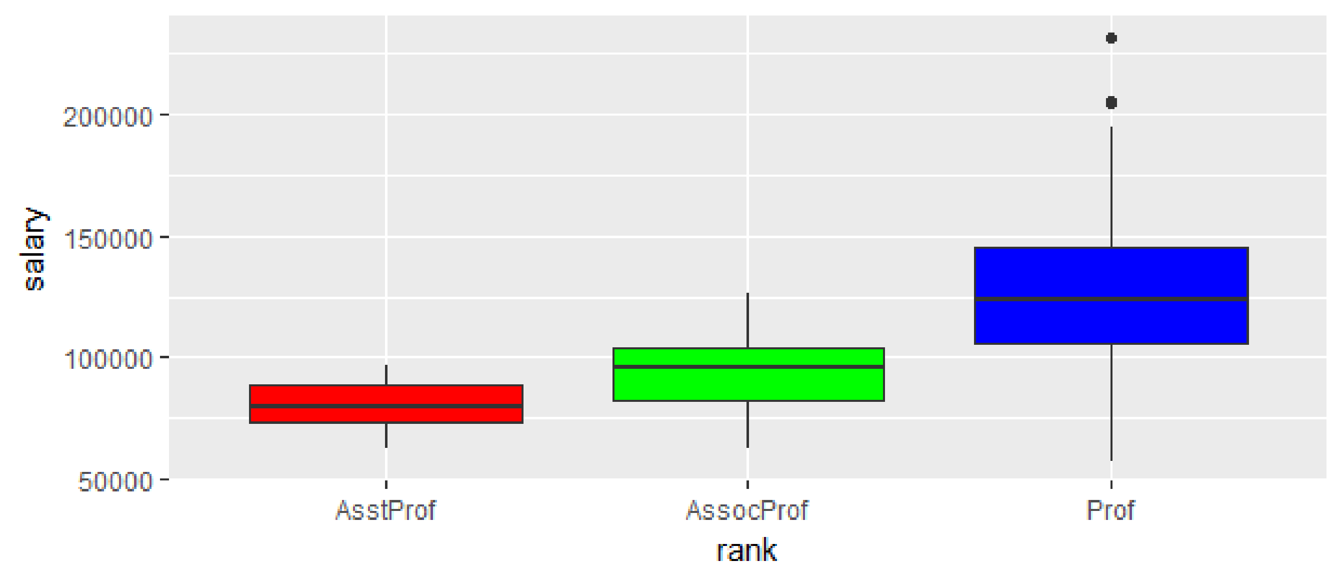
Customizes the line

Makes the Std Error shade disappear

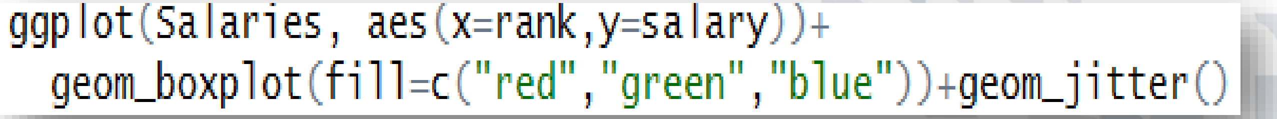
Boxplot



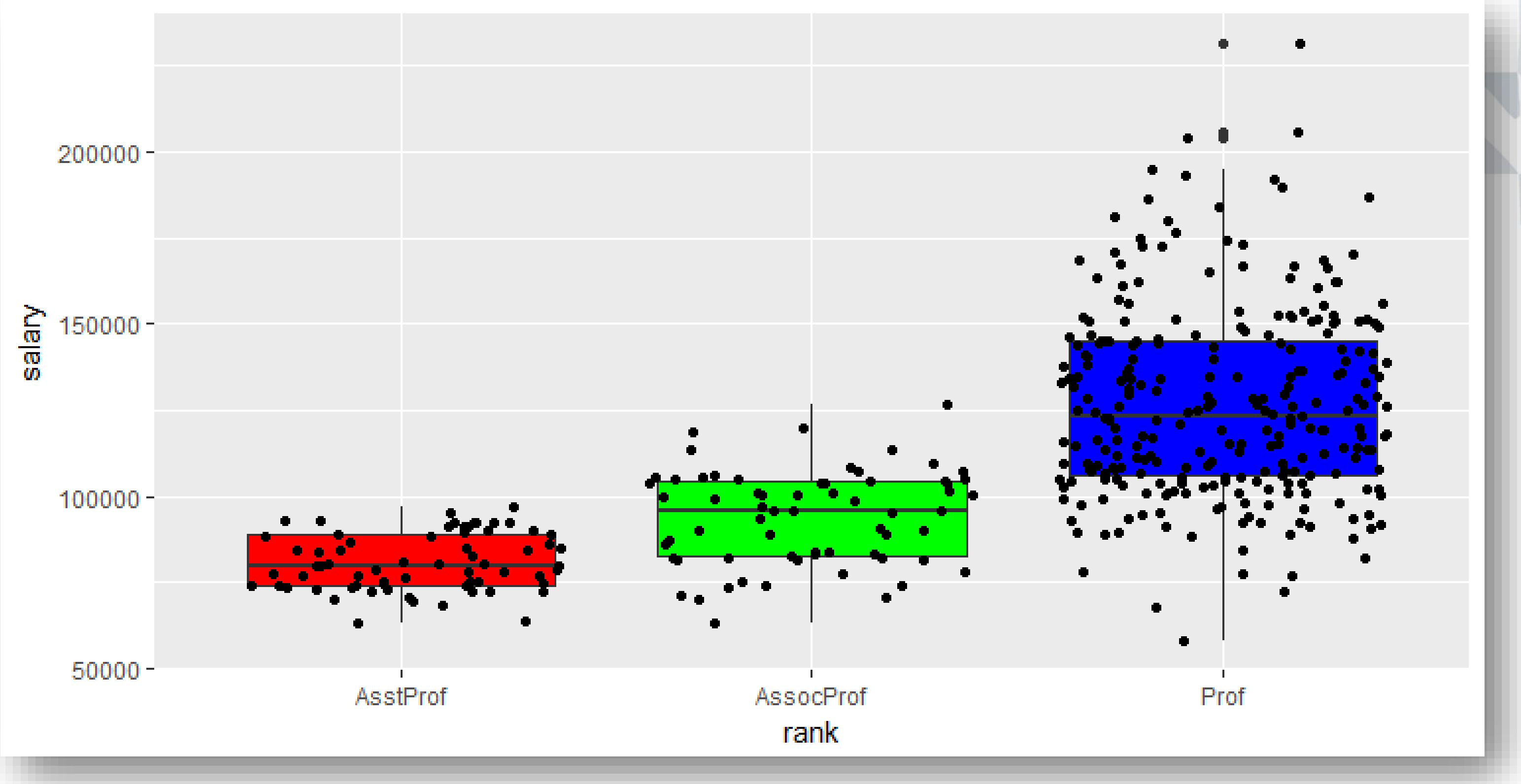
```
ggplot(Salaries, aes(x=rank,y=salary))+
  geom_boxplot(fill=c("red","green","blue"))
```



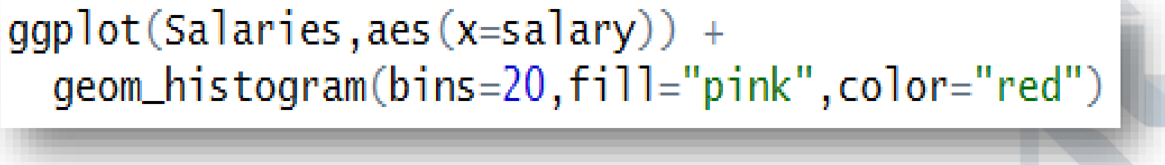
Boxplot with Jitter



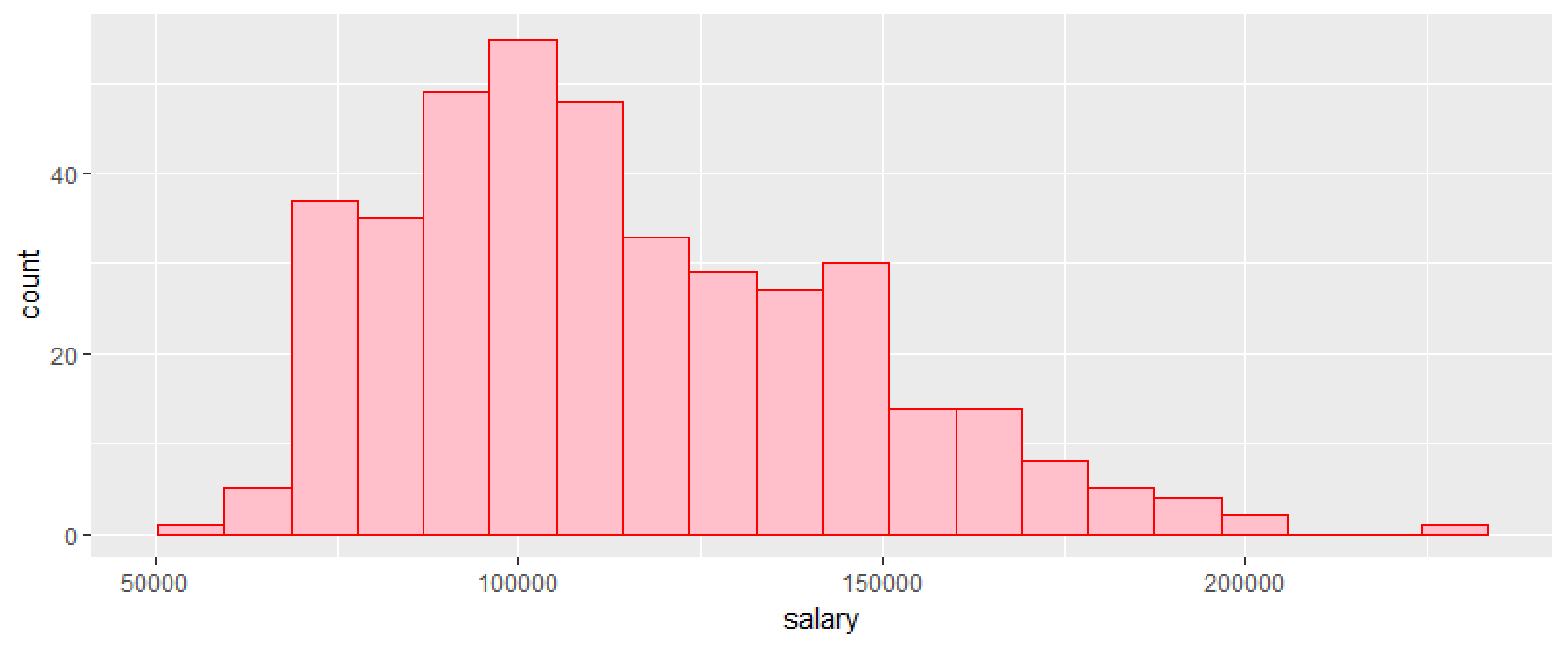
```
ggplot(Salaries, aes(x=rank,y=salary))+
  geom_boxplot(fill=c("red","green","blue"))+geom_jitter()
```



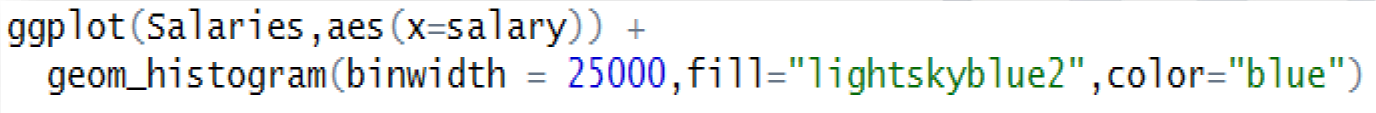
Histogram



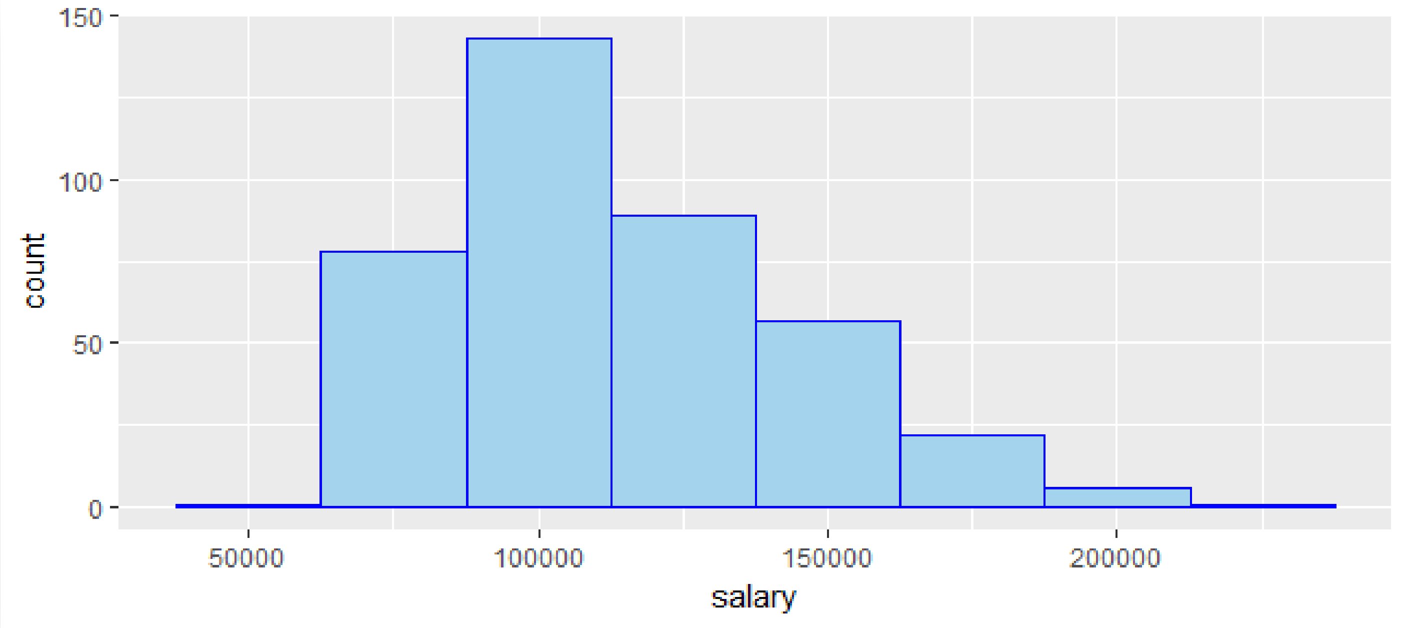
```
ggplot(Salaries,aes(x=salary)) +
  geom_histogram(bins=20,fill="pink",color="red")
```



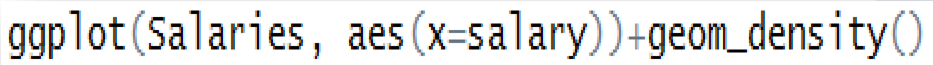
Histogram



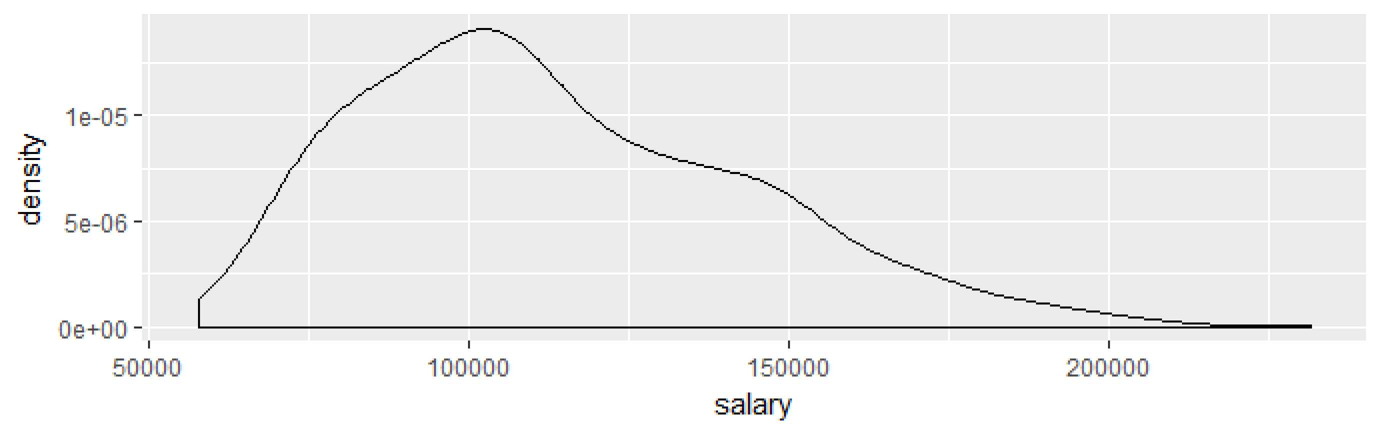
```
ggplot(Salaries,aes(x=salary)) +
  geom_histogram(binwidth = 25000,fill="lightskyblue2",color="blue")
```



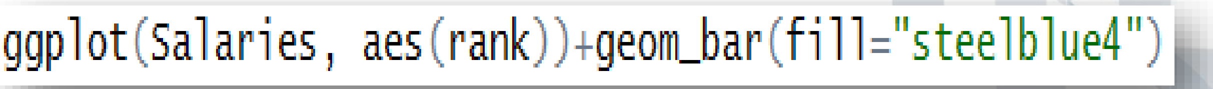
Density Plot



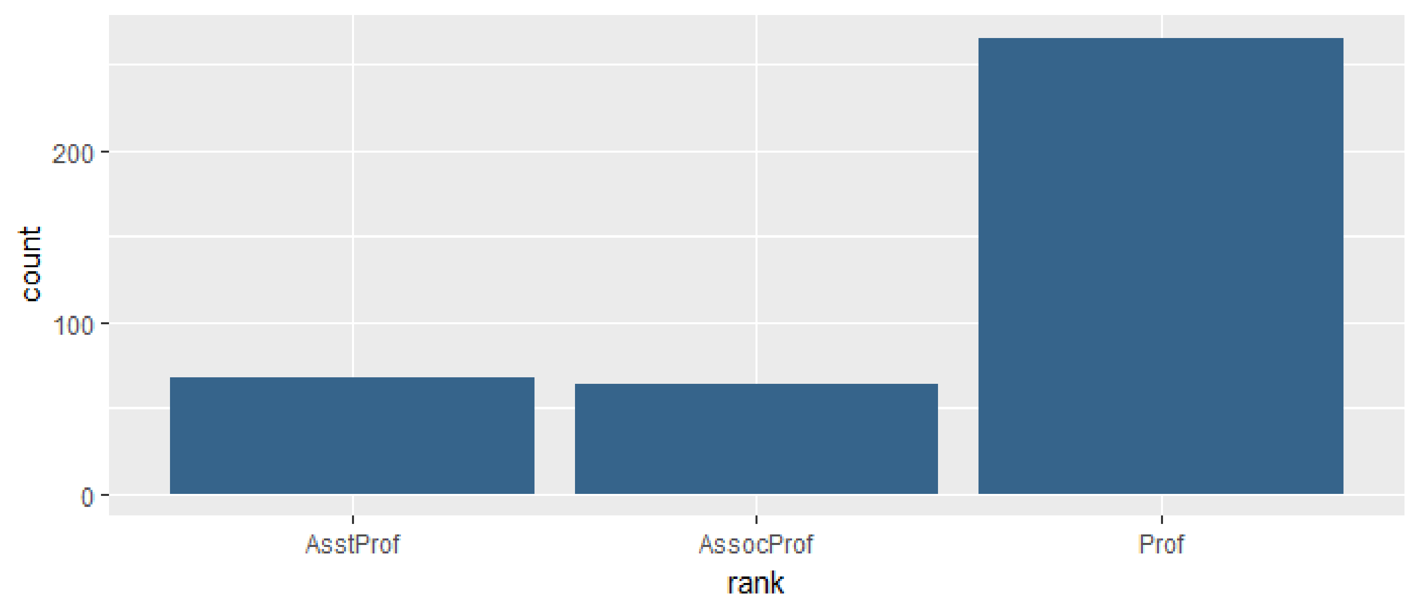
```
ggplot(Salaries, aes(x=salary))+geom_density()
```



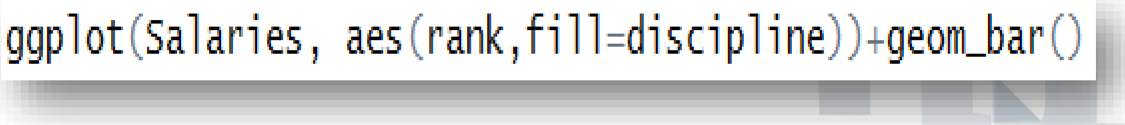
Barplot



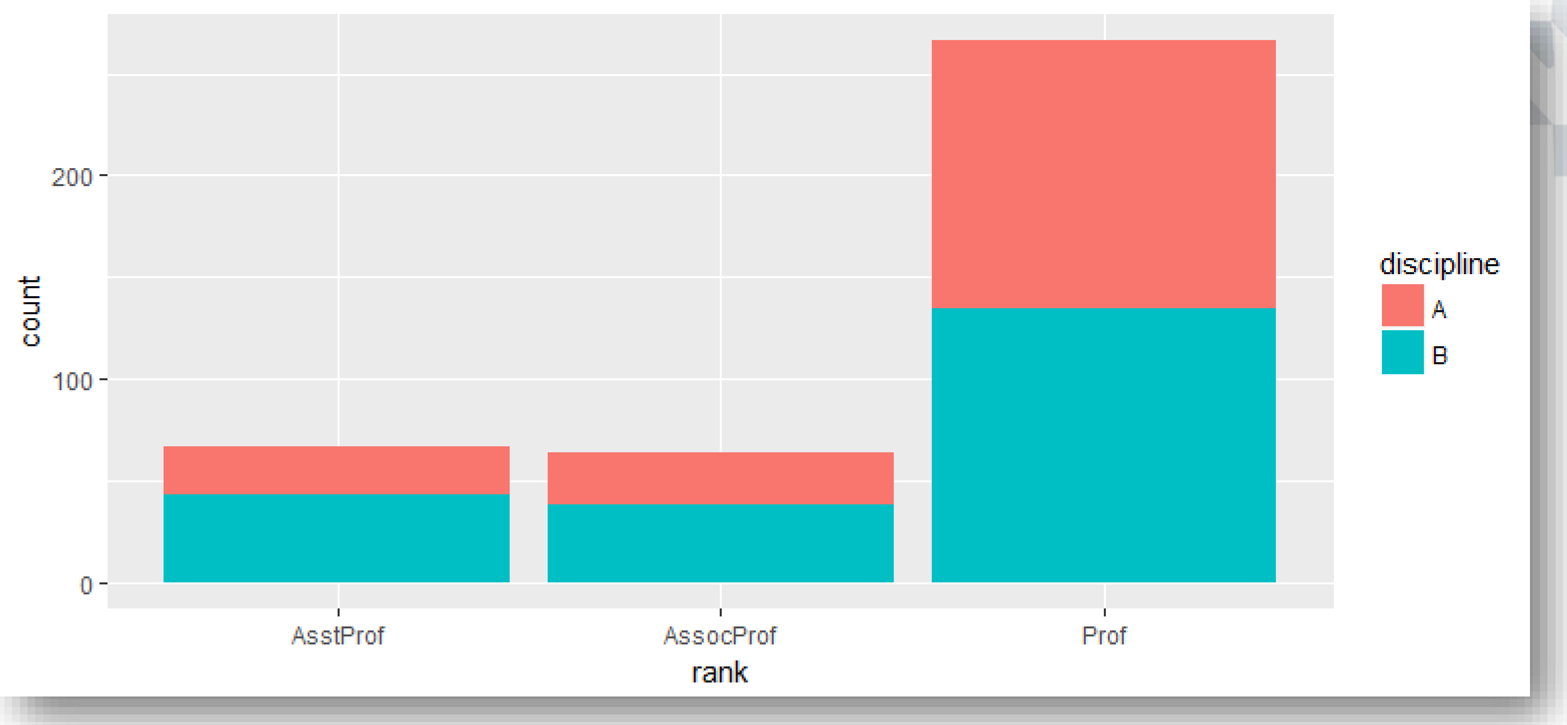
```
ggplot(Salaries, aes(rank))+geom_bar(fill="steelblue4")
```



Barplot



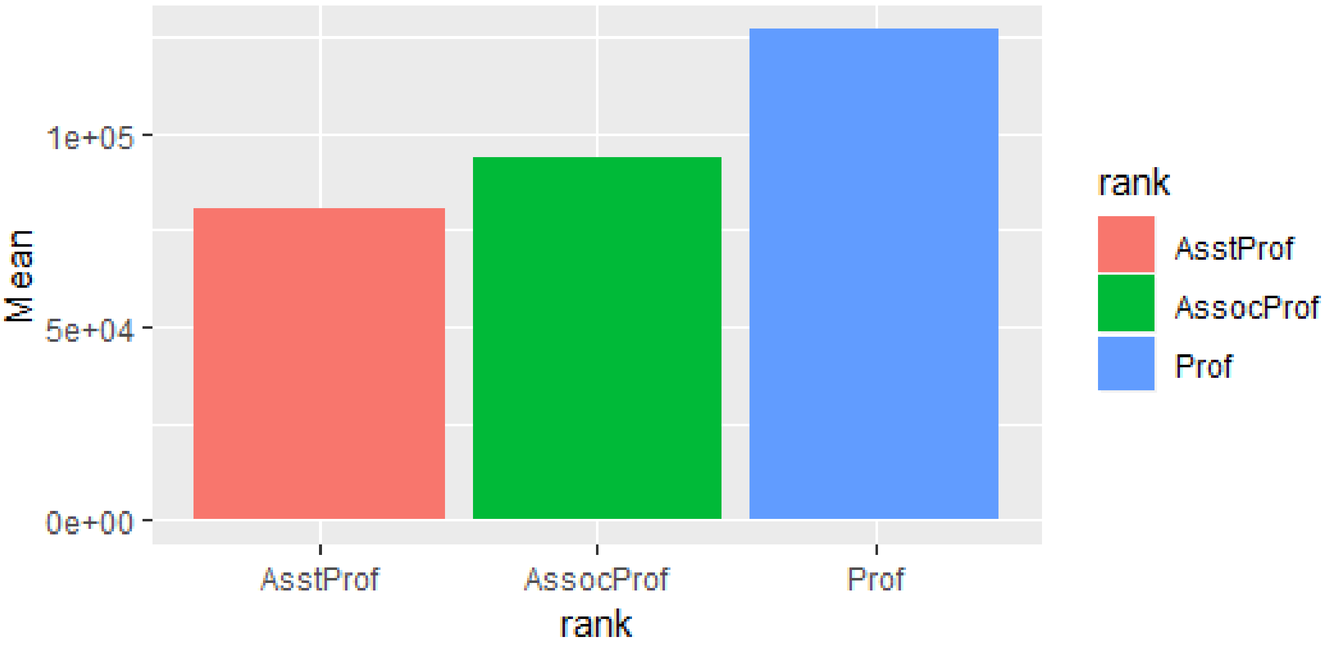
```
ggplot(Salaries, aes(rank,fill=discipline))+geom_bar()
```



Plotting Summarized Values

```
meanSals <- Salaries %>%
              group_by(rank) %>%
              summarise(Mean=mean(salary,na.rm = T))

ggplot(data=meanSals,aes(x=rank,y=Mean,fill=rank))+
  geom_bar(stat = "identity")
```

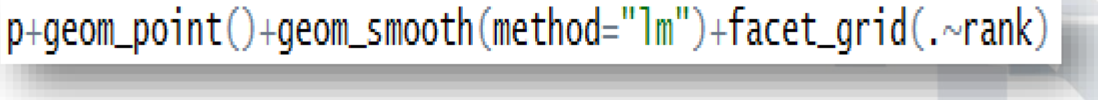


Facets

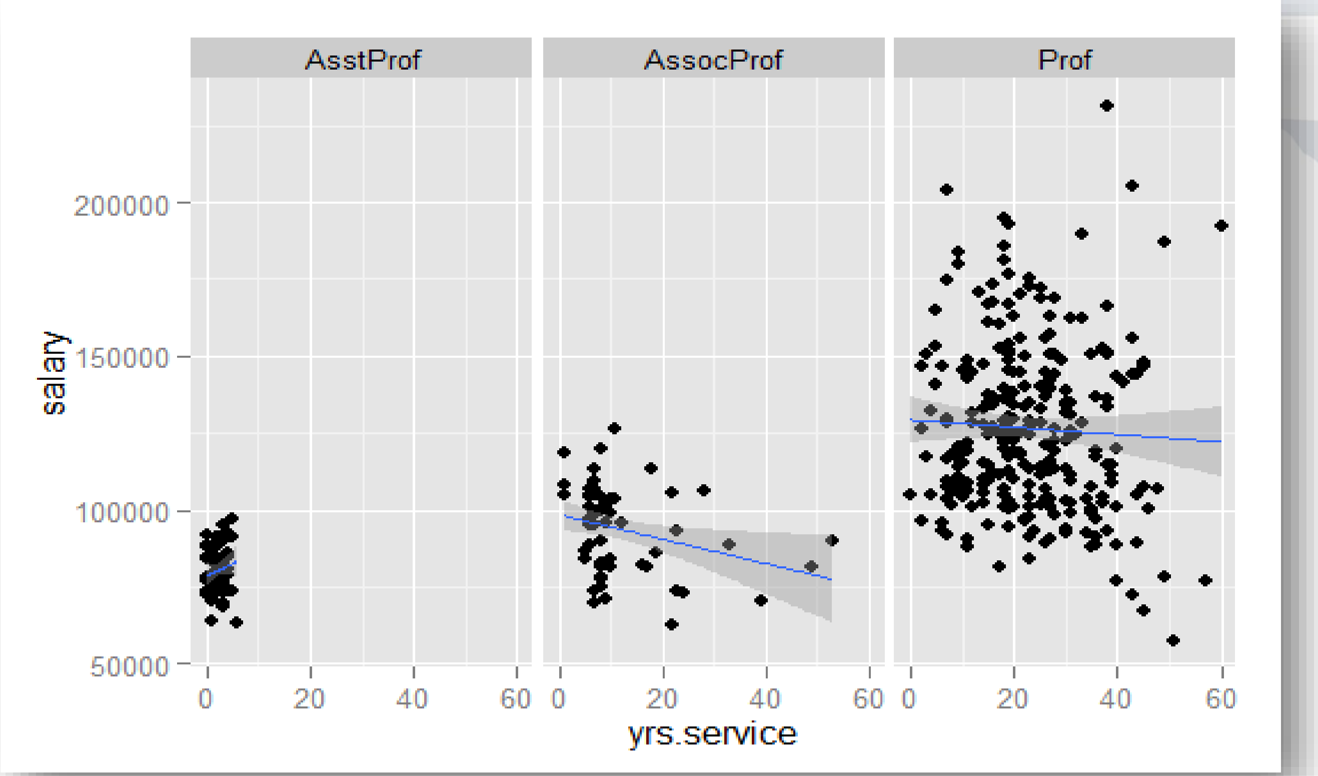
- Sometimes, the relationship become clearer if the graphs are shown side by side
- These are also called trellis graphs
- Faceted graphs can be created using facet_grid() and facet_wrap() functions

Syntax	Effect
facet_wrap(~ var, ncol=n)	Separate plots of each category in var into n columns
facet_wrap(~ var, nrow=n)	Separate plots of each category in var into n rows
facet_grid(rowvar ~ colvar)	Separate plots for each combination of rowvar and colvar in grid form
facet_grid(rowvar ~ .)	Separate plots of each category in rowvar into a single column
facet_grid(. ~ colvar)	Separate plots of each category in colvar into a single row

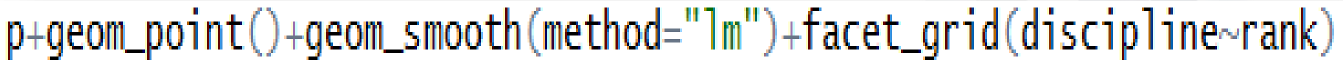
Facet Examples



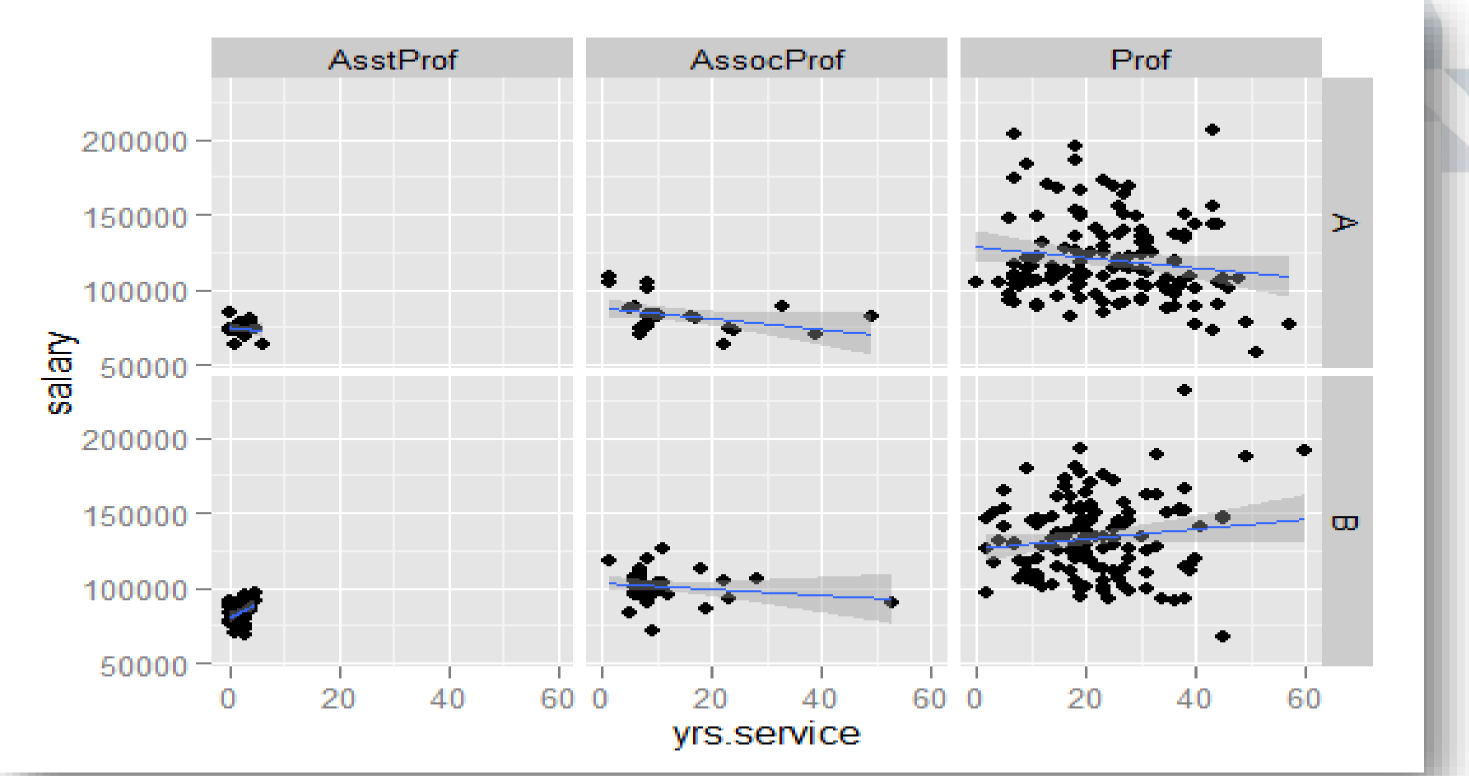
```
p+geom_point()+geom_smooth(method="lm")+facet_grid(.~rank)
```



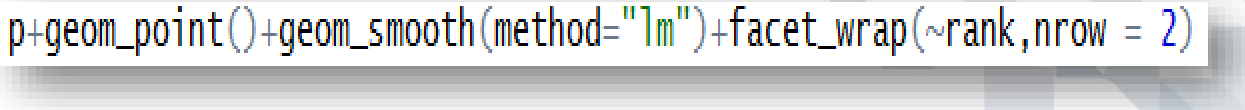
Facet Examples



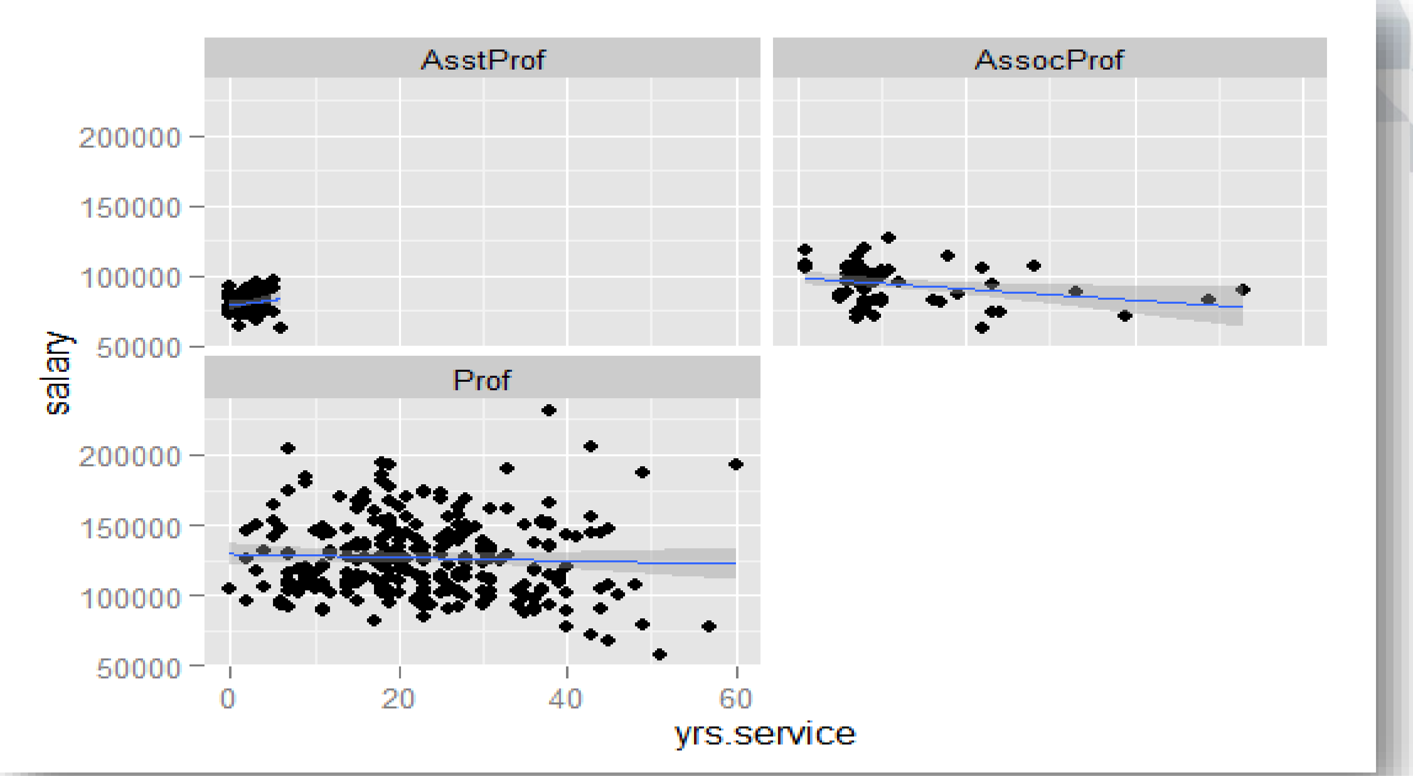
```
p+geom_point()+geom_smooth(method="lm")+facet_grid(discipline~rank)
```



Facet Examples



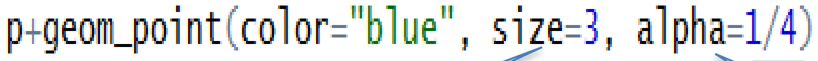
```
p+geom_point()+geom_smooth(method="lm")+facet_wrap(~rank,nrow = 2)
```



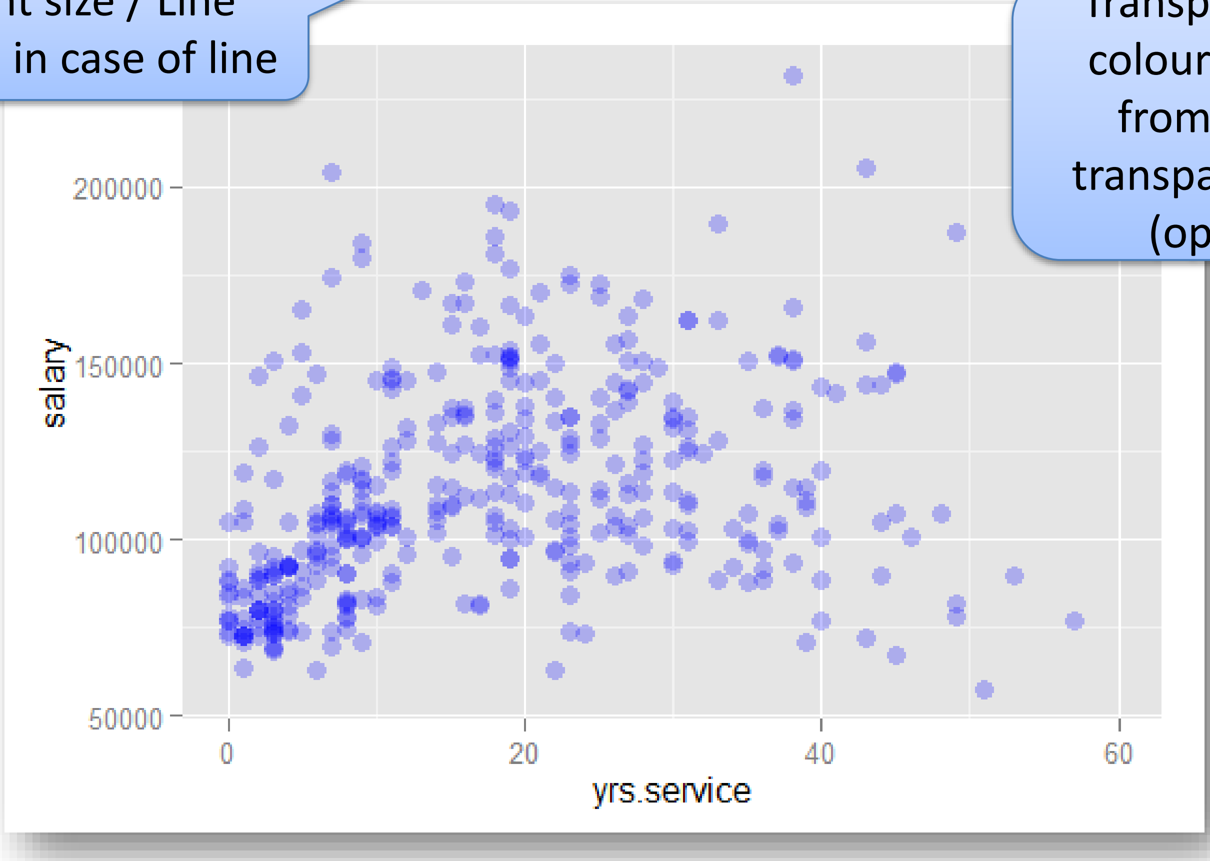
Annotating Graph

- Labels can be given by functions xlab(), ylab(), labs(), ggtitle()
- For overall effects, use theme()
- By default, we have theme_gray()
- We can set background colourless by theme_bw()

Examples



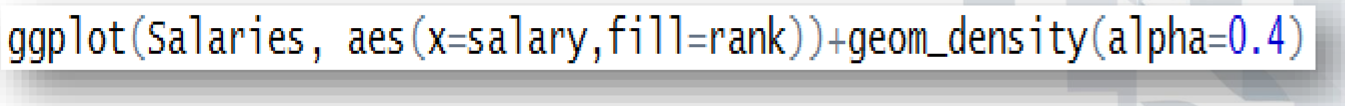
```
p+geom_point(color="blue", size=3, alpha=1/4)
```



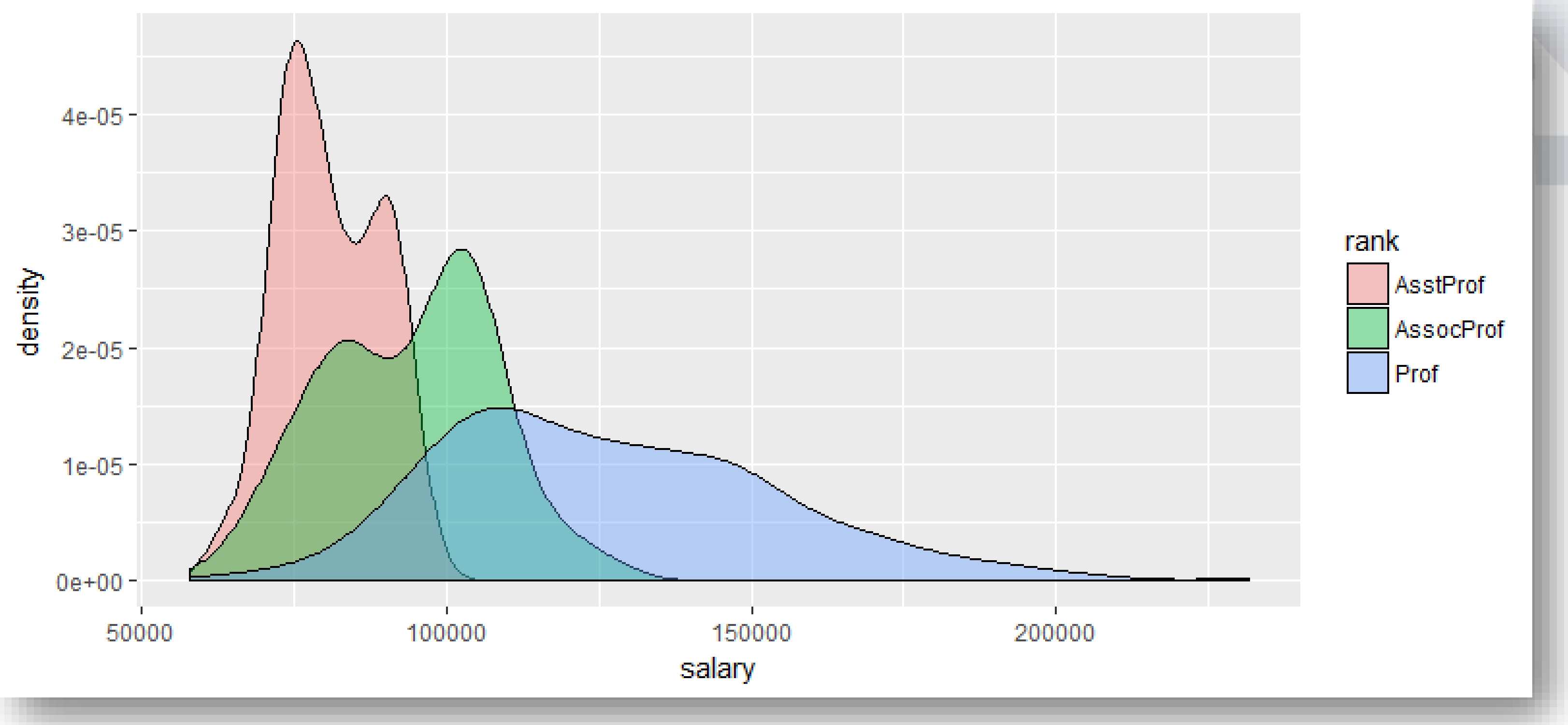
Point size / Line width in case of line

Transparency of colours ranging from 0 (fully transparent) to 1 (opaque)

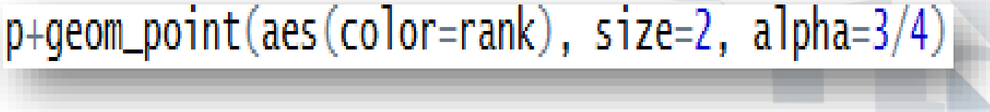
Boxplot



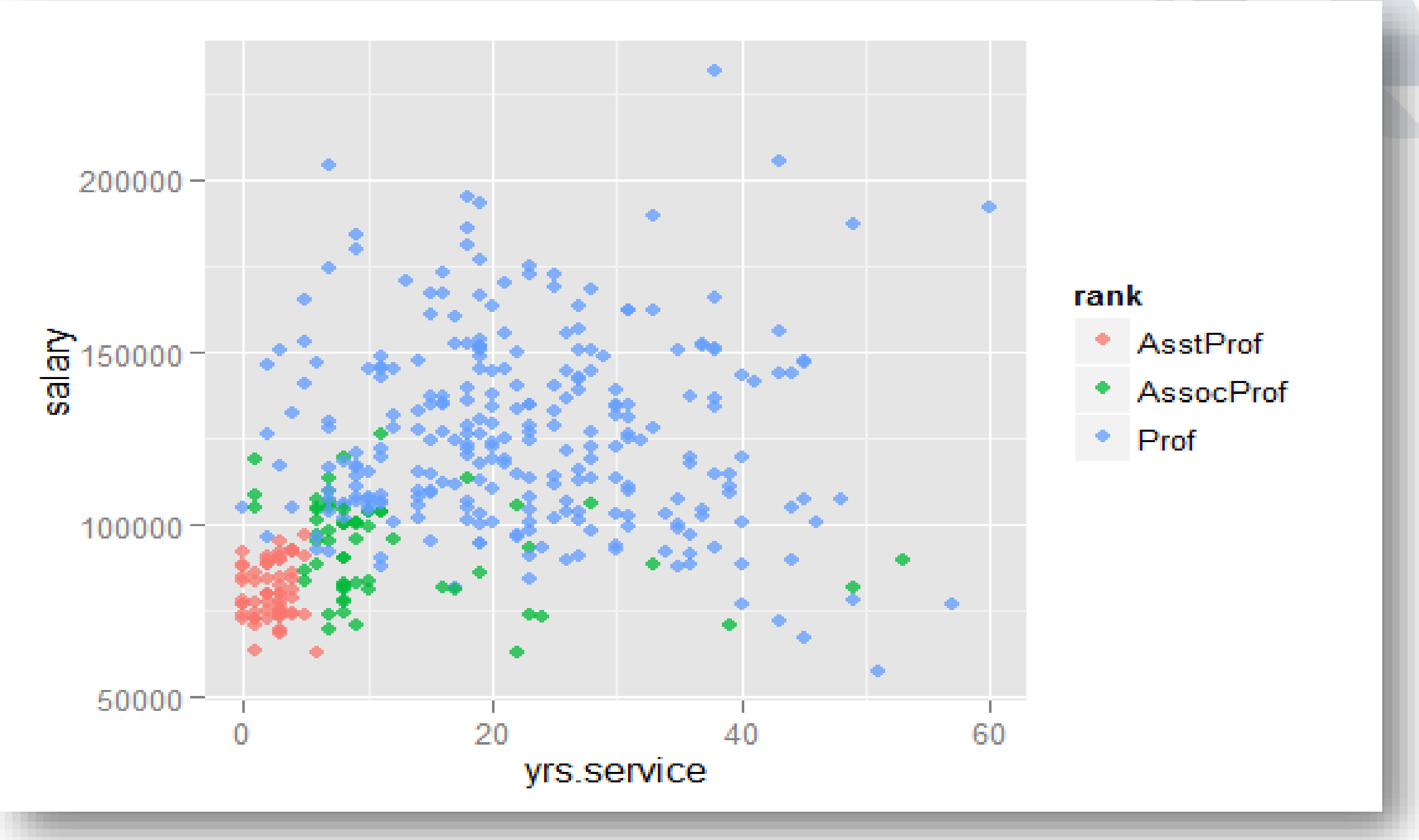
```
ggplot(Salaries, aes(x=salary,fill=rank))+geom_density(alpha=0.4)
```



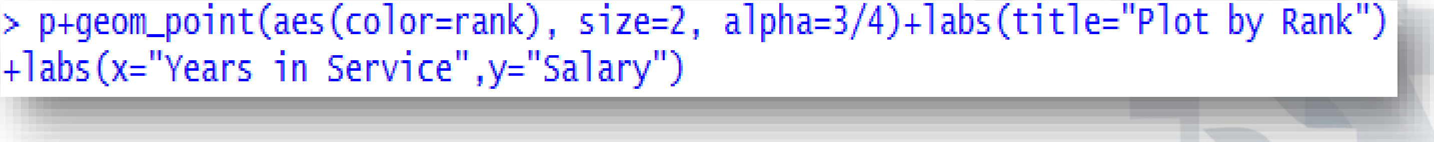
Examples



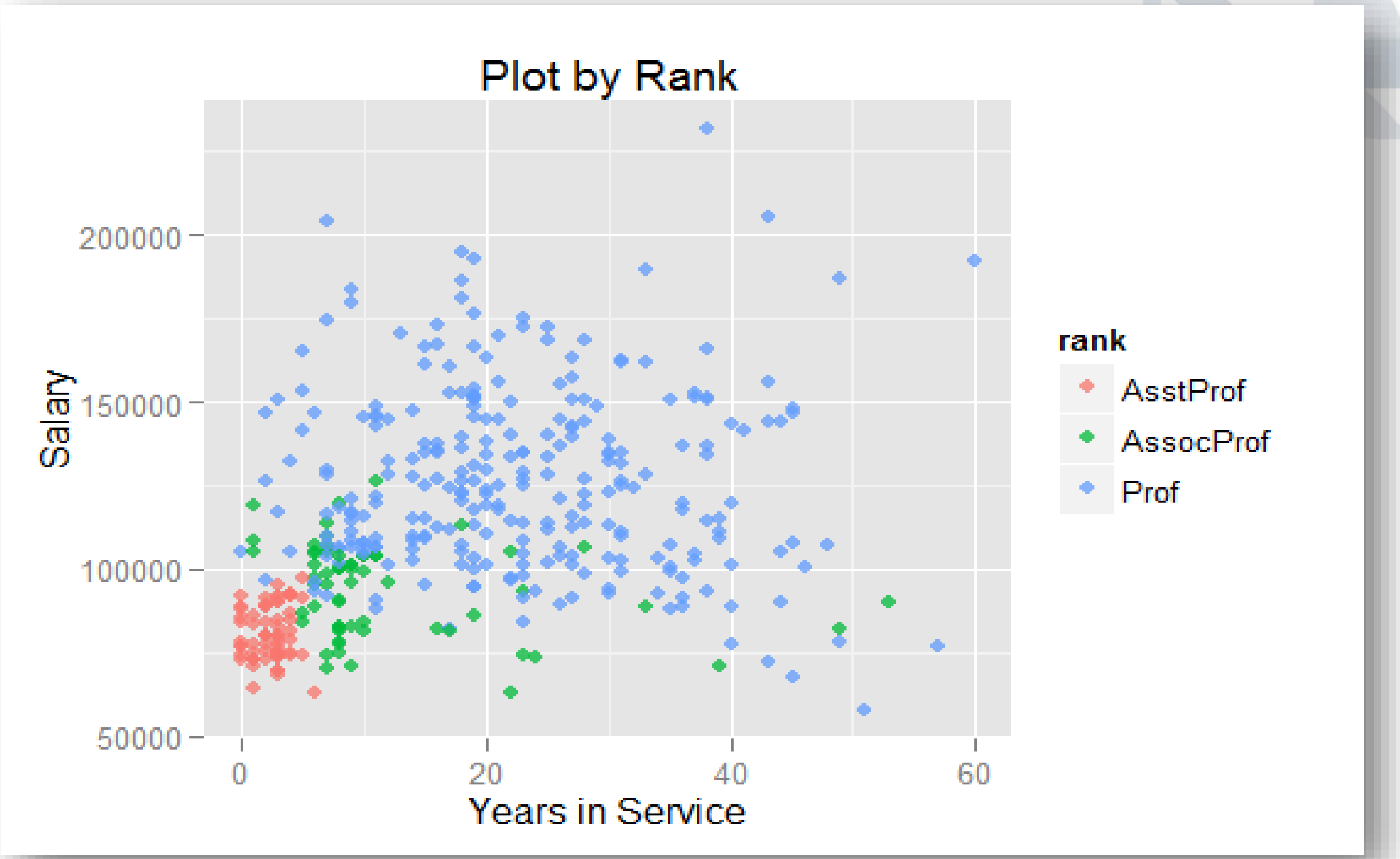
```
p+geom_point(aes(color=rank), size=2, alpha=3/4)
```



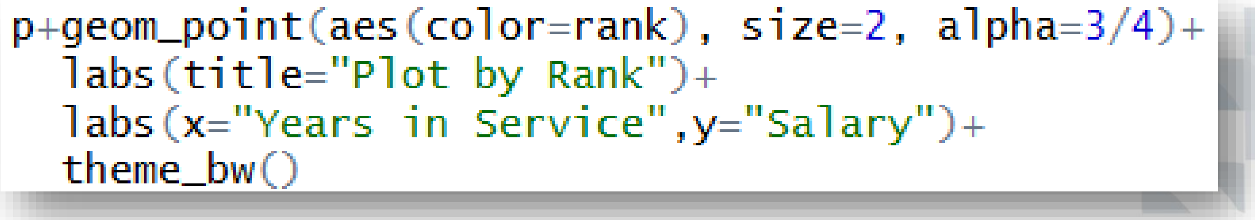
Rendering labels



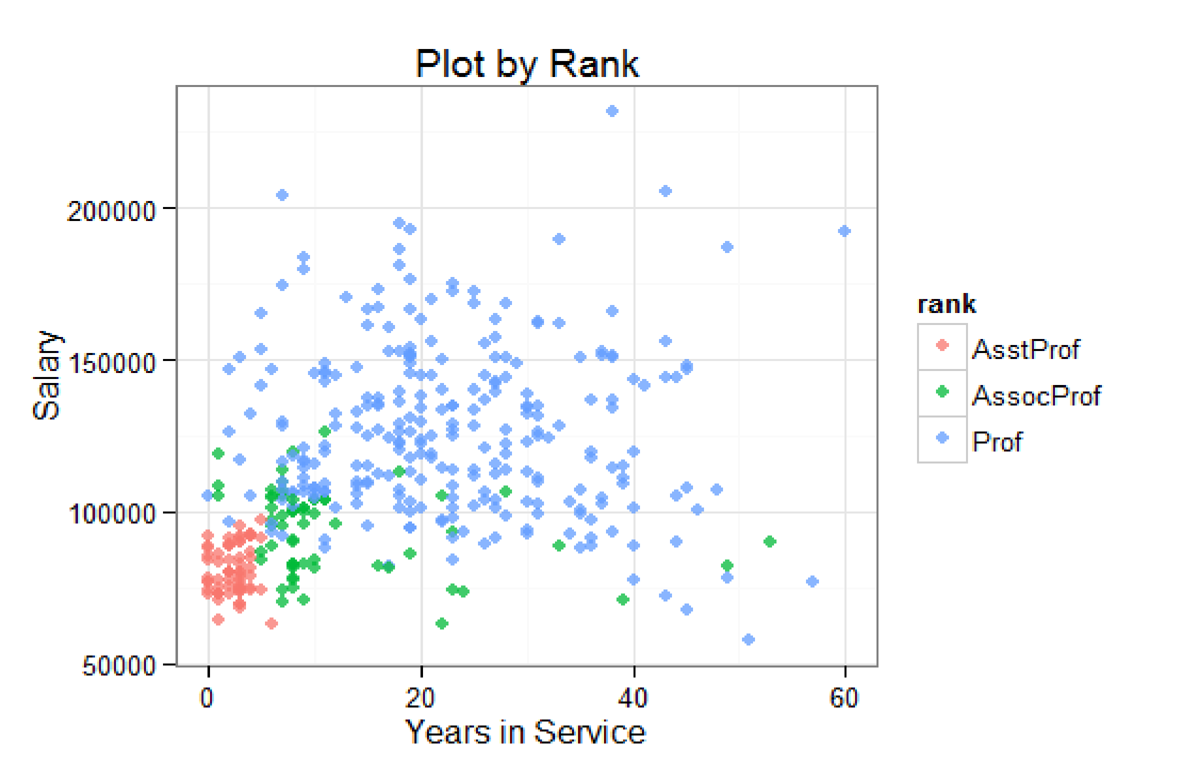
```
> p+geom_point(aes(color=rank), size=2, alpha=3/4)+labs(title="Plot by Rank")
+labs(x="Years in Service",y="Salary")
```



Changing the Theme



```
p+geom_point(aes(color=rank), size=2, alpha=3/4)+
  labs(title="Plot by Rank")+
  labs(x="Years in Service",y="Salary")+
  theme_bw()
```


Plot by Rank
Salary
Years in Service
rank
AsstProf
AssocProf
Prof