Graunt's and Halley's Life Table with ggplot

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Source of Data

Data Input

- **Graunt**'s Life Table

```
rm(list = ls())
graunt <- data.frame(x = c(0, seq(6, 76, by = 10)), lx.17th = c(100, 64, 40, 25, 16, 10, 6, 3, 1))
```

More data

- US 1993 life table for the same age group

```
us.93 <- data.frame(x = graunt$x, lx.93 = c(100, 99, 99, 98, 97, 95, 92, 84, 70))
```

Data Extraction

There are many ways to extract part of `us.93` data frame.

```
us.93["lx.93"]
```

```
##   lx.93
## 1   100
## 2    99
## 3    99
## 4    98
## 5    97
## 6    95
## 7    92
## 8    84
## 9    70
```

```
us.93["lx.93"][[1]]
```

```
## [1] 100  99  99  98  97  95  92  84  70
```

```
us.93["lx.93"]$lx.93
```

```
## [1] 100  99  99  98  97  95  92  84  70
```

```
us.93["lx.93"]$lx
```

```
## [1] 100  99  99  98  97  95  92  84  70
```

```r
us.93[2]
```

```
##   lx.93
## 1   100
## 2    99
## 3    99
## 4    98
## 5    97
## 6    95
## 7    92
## 8    84
## 9    70
```

```r
us.93[2][[1]]
```

```
## [1] 100  99  99  98  97  95  92  84  70
```

```r
us.93[2]$lx.93
```

```
## [1] 100  99  99  98  97  95  92  84  70
```

```r
us.93[, "lx.93"]
```

```
## [1] 100  99  99  98  97  95  92  84  70
```

```r
us.93[, 2]
```

```
## [1] 100  99  99  98  97  95  92  84  70
```

```r
us.93$lx.93
```

```
## [1] 100  99  99  98  97  95  92  84  70
```

```r
us.93$lx
```

```
## [1] 100  99  99  98  97  95  92  84  70
```

Into one single data frame

Combine two data frames into one single data frame

```r
(graunt.us <- data.frame(graunt, lx.93 = us.93$lx))
```

```
##    x lx.17th lx.93
## 1  0     100   100
## 2  6      64    99
## 3 16      40    99
## 4 26      25    98
## 5 36      16    97
## 6 46      10    95
## 7 56       6    92
## 8 66       3    84
## 9 76       1    70
```

Life Expectancy

The basic principle is that the area under the survival function is the life expectancy.

$X \geq 0$, $X \sim F(x) => X \equiv F^{-1}(U), U \sim U(0,1)$, therefore,

$E(X) = E\{F^{-1}(U)\} = \int_0^1 F^{-1}(u)du = \int_0^\infty 1 - F(x)dx = \int_0^\infty S(x)dx$

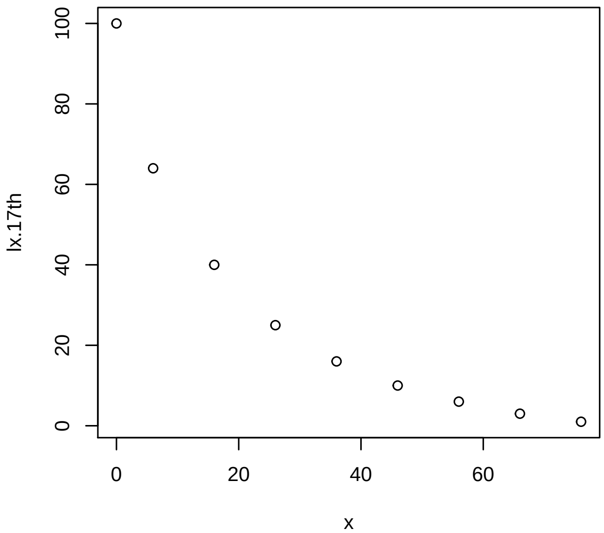
Step by step approach to draw survival curve

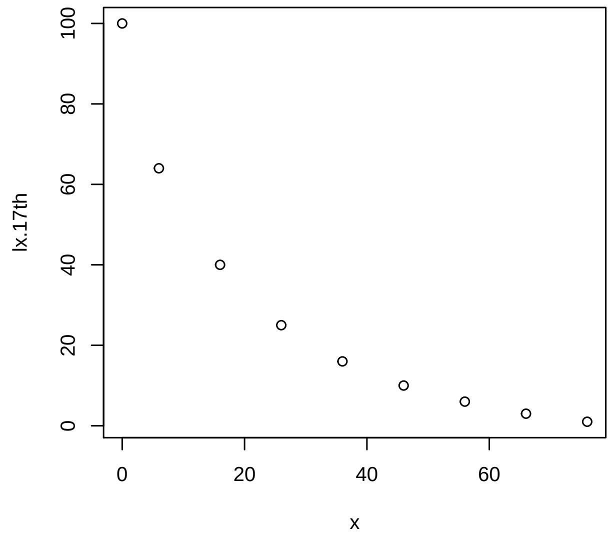
1. Basic plot with points and lines, compare the following threes methods

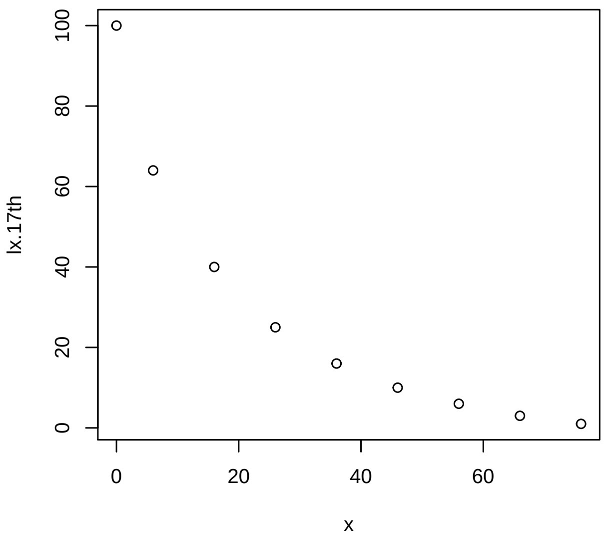
```r
library(extrafont)
```

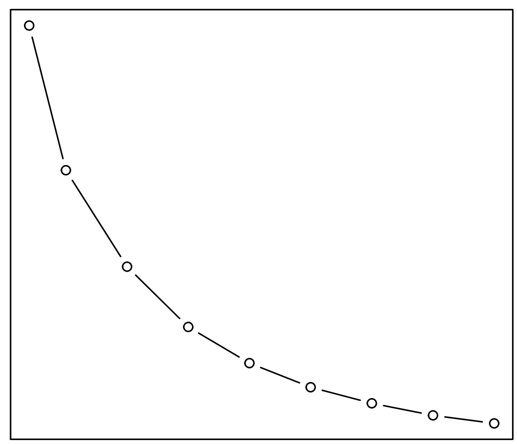
```
## Registering fonts with R
```

```r
par(family = "Helvetica")
par(mfrow = c(2, 2))
plot(graunt)
plot(lx.17th ~ x, data = graunt)
plot(graunt)
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
```



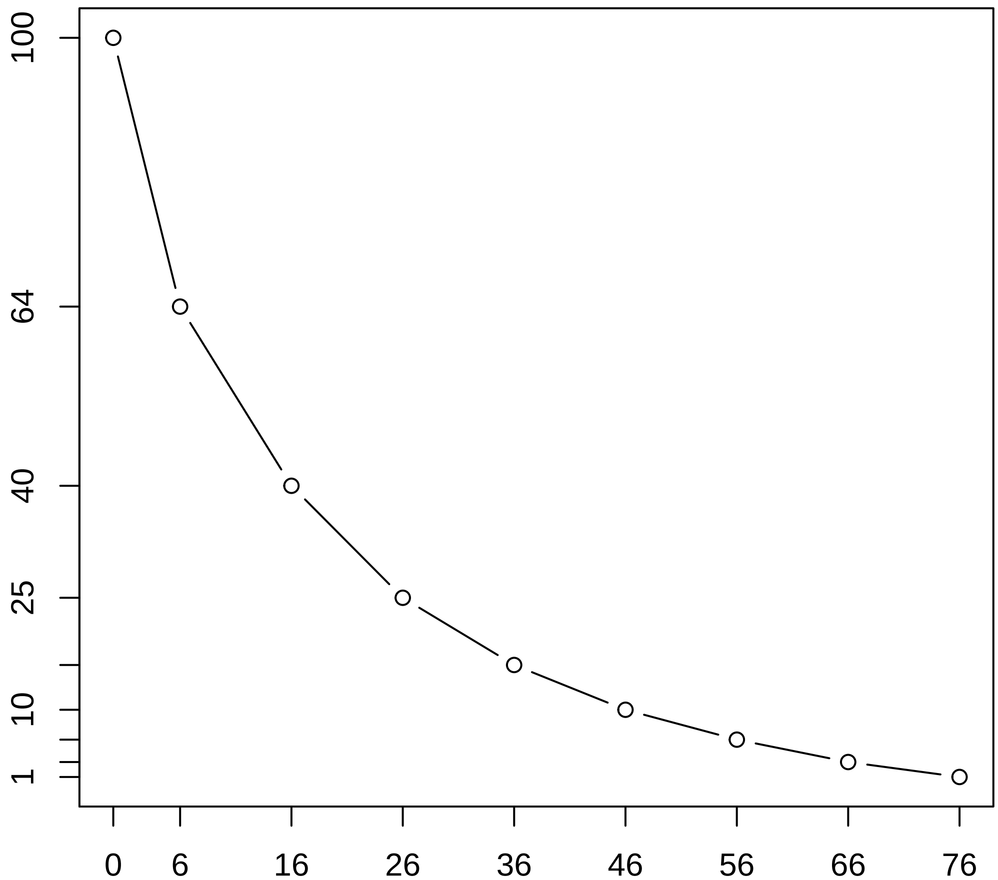






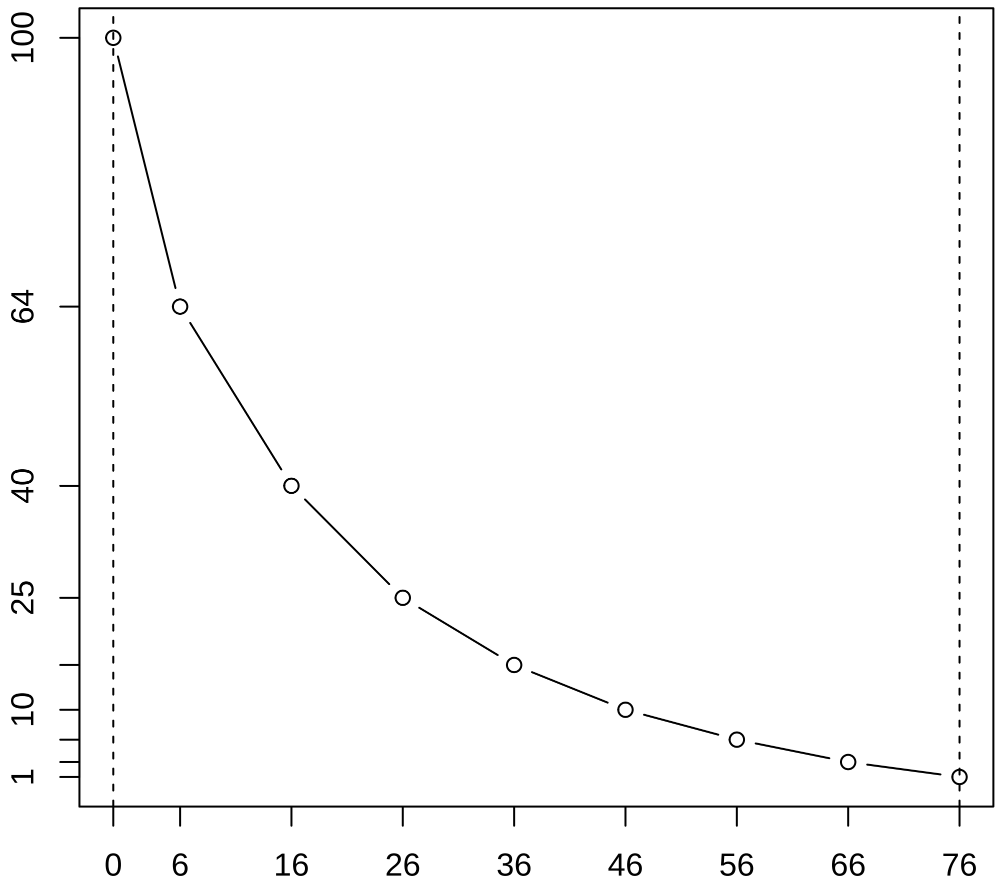
2. Denote the ages and observed survival rates on the axes

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th)
```



3. Denote the age 0 and 76 by dotted lines

```
par(family = "Helvetica")
plot(graunt, ann=F, xaxt="n", yaxt="n", type = "b")
axis(side = 1, at=graunt$x, labels=graunt$x)
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
```



Setting up coordinates for `polygon()` (Clockwise)

```
par(family = "Helvetica")
(graunt.x <- c(graunt$x, 0))
```

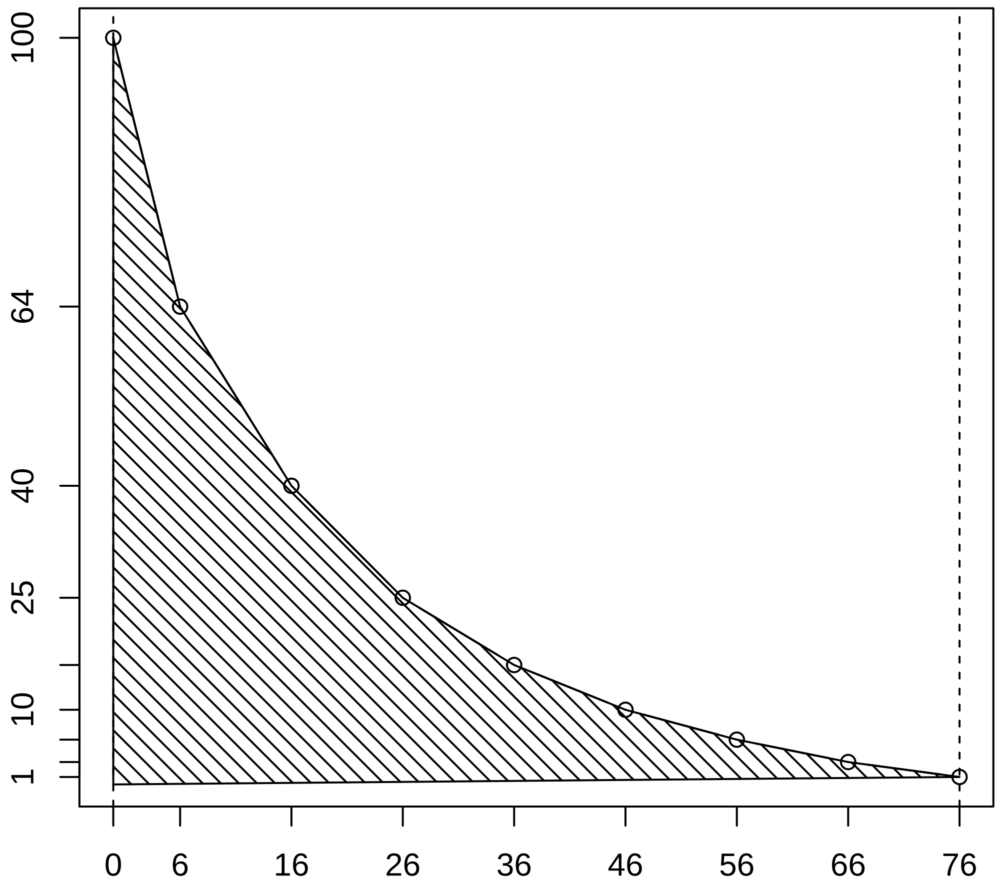
```
## [1]  0  6 16 26 36 46 56 66 76  0
```

```
(graunt.y <- c(graunt$lx.17th, 0))
```

```
## [1] 100  64  40  25  16  10   6   3   1   0
```

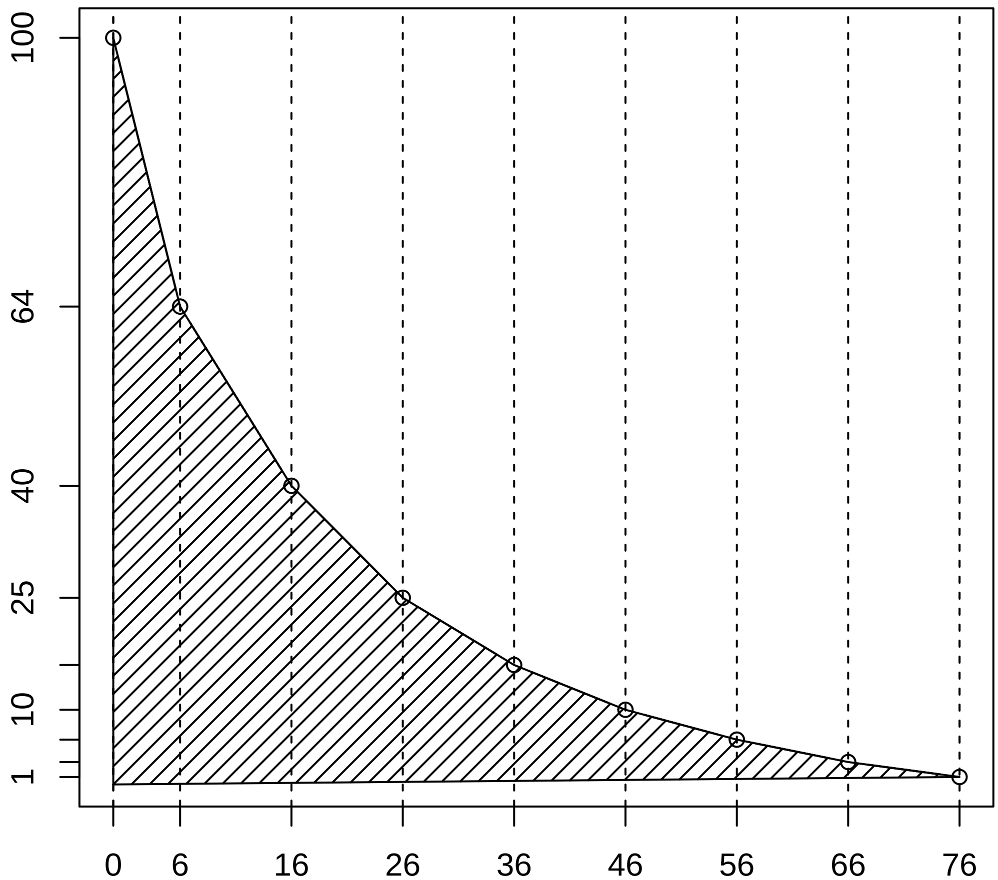
4. Shading

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
polygon(graunt.x, graunt.y, density = 15, angle = 135)
```



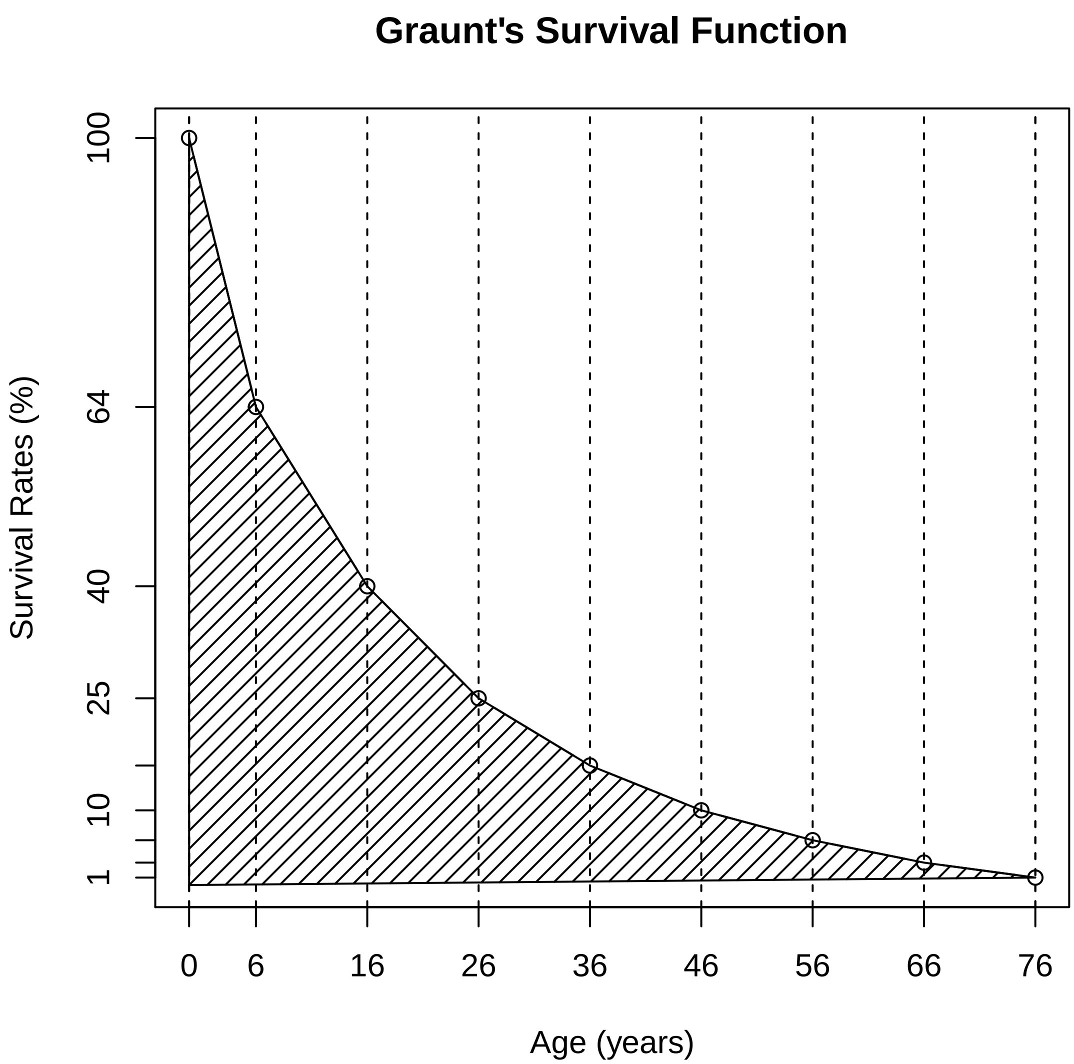
5. Grids

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
polygon(graunt.x, graunt.y, density = 15)
abline(v = graunt$x, lty = 2)
```



6. Title, x-axis label, and y-axis label

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
polygon(graunt.x, graunt.y, density = 15)
abline(v = graunt$x, lty = 2)
main.title <- "Graunt's Survival Function"
x.lab <- "Age (years)"
y.lab <- "Survival Rates (%)"
title(main = main.title, xlab = x.lab, ylab = y.lab)
```



Area under the curve

- The area under the curve can be approximated by the sum of the areas of trapezoids, therefore the area is
  - $\sum_{i=1}^{n-1}(x_{i+1} - x_i) \times \frac{1}{2}(y_i + y_{i+1})$.
  - `diff()`, `head()`, and `tail()` can be used to write a function to compute the area easily.

```
area.R <- function(x, y) {
  sum(diff(x) * (head(y, -1) + tail(y, -1))/2)
  }
area.R(graunt$x, graunt$lx.17th)/100
```

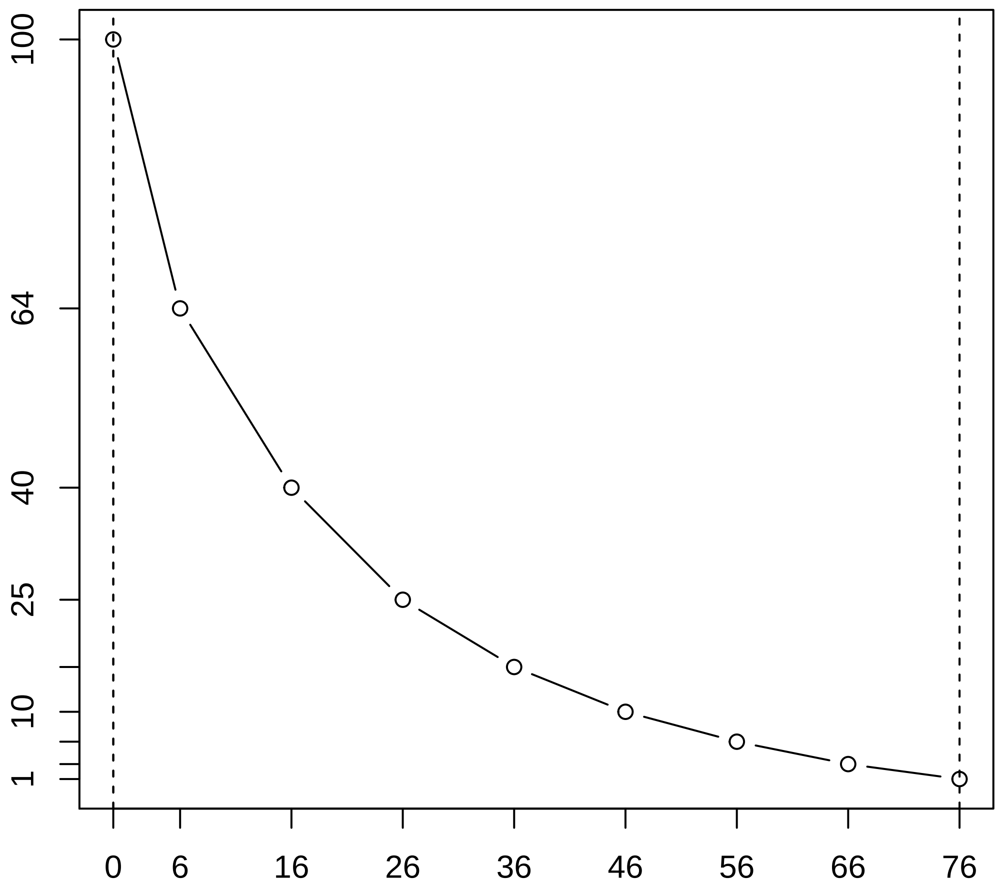
```
## [1] 18.17
```

Comparison with US 1993 life table

The shaded area between the survival functions of Graunt's and US 1993 represents the difference of life expectancies.

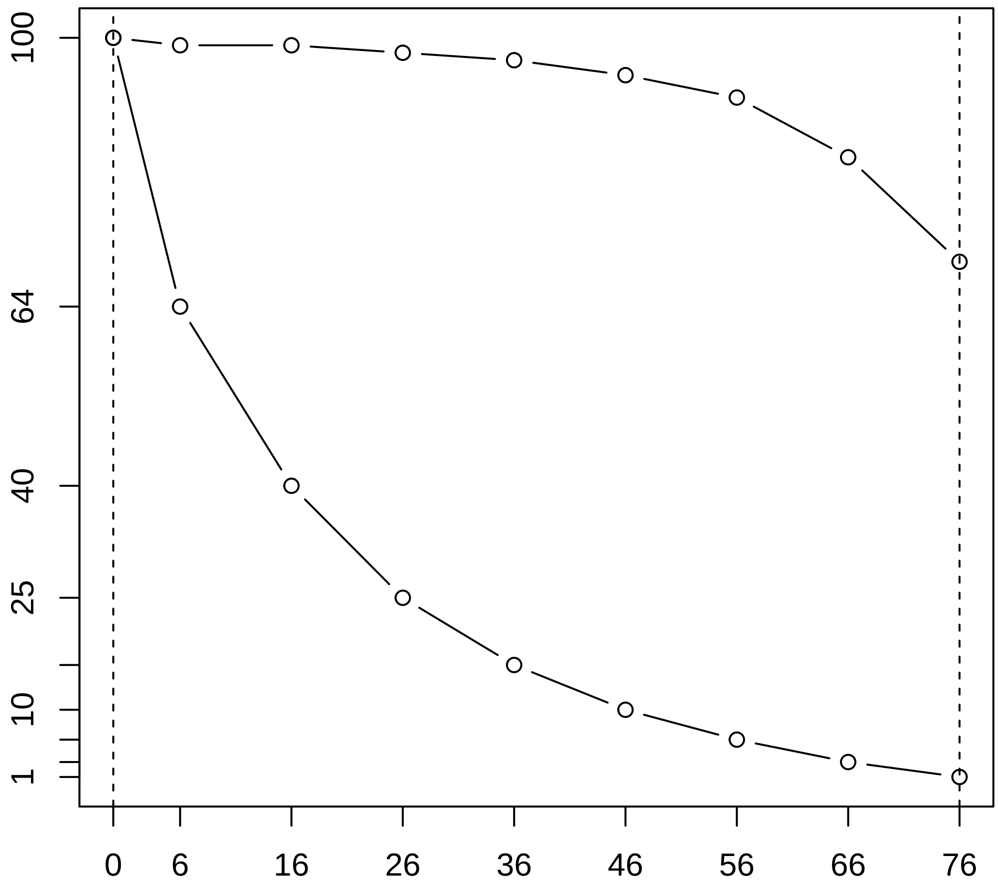
1. Draw Graunt's first with axes, lower and upper limits

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx, labels = graunt$lx.17th)
abline(v=c(0, 76), lty = 2)
abline(v = c(0, 76), lty = 2)
```



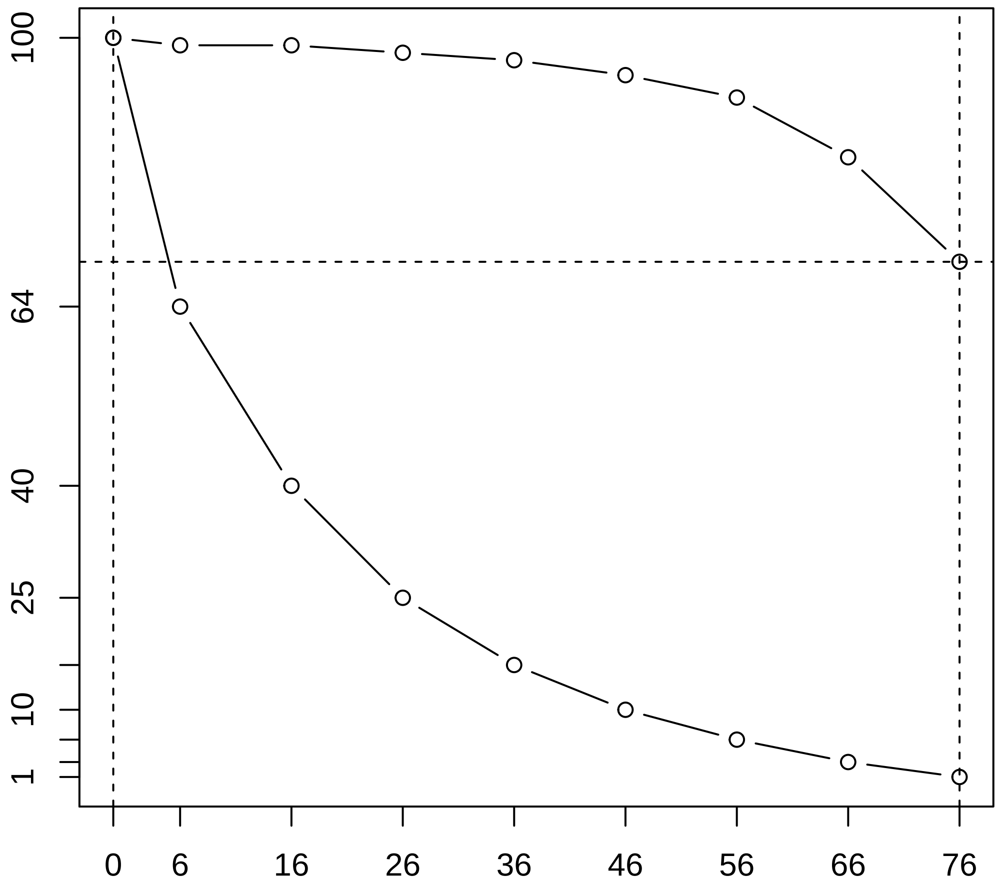
2. Add US 1993 survival function

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
lines(us.93$x, us.93$lx.93, type = "b")
```



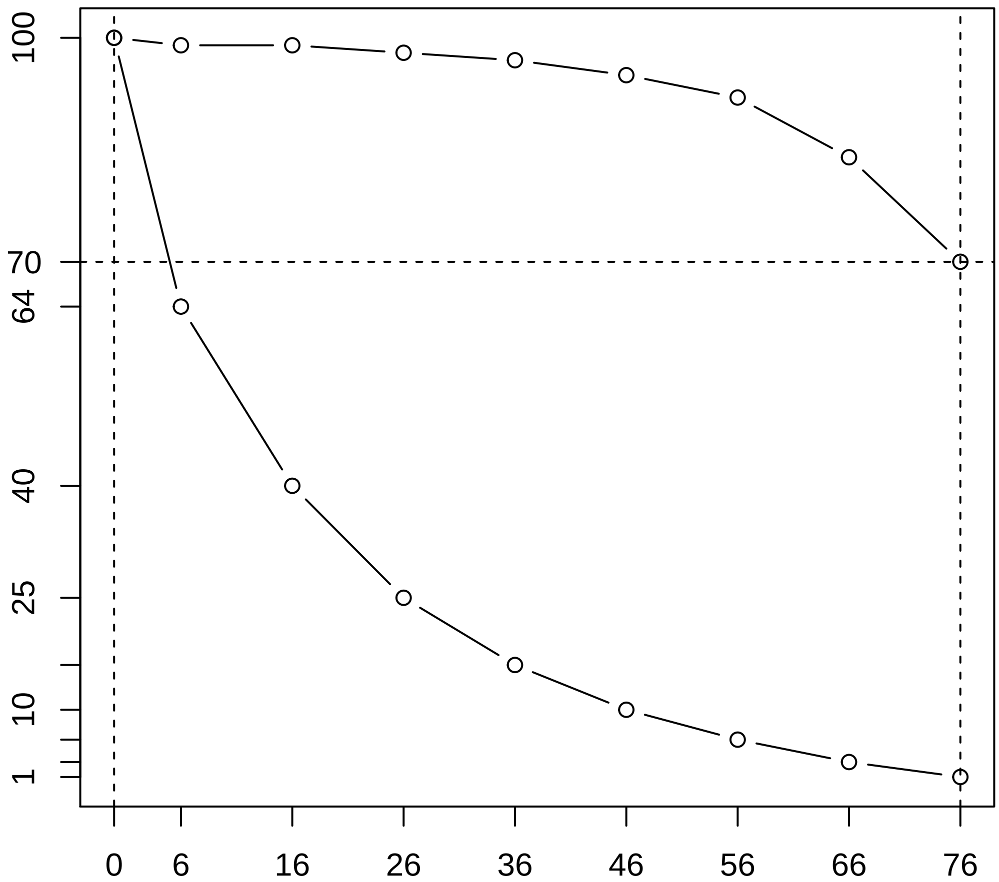
3. Actually, US 1993 life table is truncated at the age 76. Specify that point.

```r
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
lines(us.93$x, us.93$lx.93, type = "b")
abline(h = 70, lty = 2)
```



4. Using `las = 1` to specify 70%.

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
lines(us.93$x, us.93$lx.93, type = "b")
abline(h = 70, lty = 2)
axis(side = 2, at = 70, labels = 70, las = 1)
```

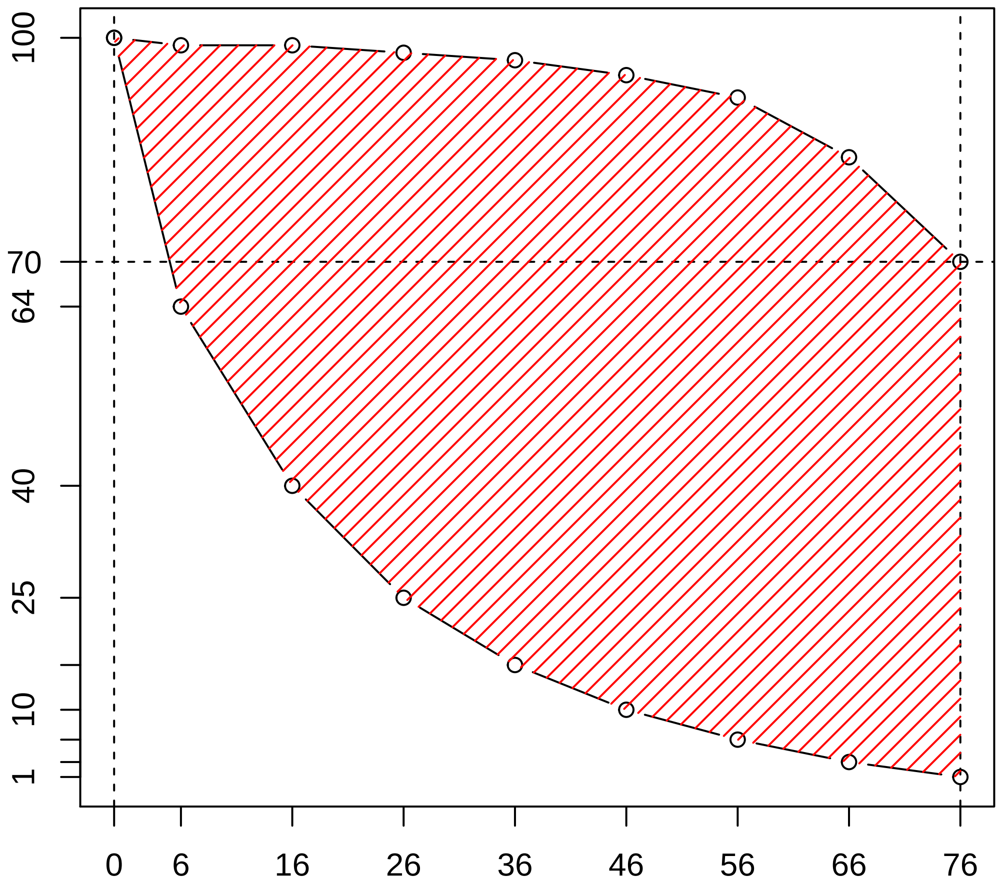


Setting coordinates for `polygon()`

```
us.graunt.x <- c(us.93$x, rev(graunt$x))
us.graunt.y <- c(us.93$lx.93, rev(graunt$lx.17th))
```

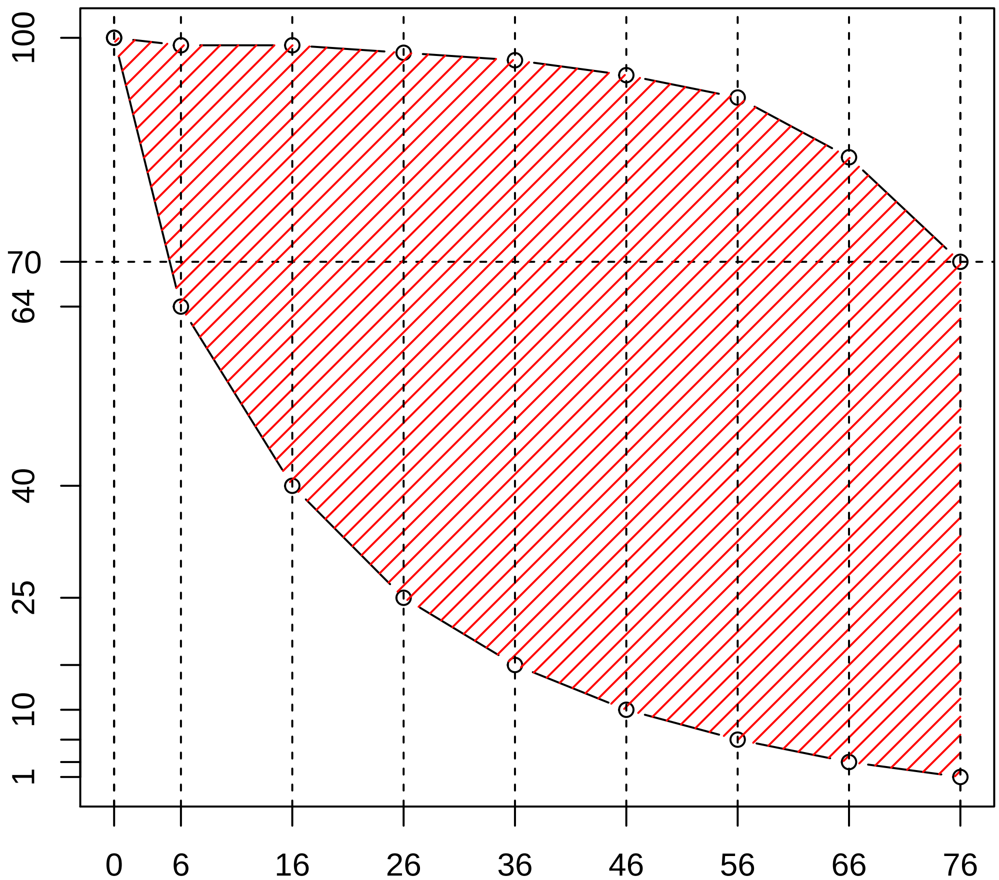
5. Shading

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
lines(us.93$x, us.93$lx.93, type = "b")
abline(h = 70, lty = 2)
axis(side = 2, at = 70, labels = 70, las = 1)
polygon(us.graunt.x, us.graunt.y, density = 15, col = "red", border = NA)
```



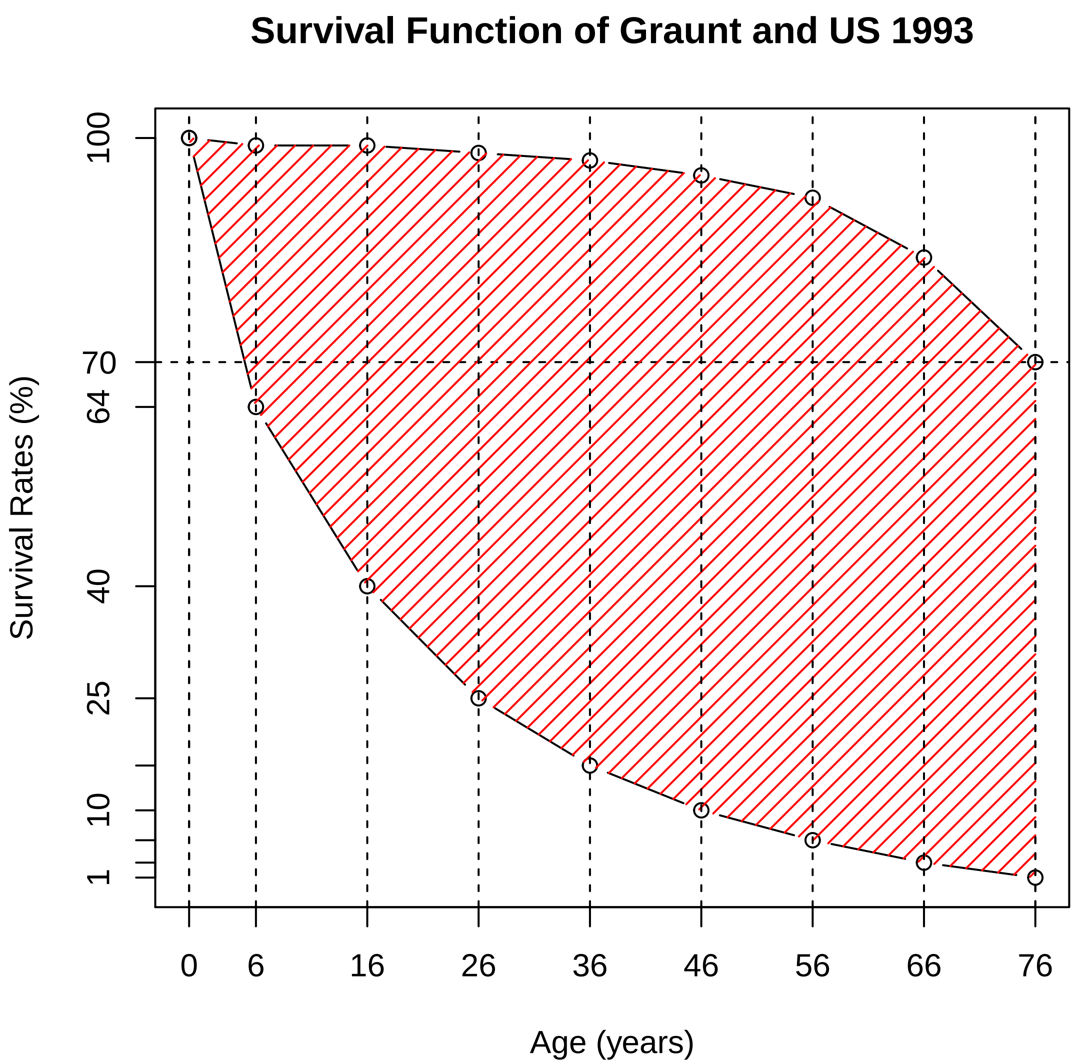
6. Grids

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
lines(us.93$x, us.93$lx.93, type = "b")
abline(h = 70, lty = 2)
axis(side = 2, at = 70, labels = 70, las = 1)
polygon(us.graunt.x, us.graunt.y, density = 15, col = "red", border = NA)
abline(v = graunt$x, lty = 2)
```



7. Title, x-axis and y-axis labels

```
par(family = "Helvetica")
plot(graunt, ann = FALSE, xaxt = "n", yaxt = "n", type = "b")
axis(side = 1, at = graunt$x, labels = graunt$x)
axis(side = 2, at = graunt$lx, labels = graunt$lx.17th)
abline(v = c(0, 76), lty = 2)
lines(us.93$x, us.93$lx.93, type = "b")
abline(h = 70, lty = 2)
axis(side = 2, at = 70, labels = 70, las = 1)
polygon(us.graunt.x, us.graunt.y, density = 15, col = "red", border = NA)
abline(v = graunt$x, lty = 2)
main.title.g.us <- "Survival Function of Graunt and US 1993"
title(main = main.title.g.us, xlab = x.lab, ylab = y.lab)
```




```r
dev.copy(device = png, file = "../pics/graunt_us93.png")
```

```
## quartz_off_screen
##                 3
```

Life expectancy

The area under the US 1993 survival function is

```r
area.R(us.93$x, us.93$lx.93)/100
```

```
## [1] 70.92
```

The area of shaded region is

```r
area.R(us.93$x, us.93$lx.93)/100 - area.R(graunt$x, graunt$lx.17th)/100
```

```
## [1] 52.75
```

Comparison with Halley's life table

Halley's life table

```
age <- 0:84
lx <- c(1238, 1000, 855, 798, 760, 732, 710, 692, 680, 670, 661, 653, 646, 640, 634, 628, 622, 616, 610
length(lx)
```

```
## [1] 85
```

```
halley <- data.frame(age, lx)
halley$px <- round(halley$lx/1238*100, digits = 1)
head(halley)
```

```
##   age   lx    px
## 1   0 1238 100.0
## 2   1 1000  80.8
## 3   2  855  69.1
## 4   3  798  64.5
## 5   4  760  61.4
## 6   5  732  59.1
```

```
tail(halley)
```

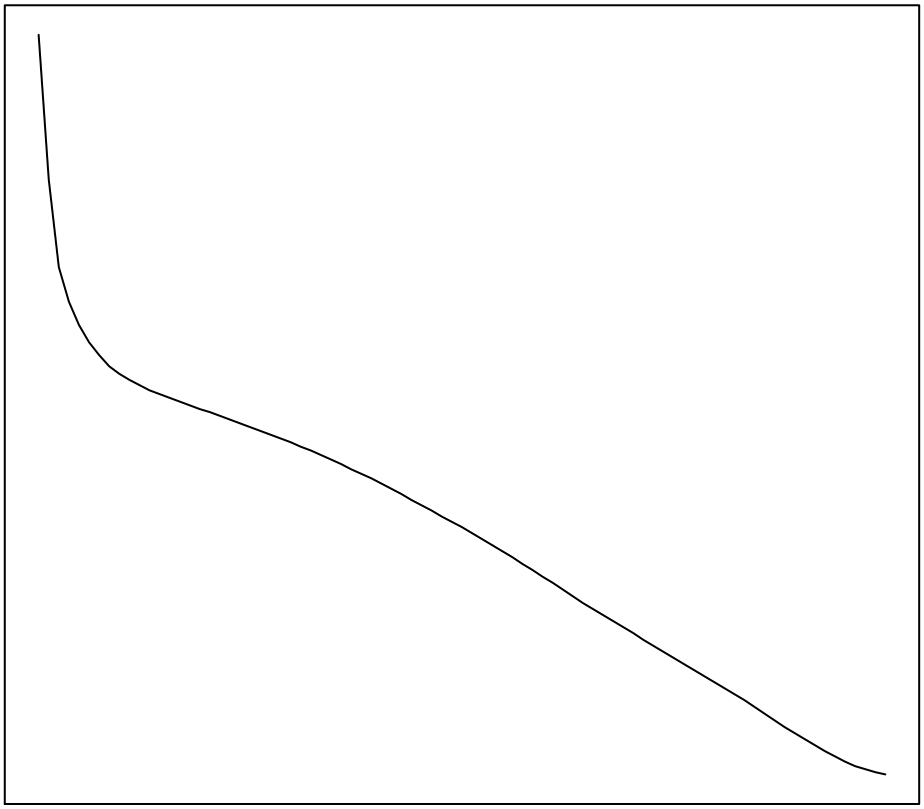
```
##    age lx  px
## 80  79 50 4.0
## 81  80 41 3.3
## 82  81 34 2.7
## 83  82 28 2.3
## 84  83 23 1.9
## 85  84 20 1.6
```

R base graphics

To make the comparison easy, plot the points at the same age group of Graunt's, 0, 6, 16, 26, 36, 46, 56, 66, 76. Step by step approach

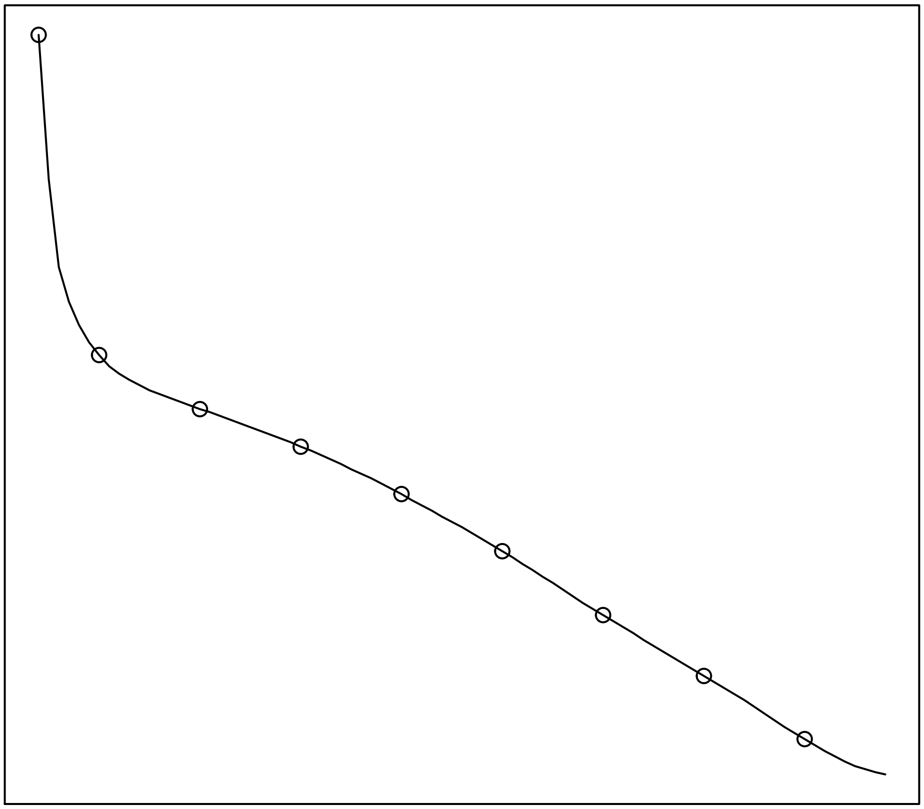
1. Halley's survival function first

```
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
```



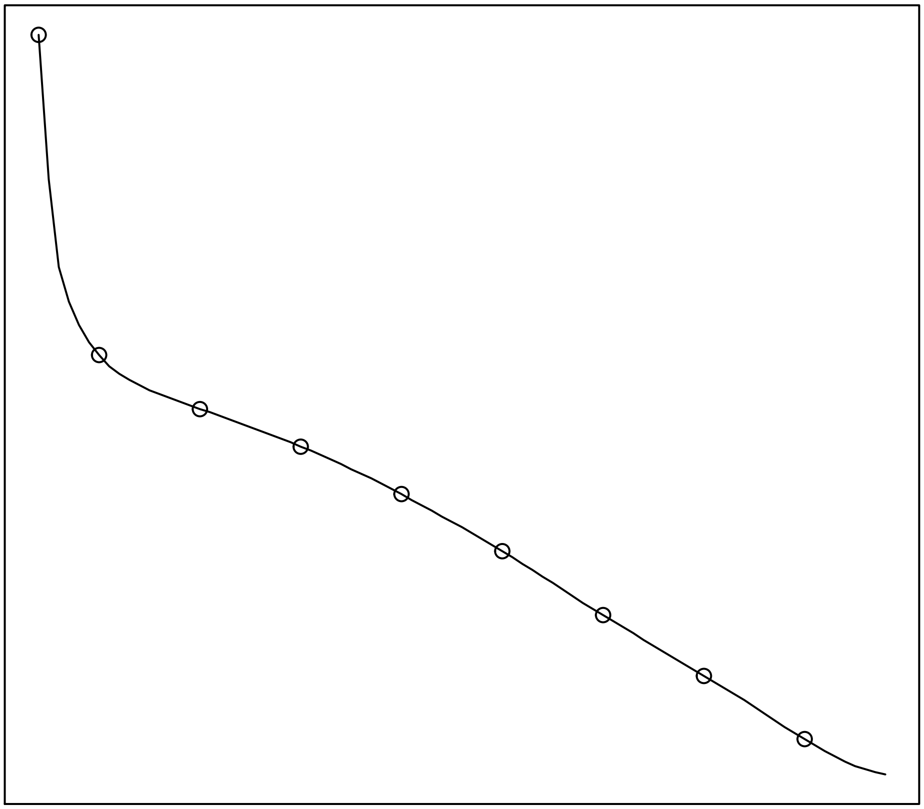
2. Mark the points at 0, 6, 16, 26, 36, 46, 56, 66, 76 on Halley's survival function.

```
age.graunt <- age %in% graunt$x
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
points(px[age.graunt] ~ age[age.graunt], data = halley)
```



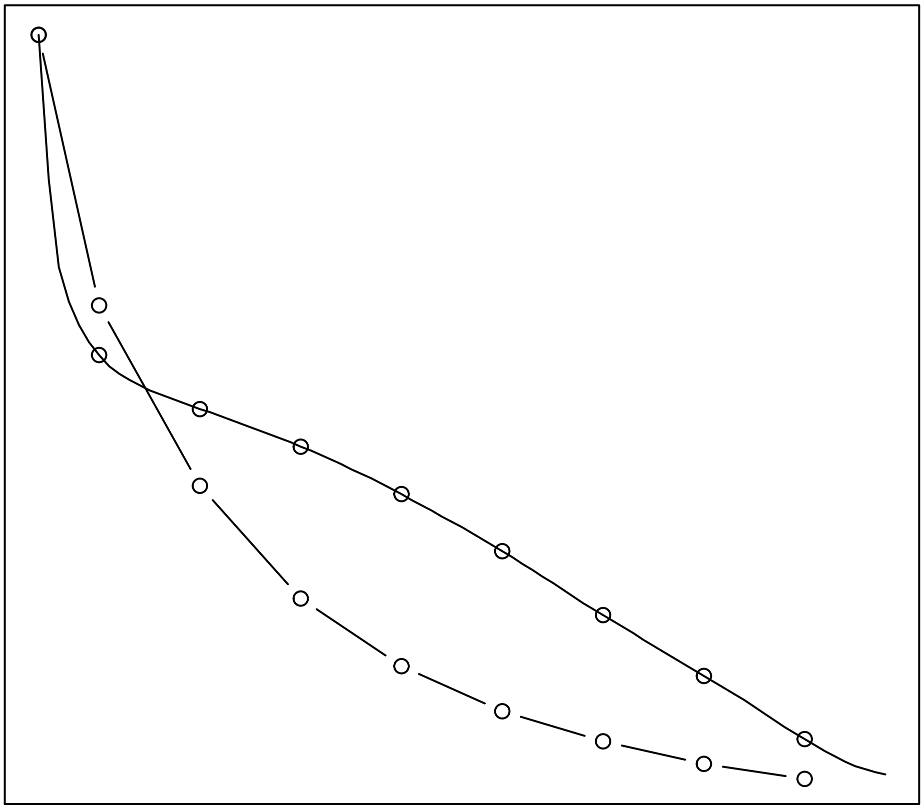
Using `subset()`

```
halley.graunt <- subset(halley, age.graunt)
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
points(px ~ age, data = halley.graunt)
```



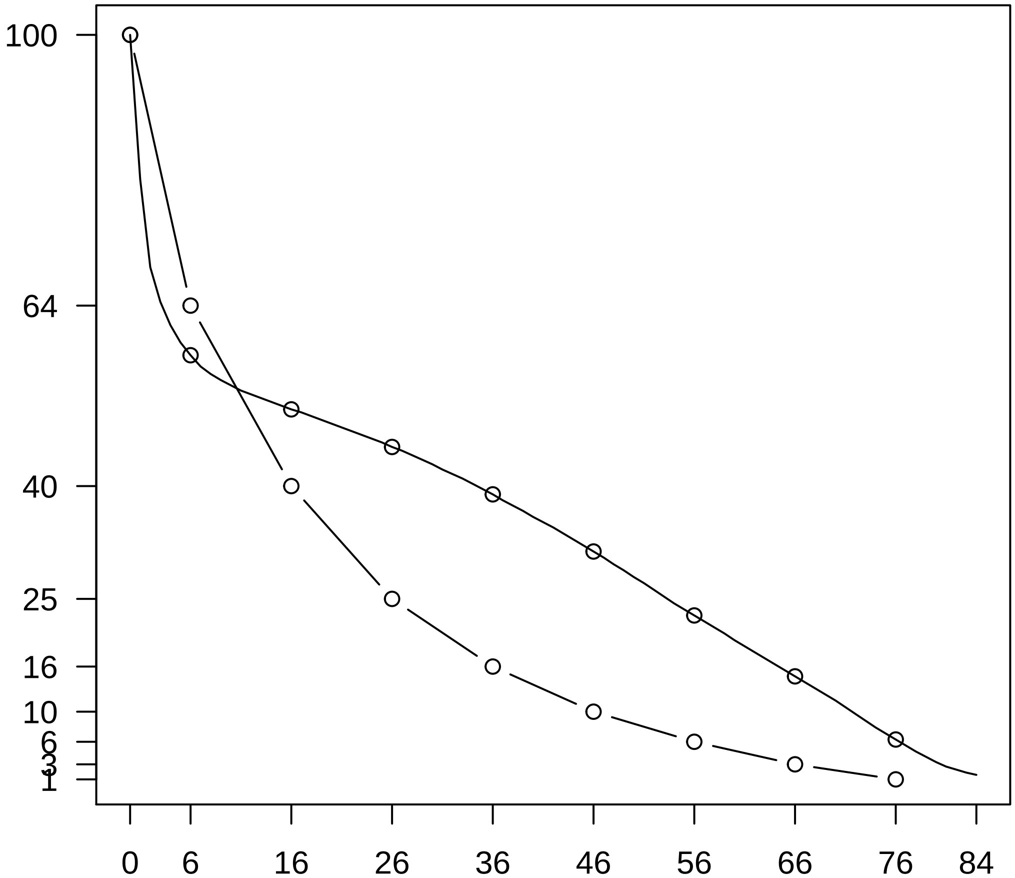
3. Add Graunt's survival function

```
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
points(px ~ age, data = halley.graunt)
lines(lx.17th ~ x, data = graunt, type = "b")
```



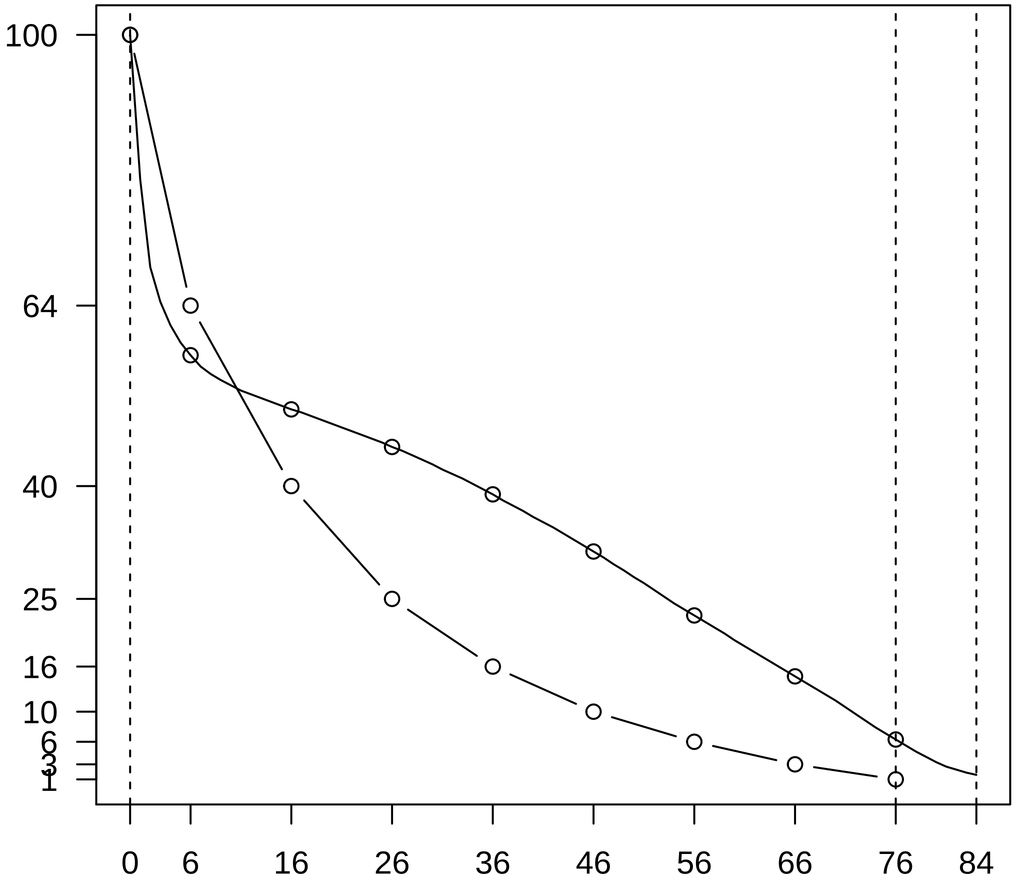
4. x-axis label and y-axis label with `las = 1`

```
par(family = "Helvetica")
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
points(px ~ age, data = halley.graunt)
lines(lx.17th ~ x, data = graunt, type = "b")
axis(side = 1, at = c(graunt$x, 84), labels = c(graunt$x, 84))
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th, las = 1)
```



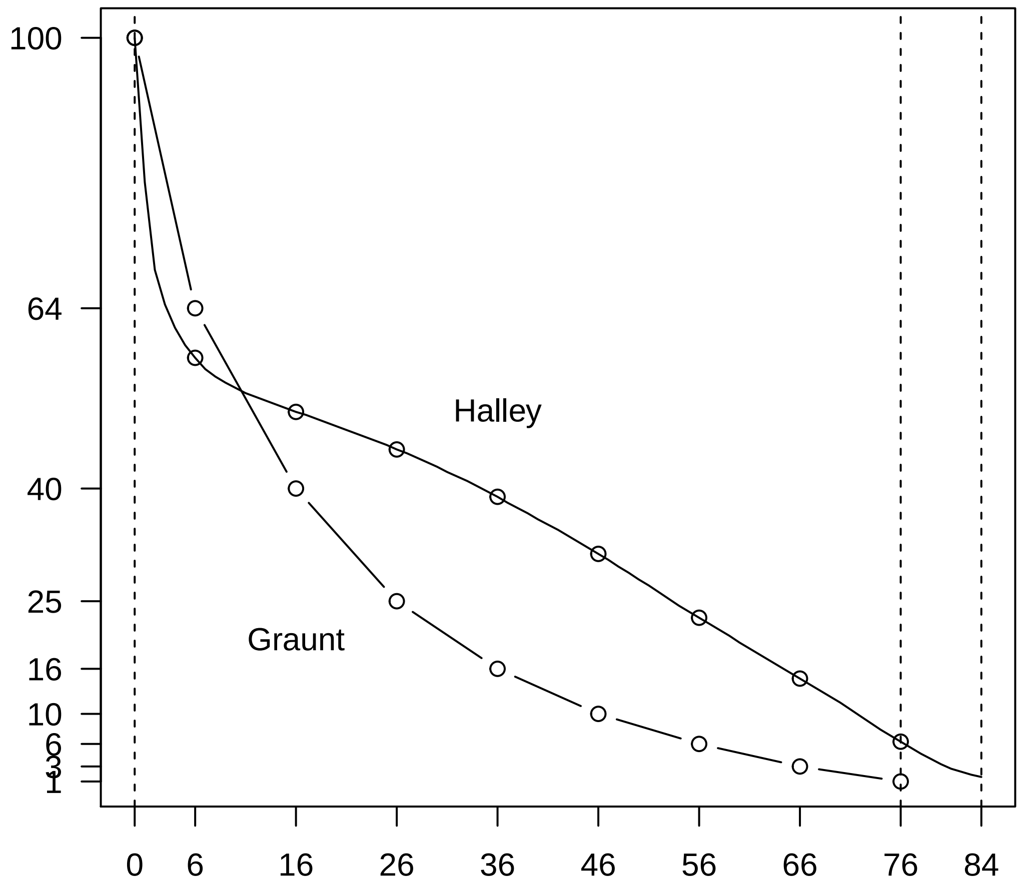
5. Vertical dotted lines at the ages 0, 76, and 84

```
par(family = "Helvetica")
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
points(px ~ age, data = halley.graunt)
lines(lx.17th ~ x, data = graunt, type = "b")
axis(side = 1, at = c(graunt$x, 84), labels = c(graunt$x, 84))
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th, las = 1)
abline(v = c(0, 76, 84), lty = 2)
```



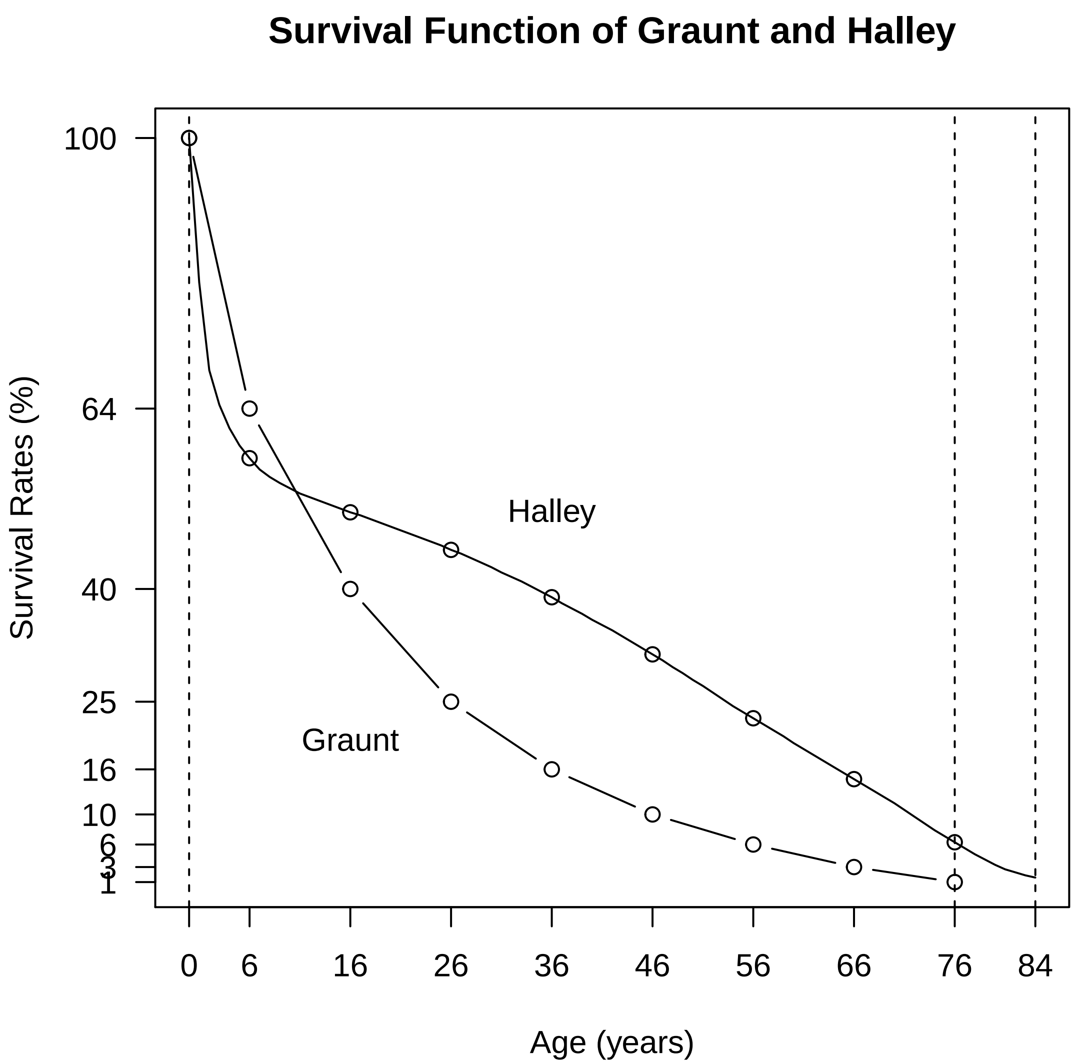
6. Specify the developers at proper coordinates with `text()`

```
par(family = "Helvetica")
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
points(px ~ age, data = halley.graunt)
lines(lx.17th ~ x, data = graunt, type = "b")
axis(side = 1, at = c(graunt$x, 84), labels = c(graunt$x, 84))
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th, las = 1)
abline(v = c(0, 76, 84), lty = 2)
text(x = c(16, 36), y = c(20, 50), label = c("Graunt", "Halley"))
```



7. Main title, x-axis label, and y-axis label

```
par(family = "Helvetica")
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
points(px ~ age, data = halley.graunt)
lines(lx.17th ~ x, data = graunt, type = "b")
axis(side = 1, at = c(graunt$x, 84), labels = c(graunt$x, 84))
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th, las = 1)
abline(v = c(0, 76, 84), lty = 2)
text(x = c(16, 36), y = c(20, 50), label = c("Graunt", "Halley"))
main.title.2 <- "Survival Function of Graunt and Halley"
title(main = main.title.2, xlab = x.lab, ylab = y.lab)
```



Polygon

Setting the coordinates for `polygon()`. The intersection is found at `x = 10.8, y = 52.8` with `locator(1)` and couple of trial and errors.

- Upper region

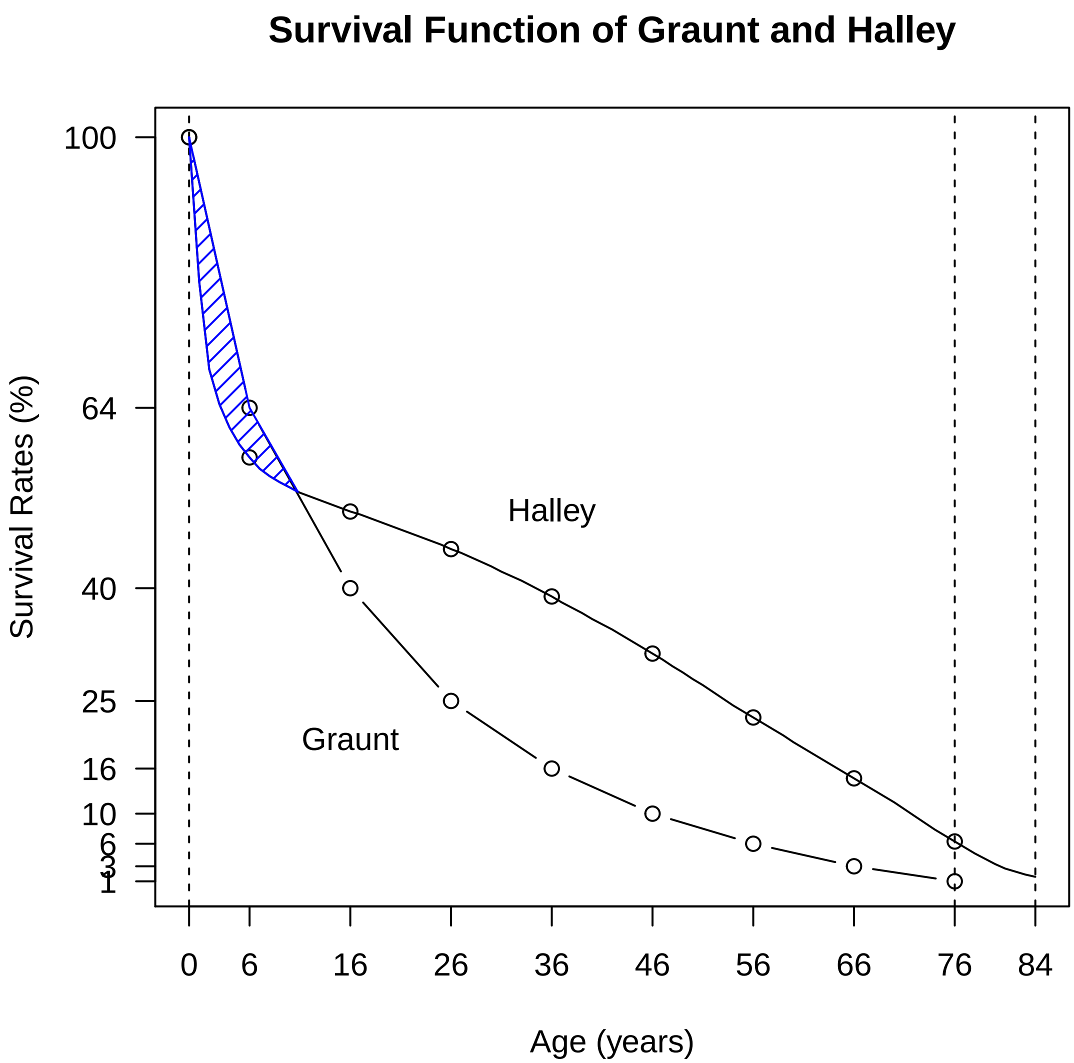
```
poly.1.x <- c(graunt$x[1:2], 10.8, halley$age[11:1])
poly.1.y <- c(graunt$lx.17th[1:2], 52.8, halley$px[11:1])
poly.upper <- data.frame(x = poly.1.x, y = poly.1.y)
```

- Lower region

```
poly.2.x <- c(10.8, halley$age[12:85], graunt$x[9:3])
poly.2.y <- c(52.8, halley$px[12:85], graunt$lx.17th[9:3])
poly.lower <- data.frame(x = poly.2.x, y = poly.2.y)
```

8. Shading upper region first

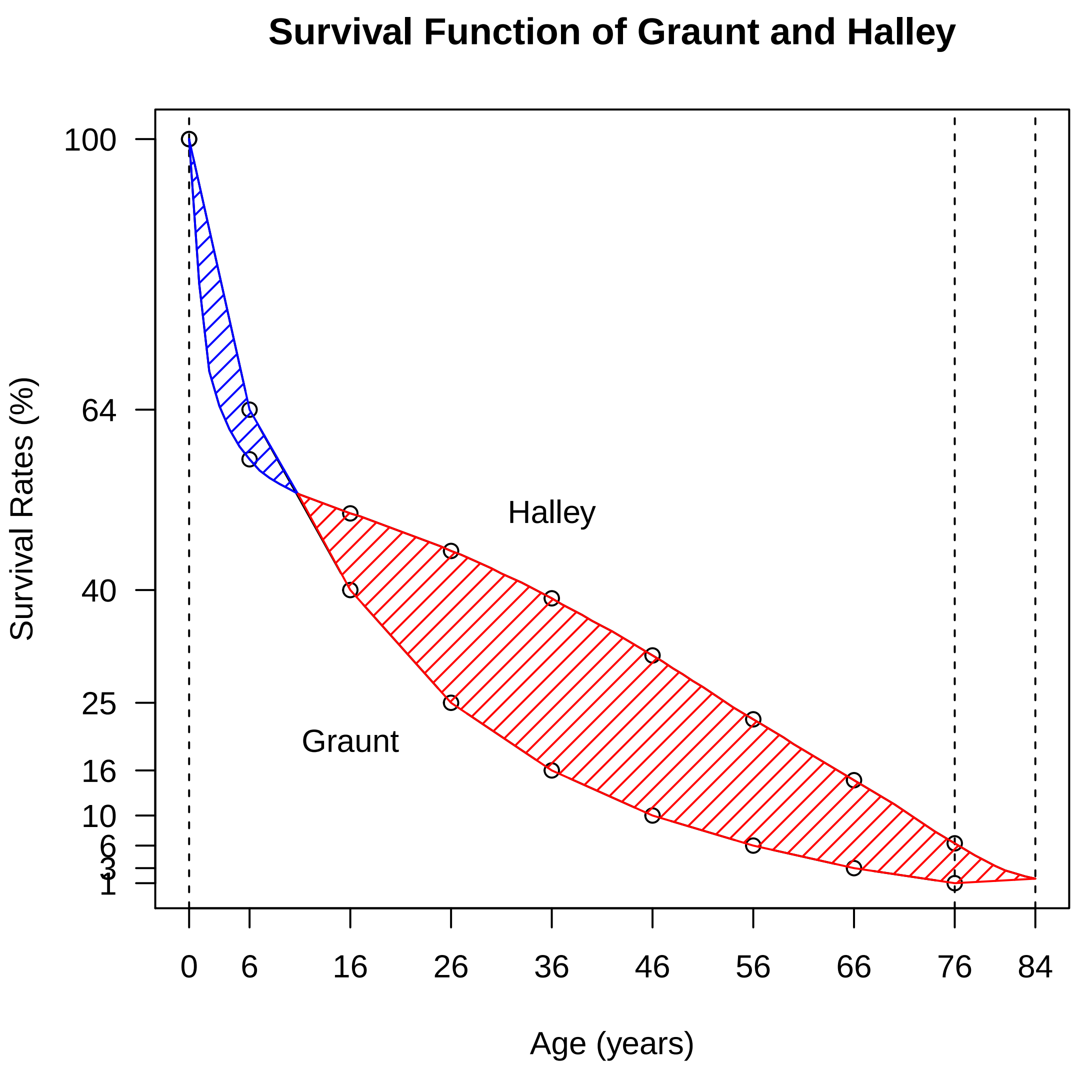
```r
par(family = "Helvetica")
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
points(px ~ age, data = halley.graunt)
lines(lx.17th ~ x, data = graunt, type = "b")
axis(side = 1, at = c(graunt$x, 84), labels = c(graunt$x, 84))
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th, las = 1)
abline(v=c(0, 76, 84), lty = 2)
text(x = c(16, 36), y = c(20, 50), label = c("Graunt", "Halley"))
title(main = main.title.2, xlab = x.lab, ylab = y.lab)
polygon(poly.1.x, poly.1.y, angle = 45, density = 15, col = "blue")
```



9. Shading lower region next

```r
par(family = "Helvetica")
plot(px ~ age, data = halley, ann = FALSE, xaxt = "n", yaxt = "n", type = "l")
points(px ~ age, data = halley.graunt)
lines(lx.17th ~ x, data = graunt, type = "b")
axis(side = 1, at = c(graunt$x, 84), labels = c(graunt$x, 84))
axis(side = 2, at = graunt$lx.17th, labels = graunt$lx.17th, las = 1)
```

```r
abline(v=c(0, 76, 84), lty = 2)
text(x = c(16, 36), y = c(20, 50), label = c("Graunt", "Halley"))
title(main = main.title.2, xlab = x.lab, ylab = y.lab)
polygon(poly.1.x, poly.1.y, angle = 45, density = 15, col = "blue")
polygon(poly.2.x, poly.2.y, angle = 45, density = 15, col = "red")
```




```r
dev.copy(device = png, file = "../pics/graunt_halley.png")
```

```
## quartz_off_screen
##                 4
```

Life expectancy

Compute the difference of life expectancies

```r
(life.exp.halley <- area.R(halley$age, halley$px)/100)
```

```
## [1] 27.872
```

```r
(life.exp.graunt <- area.R(graunt$x, graunt$lx.17th)/100)
```

```
## [1] 18.17
```

ggplot

```r
library(ggplot2)
```

Data Reshape

Attach `reshape2` package to change wide format to long format

```r
library(reshape2)
```

How `melt()` works

```r
graunt.us.melt <- melt(graunt.us, id.vars = "x", measure.vars = c("lx.17th", "lx.93"), value.name = "lx
graunt.us.melt
```

```
##     x   times  lx
## 1   0 lx.17th 100
## 2   6 lx.17th  64
## 3  16 lx.17th  40
## 4  26 lx.17th  25
## 5  36 lx.17th  16
## 6  46 lx.17th  10
## 7  56 lx.17th   6
## 8  66 lx.17th   3
## 9  76 lx.17th   1
## 10  0   lx.93 100
## 11  6   lx.93  99
## 12 16   lx.93  99
## 13 26   lx.93  98
## 14 36   lx.93  97
## 15 46   lx.93  95
## 16 56   lx.93  92
## 17 66   lx.93  84
## 18 76   lx.93  70
```

```r
str(graunt.us.melt)
```

```
## 'data.frame':    18 obs. of  3 variables:
##  $ x    : num  0 6 16 26 36 46 56 66 76 0 ...
##  $ times: Factor w/ 2 levels "lx.17th","lx.93": 1 1 1 1 1 1 1 1 1 2 ...
##  $ lx   : num  100 64 40 25 16 10 6 3 1 100 ...
```

- Change factor levels of `times`

```r
levels(graunt.us.melt$times) <- c("17th", "1993")
str(graunt.us.melt)
```

```
## 'data.frame':    18 obs. of  3 variables:
##  $ x    : num  0 6 16 26 36 46 56 66 76 0 ...
##  $ times: Factor w/ 2 levels "17th","1993": 1 1 1 1 1 1 1 1 1 2 ...
##  $ lx   : num  100 64 40 25 16 10 6 3 1 100 ...
```

- Fonts for pdf output

```r
theme.pdf <- theme(axis.title.x = element_text(family = "Helvetica"),
                   axis.title.y = element_text(family = "Helvetica"),
                   axis.text.x = element_text(family = "Helvetica"),
                   axis.text.y = element_text(family = "Helvetica"),
                   plot.title = element_text(family = "Helvetica"),
                   legend.title = element_text(family = "Helvetica"),
                   legend.text = element_text(family = "Helvetica"))
```

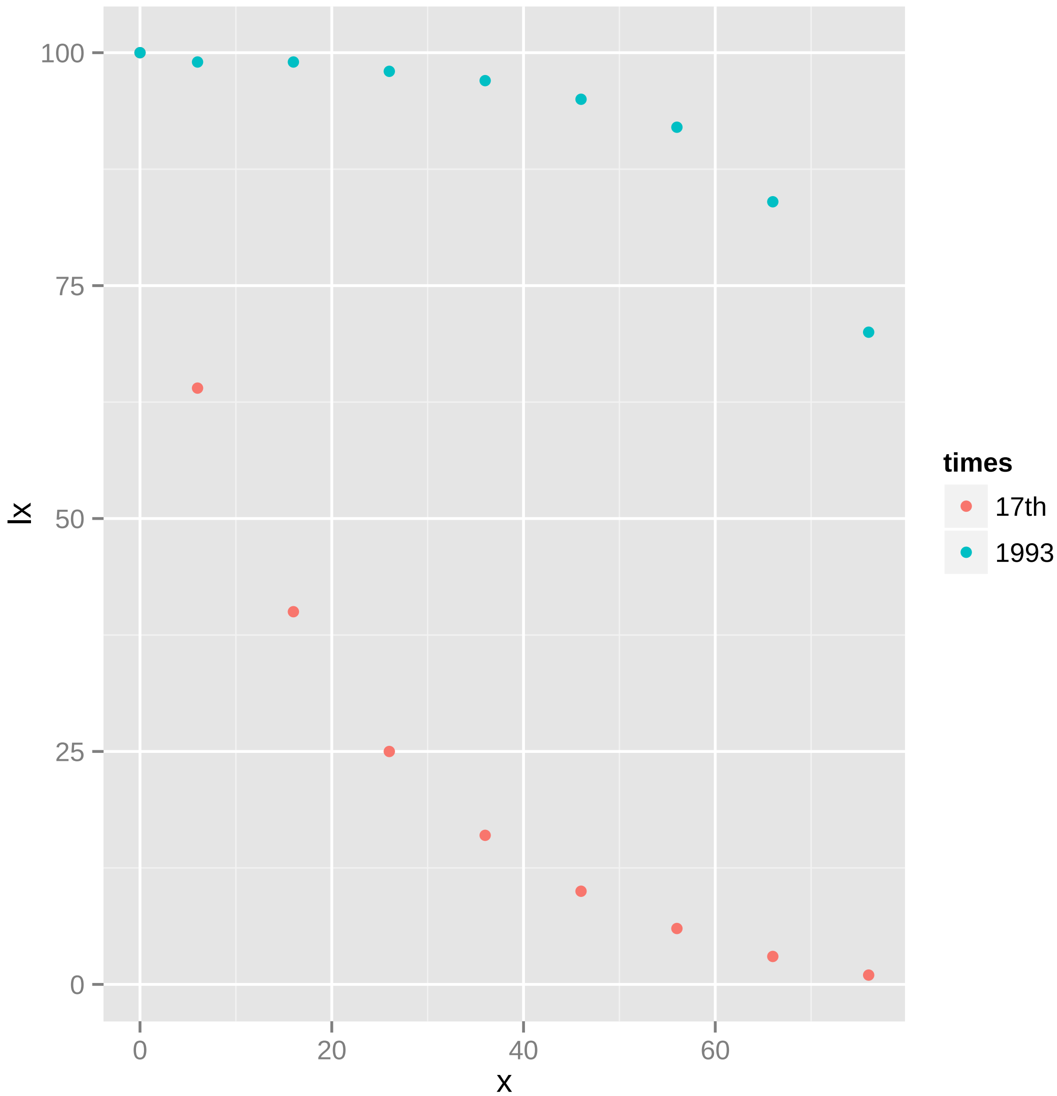
Plot

Points and Lines

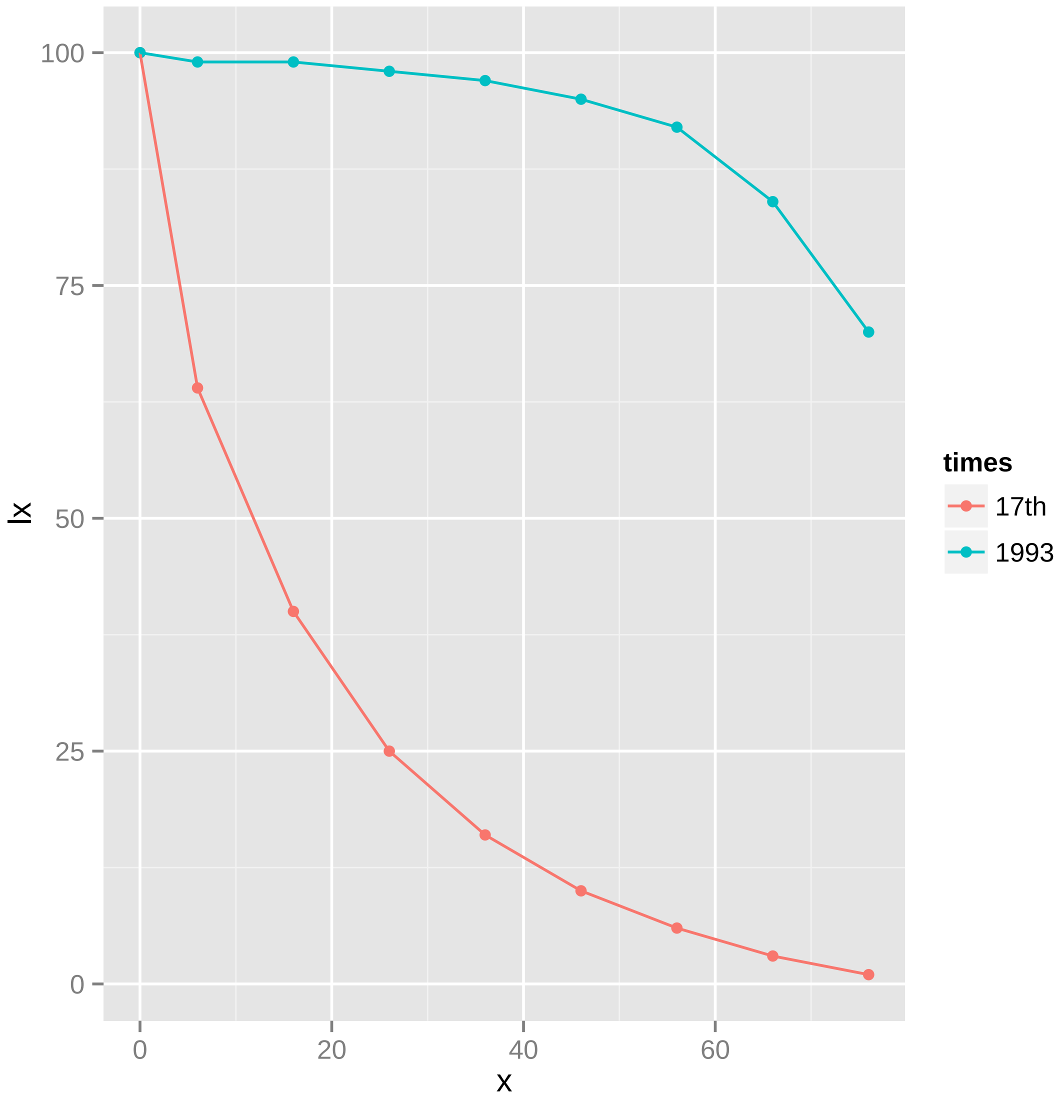
Step by step approach to understand the grammar of ggplot

- We set `ggplot()` to accept varying `data.frame()` and `aes()`in `geom_polygon`

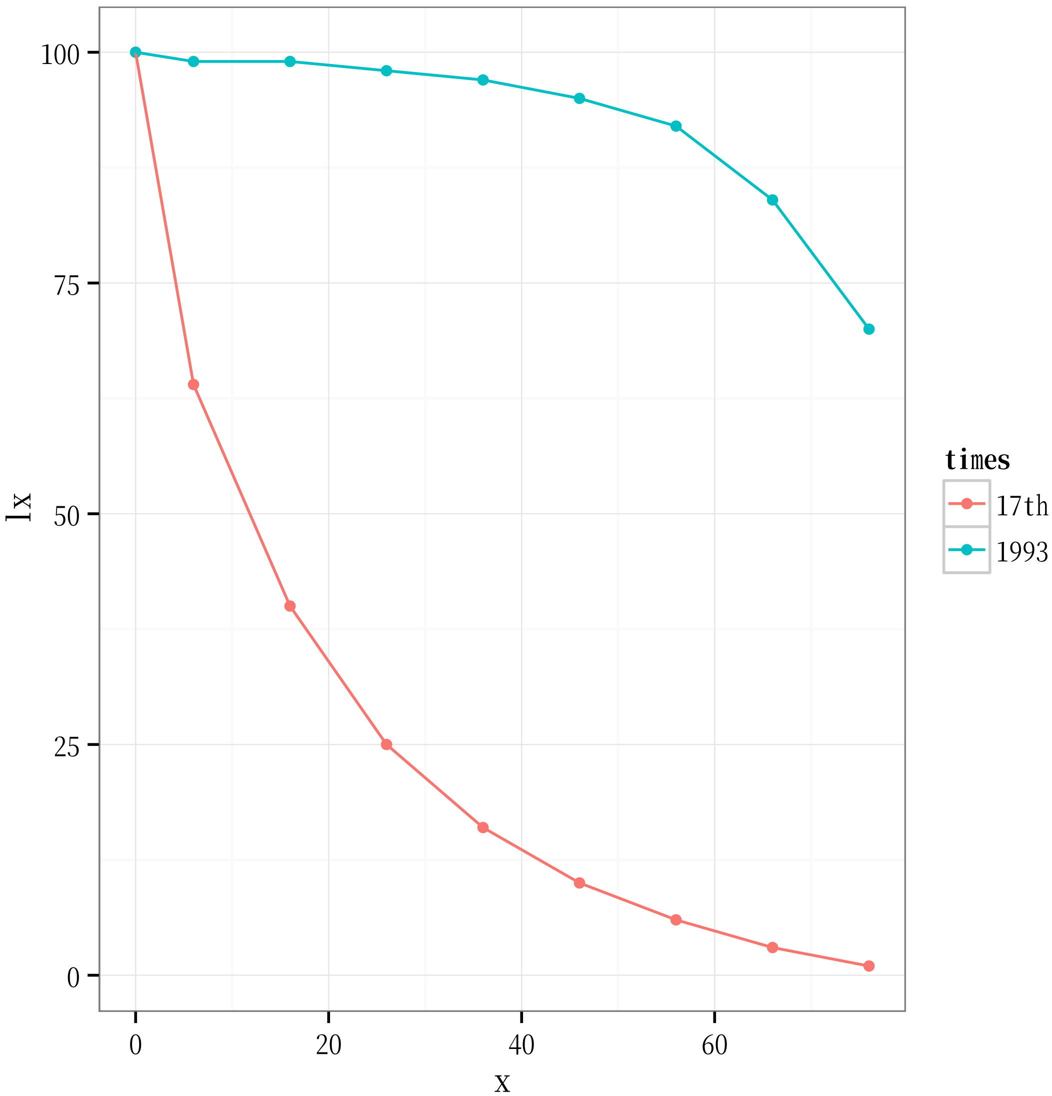
```r
g1 <- ggplot() +
  geom_point(data = graunt.us.melt, aes(x = x, y = lx, colour = times)) +
  theme.pdf
g1
```



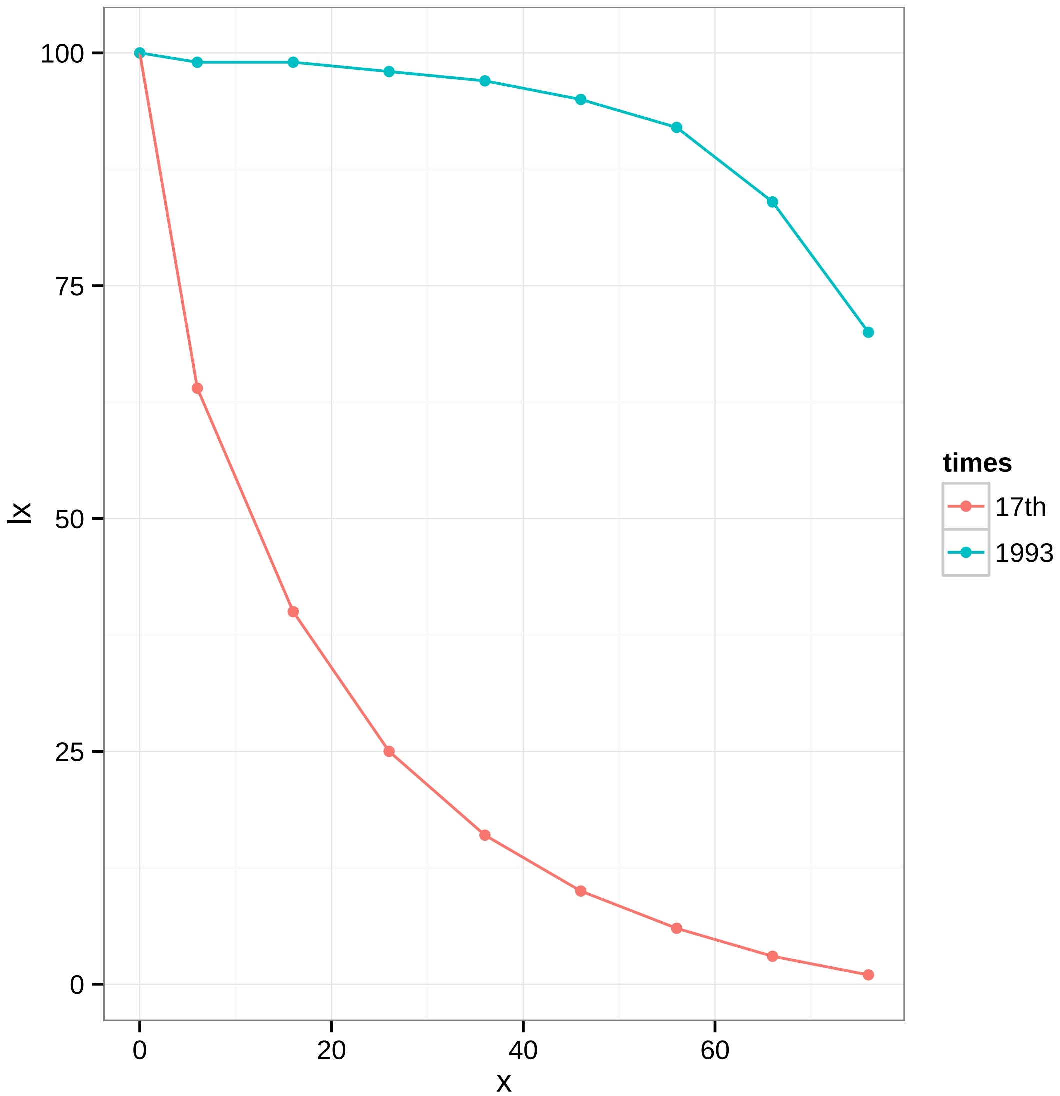

```
g2 <- g1 +
  geom_line(data = graunt.us.melt, aes(x = x, y = lx, colour = times))
g2
```




```r
g3 <- g2 +
  theme_bw()
g3
```



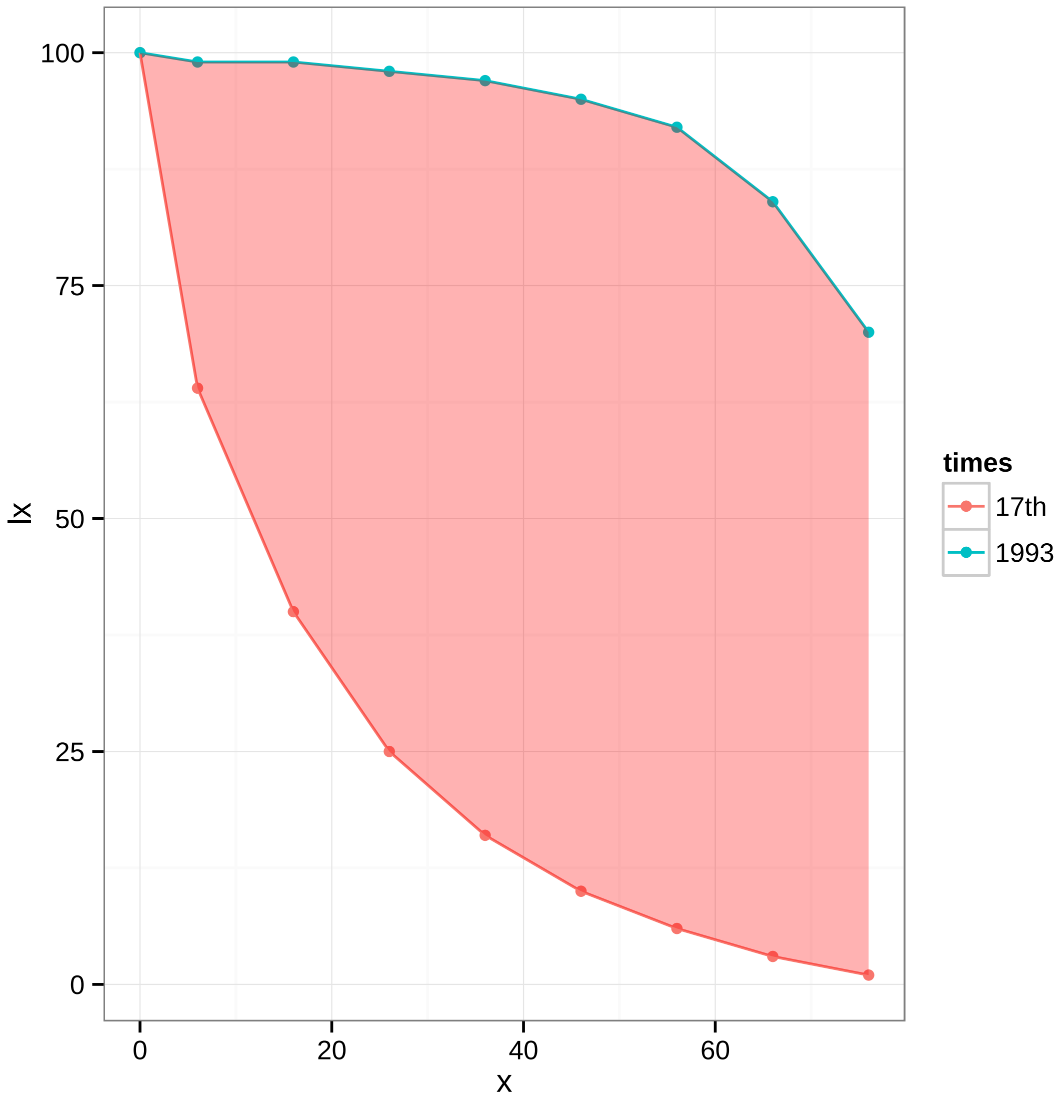

```
g3 <- g3 +
  theme.pdf
g3
```



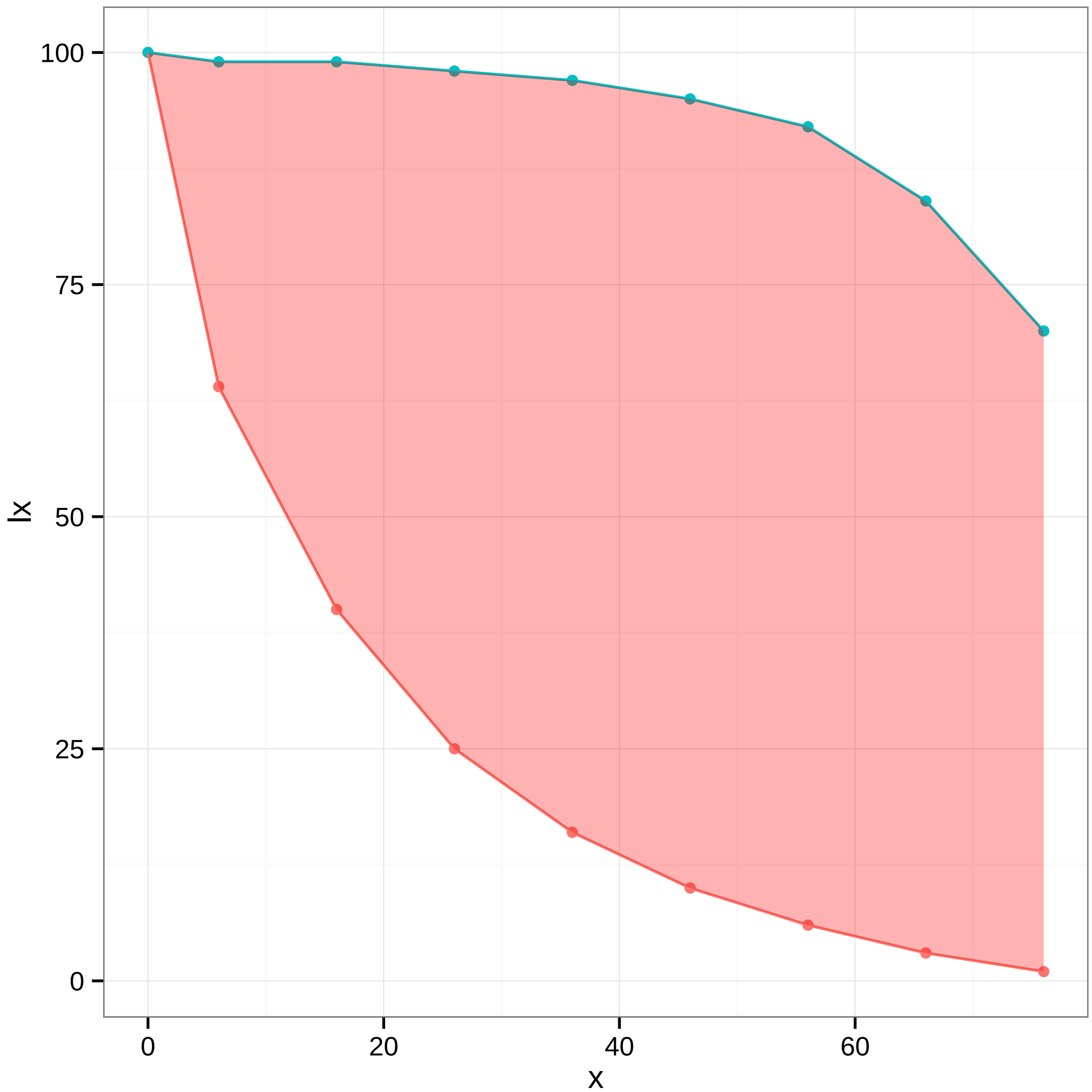
Polygon

Reuse `us.graunt.x` and `us.graunt.y` for `polygon()`. Note how to remove default legends.

```
par(family = "Helvetica")
p3 <- g3 +
  geom_polygon(data = data.frame(x = us.graunt.x, y = us.graunt.y), aes(x = x, y = y), alpha = 0.3, fill
p3
```




```
p4 <- p3 +
  guides(colour = "none")
p4
```

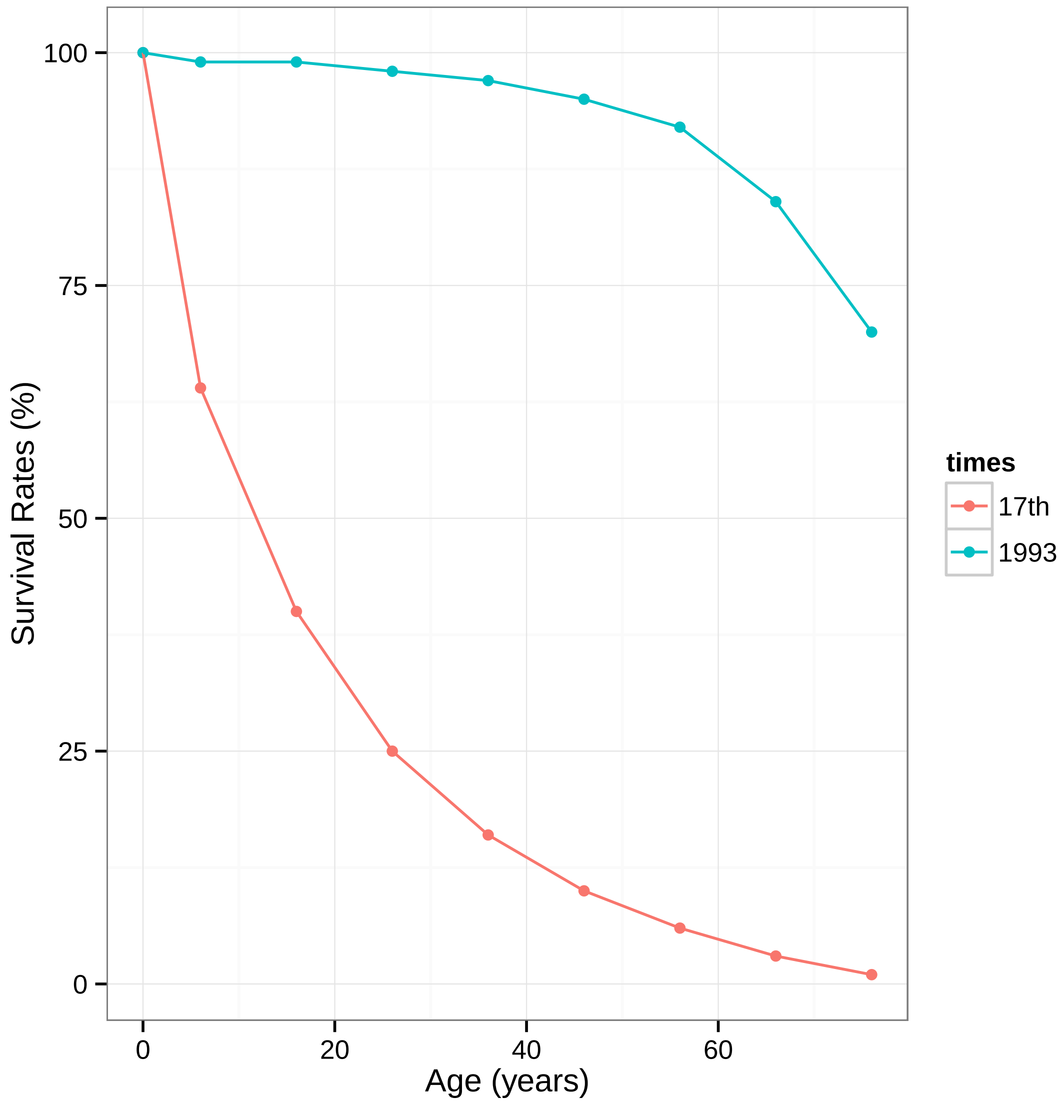


Change default annotations

Points and Lines

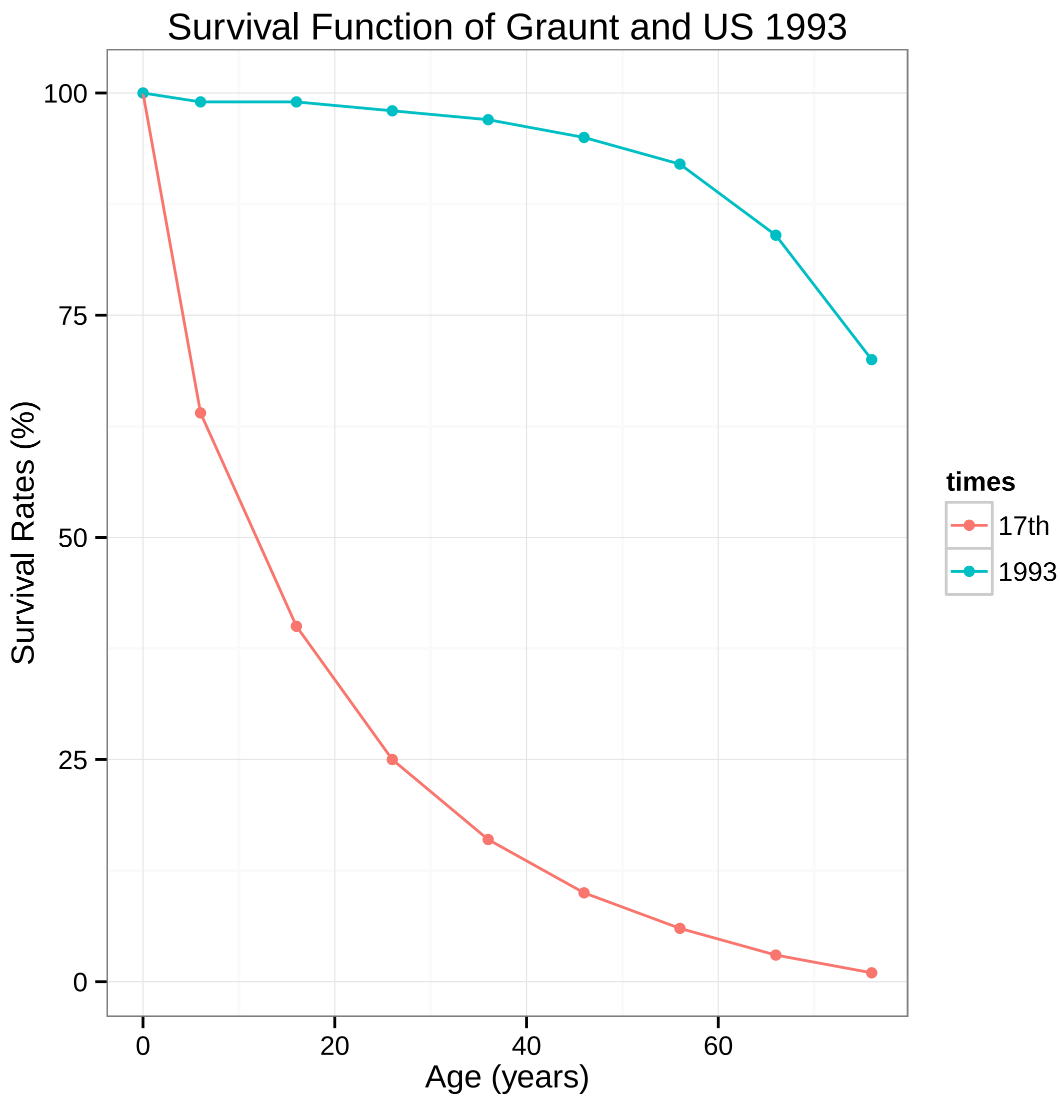
1. Change the x-axis and y-axis labels

```
(g4 <- g3 +
   xlab(x.lab) +
   ylab(y.lab))
```



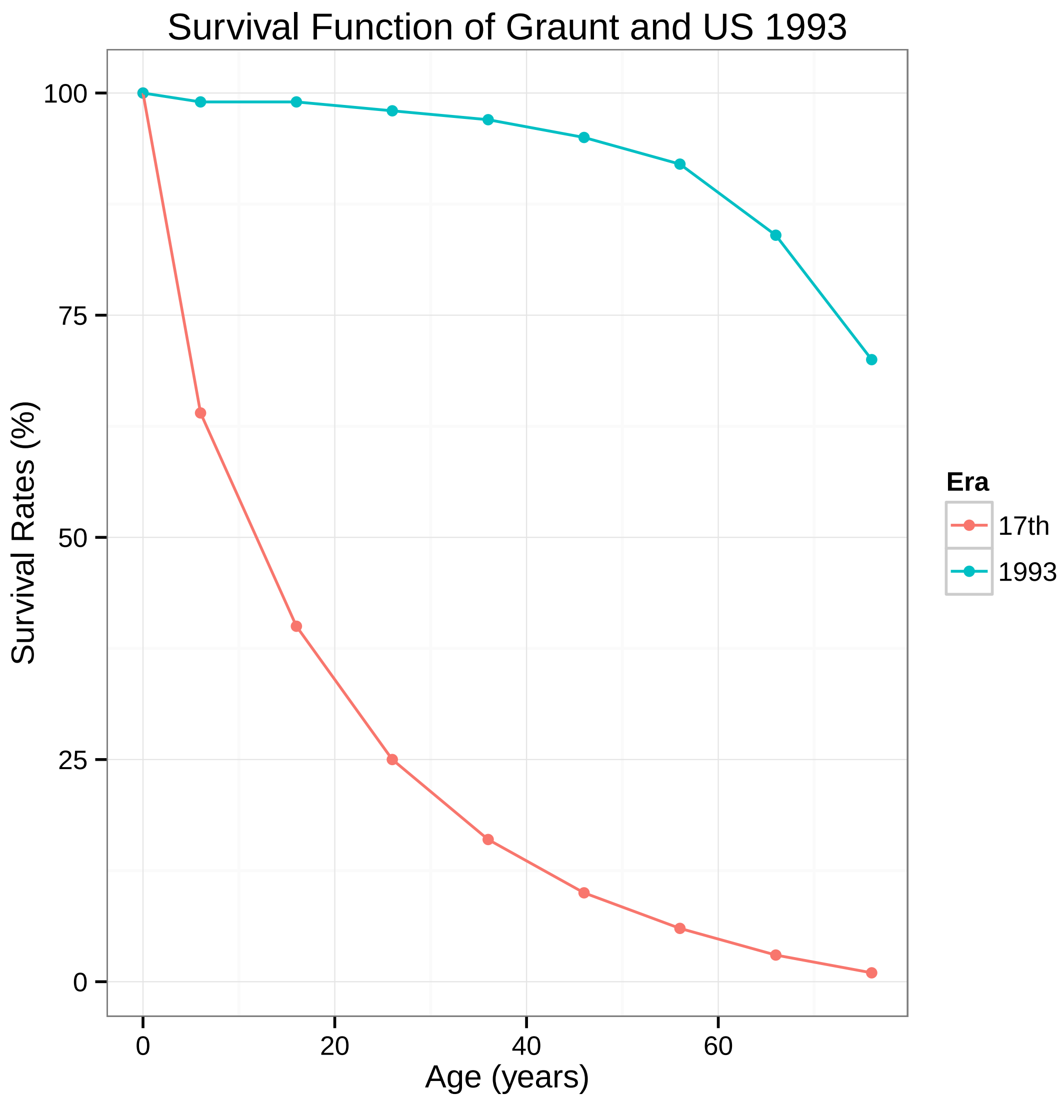
2. Main title

```
(g4 <- g3 +
   xlab(x.lab) +
   ylab(y.lab) +
   ggtitle(main.title.g.us))
```



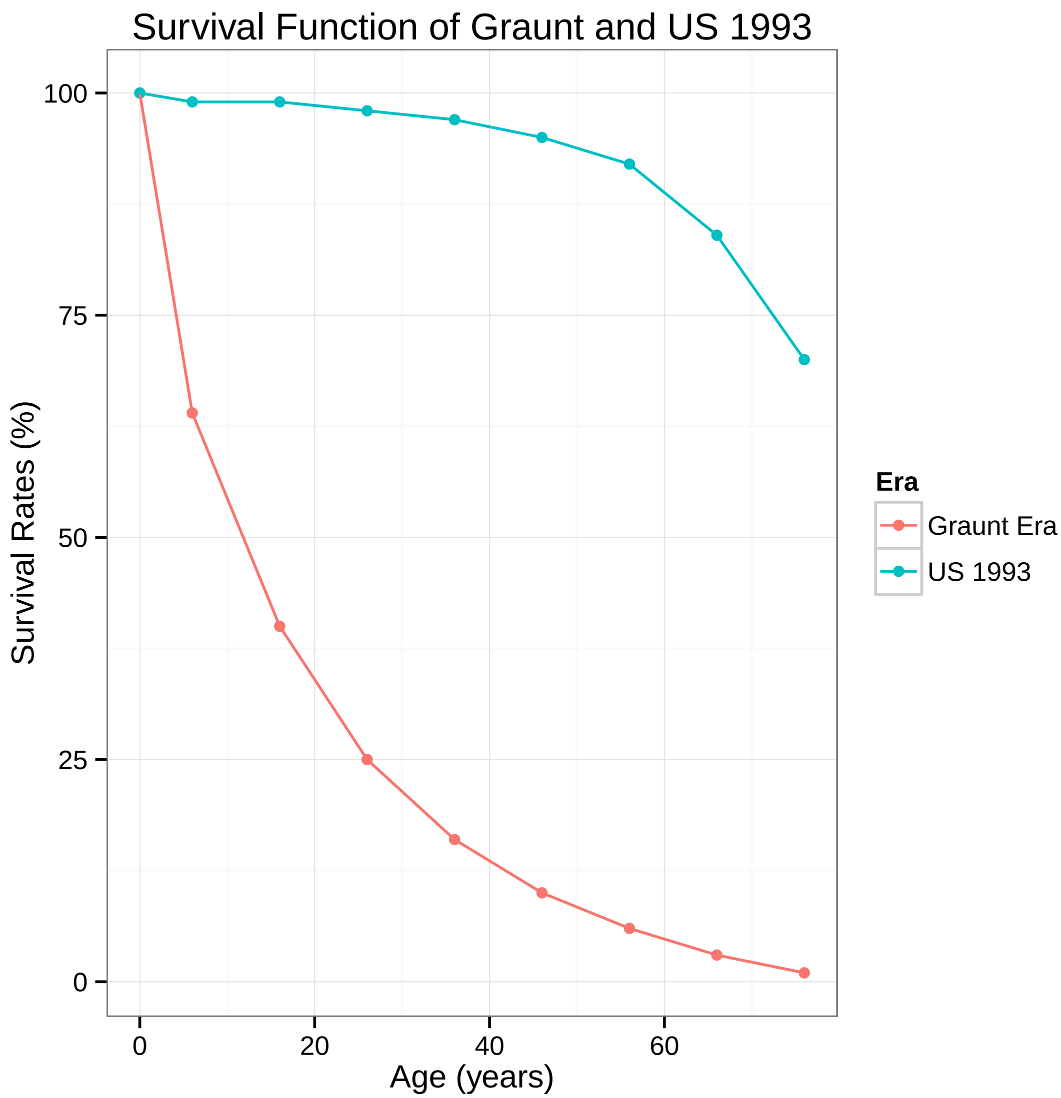
3. Change legend title

```
(g4 <- g3 +
   xlab(x.lab) +
   ylab(y.lab) +
   ggtitle(main.title.g.us) +
   labs(colour = "Era"))
```



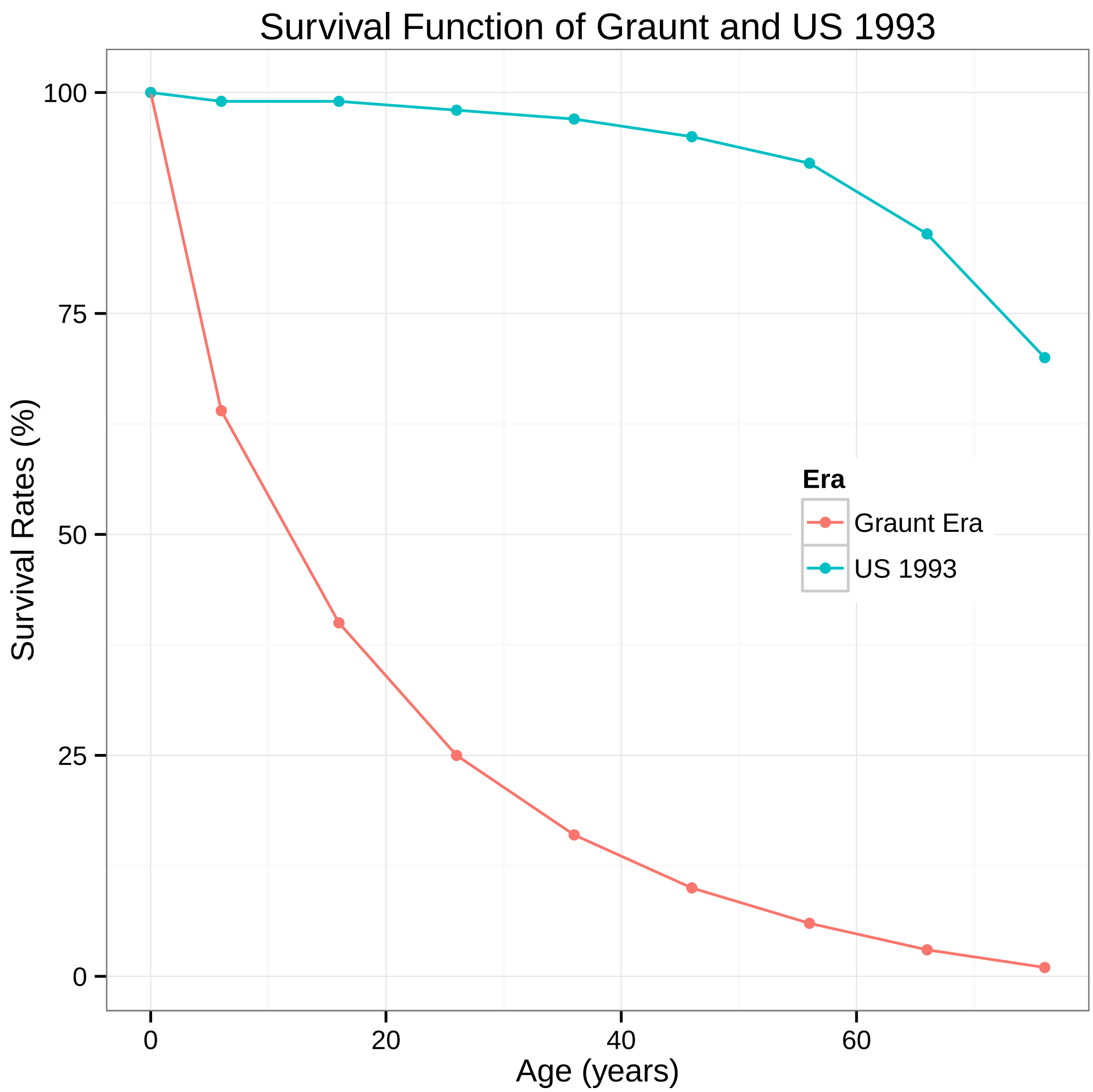
4. Change legends.

```
(g4 <- g3 +
   xlab(x.lab) +
   ylab(y.lab) +
   ggtitle(main.title.g.us) +
   labs(colour = "Era") +
   scale_colour_discrete(labels = c("Graunt Era", "US 1993")))
```



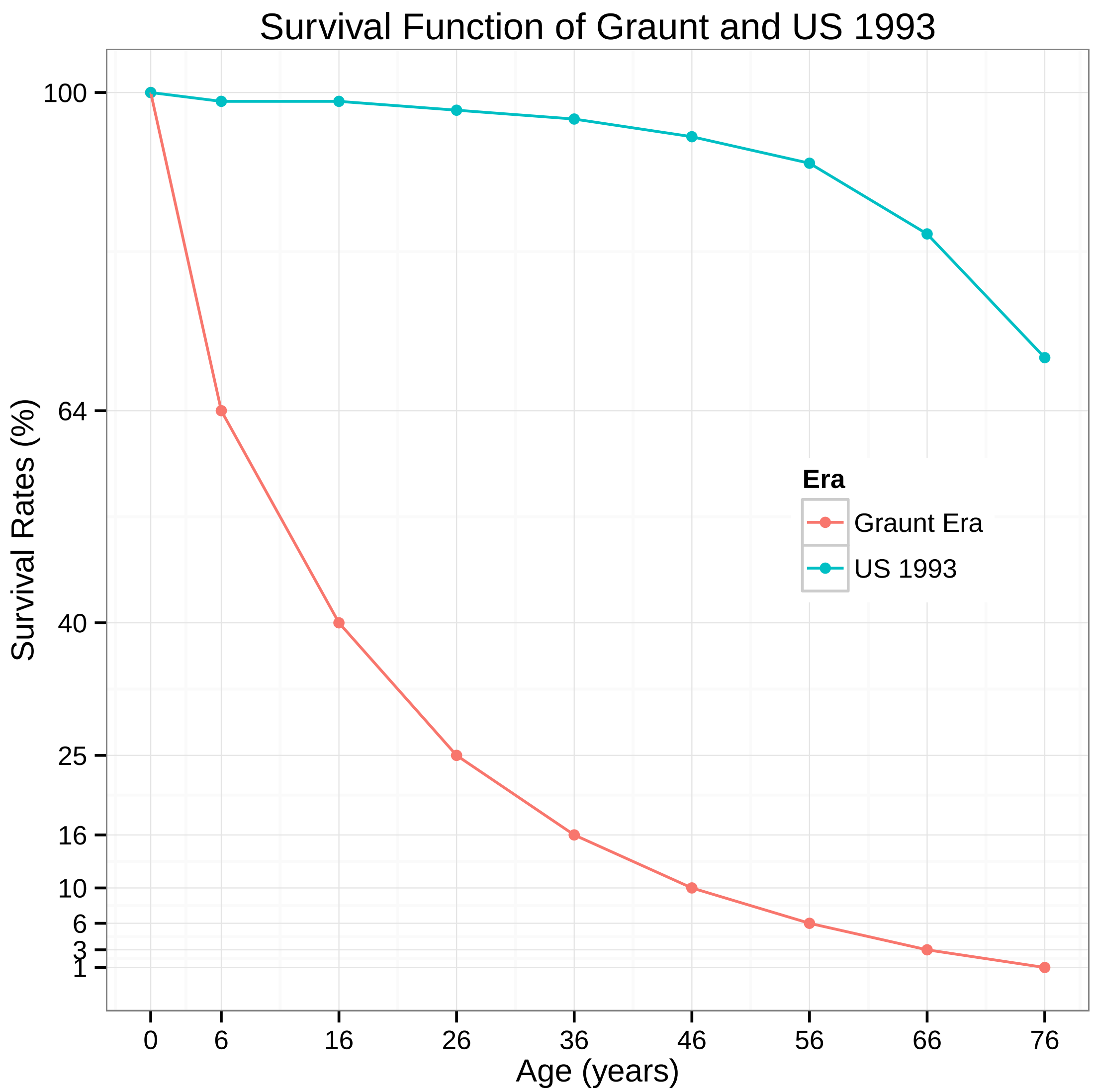
5. Place legends inside the plot

```
(g5 <- g4 +
   theme(legend.position = c(0.8, 0.5)))
```



6. Change x-axis and y-axis tick marks

```
(g6 <- g5 +
   scale_x_continuous(breaks = graunt$x) + scale_y_continuous(breaks = graunt$lx.17th))
```




```
ggsave("../pics/graunt_us_plot.png", g6)
```

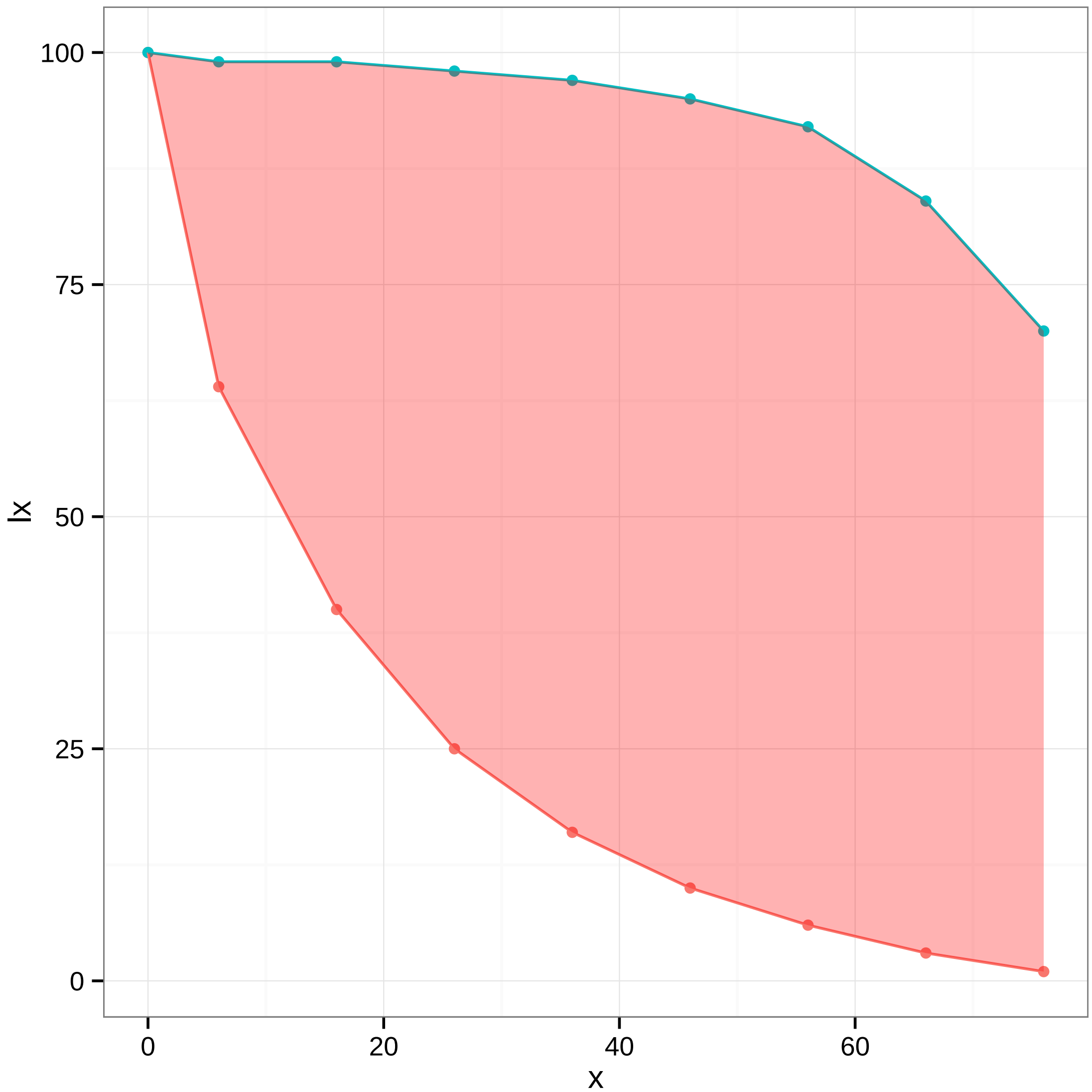
```
## Saving 6 x 6 in image
```

Polygon

Add information to the plot drawn with `polygon()`

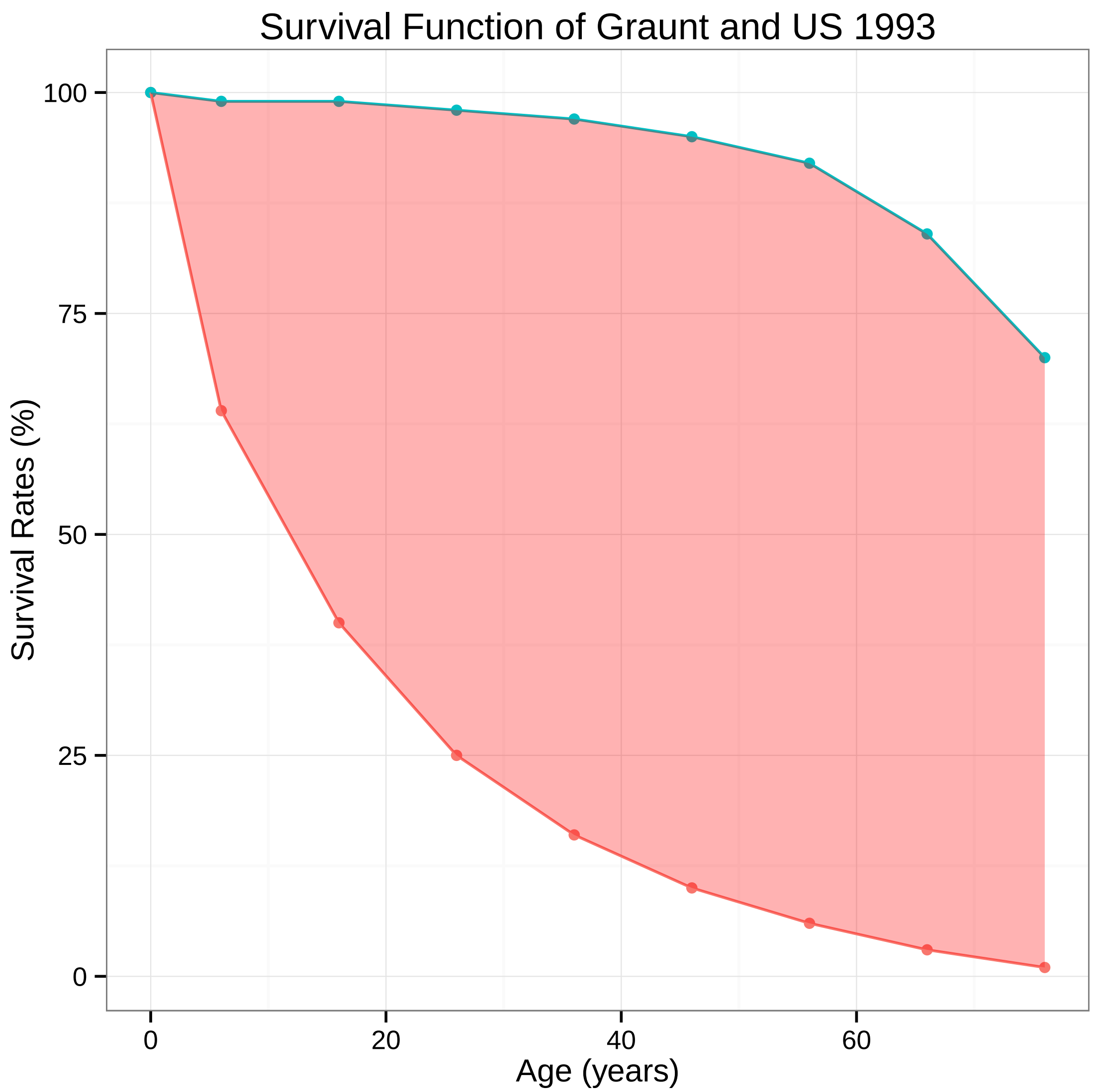
1. Start with `p4`

```
p4
```



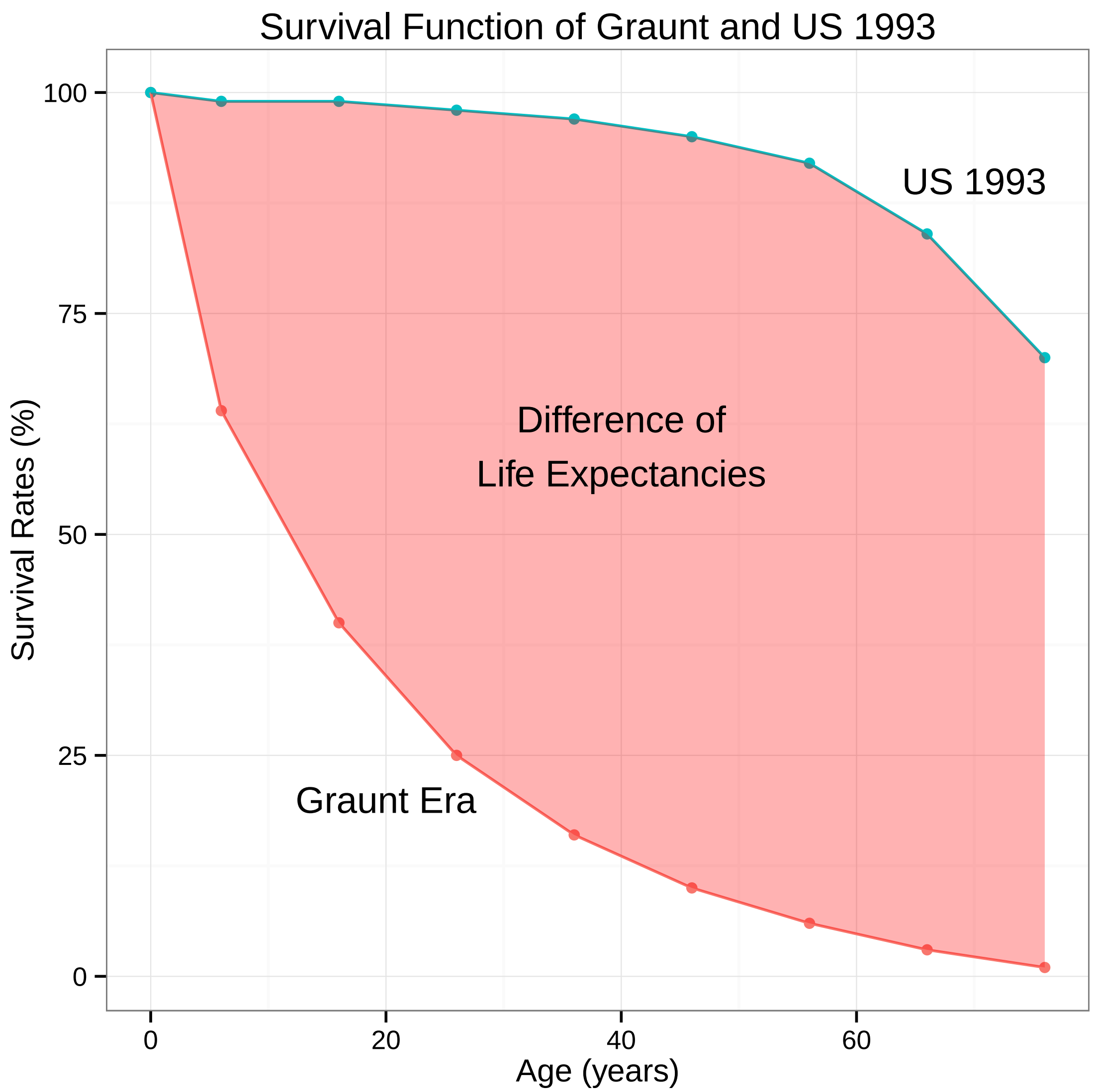
2. Main title, x-axis and y-axis labels

```
(p5 <- p4 +
   xlab(x.lab) +
   ylab(y.lab) +
   ggtitle(main.title.g.us))
```



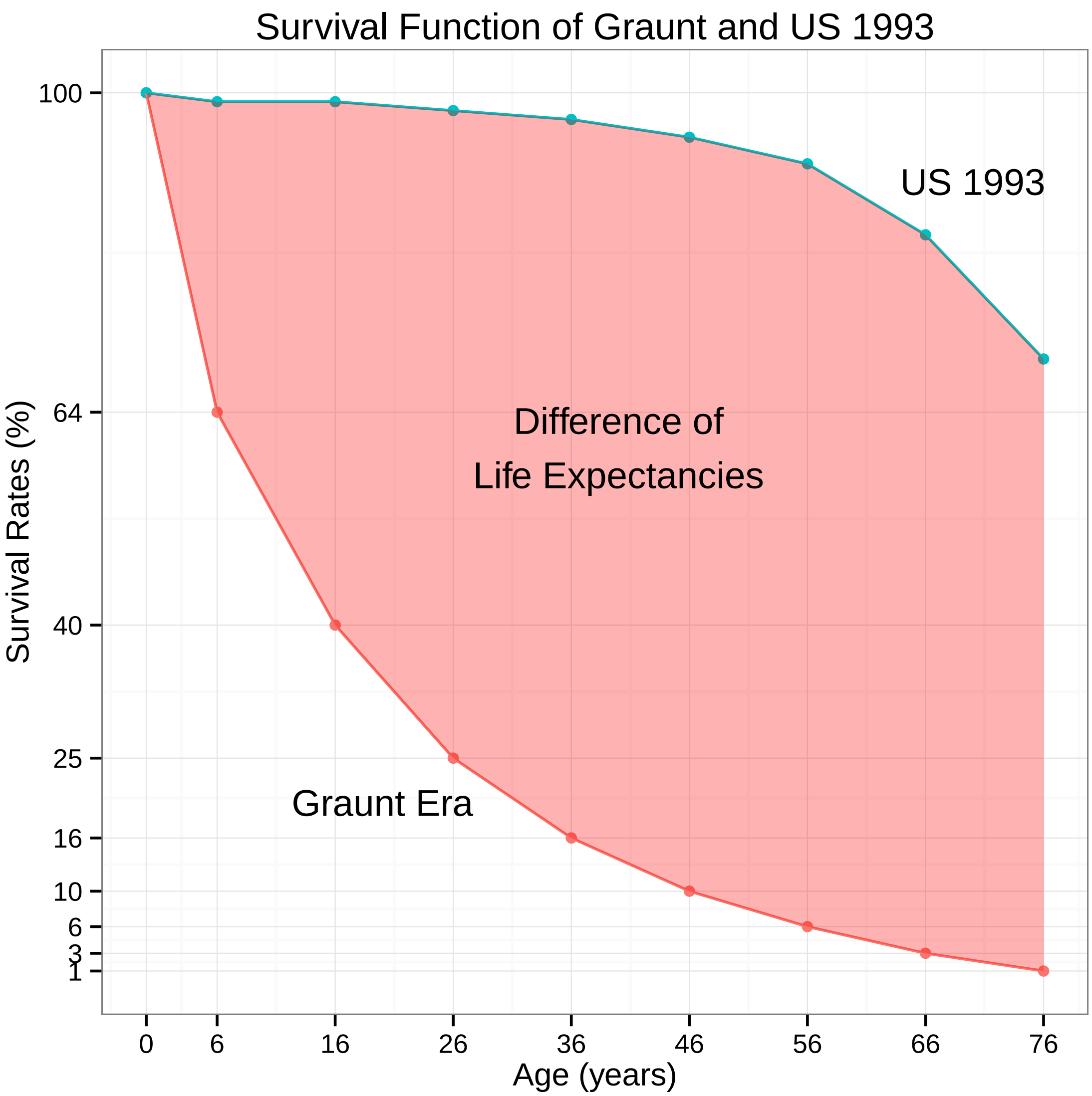
3. "Graunt Era", "US 1993", "Difference of Life Expectancies" at proper positions

```
(p6 <- p5 +
   annotate("text", x = c(20, 40, 70), y = c(20, 60, 90), label = c("Graunt Era", "Difference of\nLife E
```



4. x-axis and y-axis tick marks

```
(p7 <- p6 +
   scale_x_continuous(breaks = graunt$x) + scale_y_continuous(breaks = graunt$lx.17th))
```




```
ggsave("../pics/graunt_us_poly.png", p7)
```

```
## Saving 6 x 6 in image
```

Graunt and Halley

Data Reshaping

Since the observed ages are different, we need to final structure of the data frame to be melted. So, create copies of `graunt` and `halley` and extract parts of what we need and give feasible names.

```
graunt.2 <- graunt
names(graunt.2) <- c("x", "Graunt")
halley.2 <- halley[-2]
names(halley.2) <- c("x", "Halley")
graunt.halley.melt <- melt(list(graunt.2, halley.2), id.vars = "x", value.name = "lx", variable.name =
str(graunt.halley.melt)
```

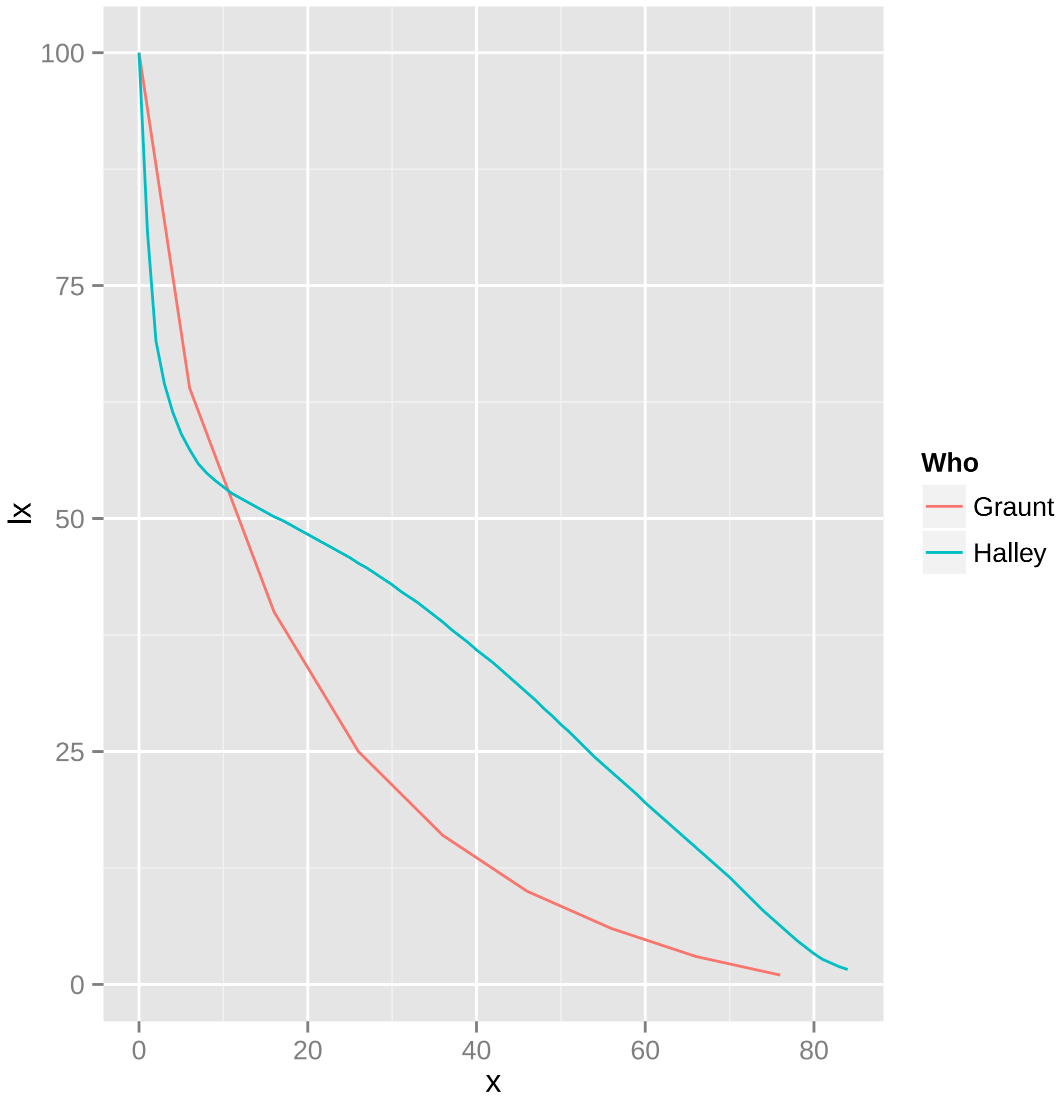
```
## 'data.frame':    94 obs. of  4 variables:
##  $ x  : num  0 6 16 26 36 46 56 66 76 0 ...
##  $ Who: Factor w/ 2 levels "Graunt","Halley": 1 1 1 1 1 1 1 1 1 2 ...
##  $ lx : num  100 64 40 25 16 10 6 3 1 100 ...
##  $ L1 : int  1 1 1 1 1 1 1 1 1 2 ...
```

```
graunt.halley.melt <- graunt.halley.melt[-4]
graunt.halley.melt.g <- subset(graunt.halley.melt, graunt.halley.melt$x %in% graunt$x)
head(graunt.halley.melt.g, n = 20)
```

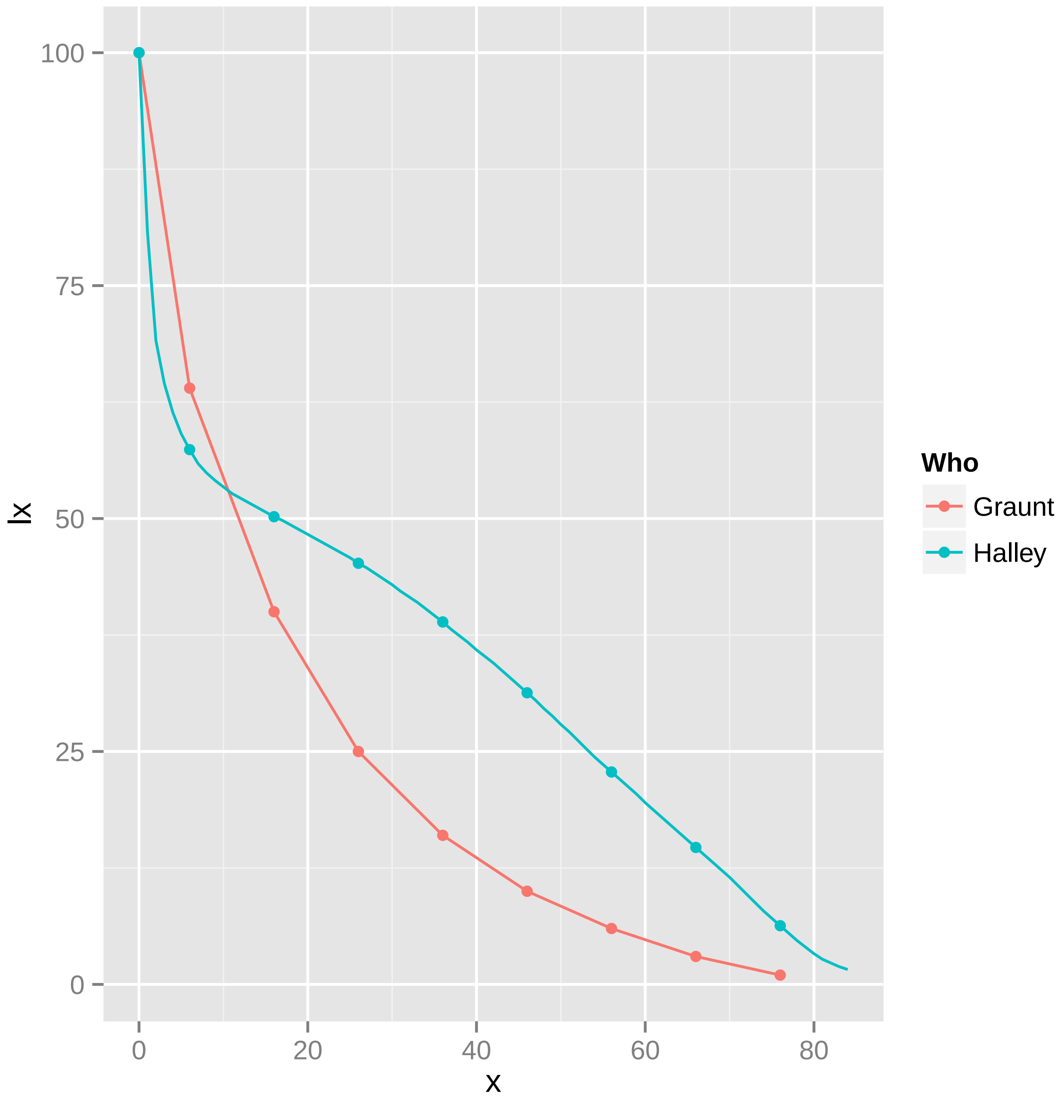
```
##     x    Who    lx
## 1   0 Graunt 100.0
## 2   6 Graunt  64.0
## 3  16 Graunt  40.0
## 4  26 Graunt  25.0
## 5  36 Graunt  16.0
## 6  46 Graunt  10.0
## 7  56 Graunt   6.0
## 8  66 Graunt   3.0
## 9  76 Graunt   1.0
## 10  0 Halley 100.0
## 16  6 Halley  57.4
## 26 16 Halley  50.2
## 36 26 Halley  45.2
## 46 36 Halley  38.9
## 56 46 Halley  31.3
## 66 56 Halley  22.8
## 76 66 Halley  14.7
## 86 76 Halley   6.3
```

Survival Function, Step by Step

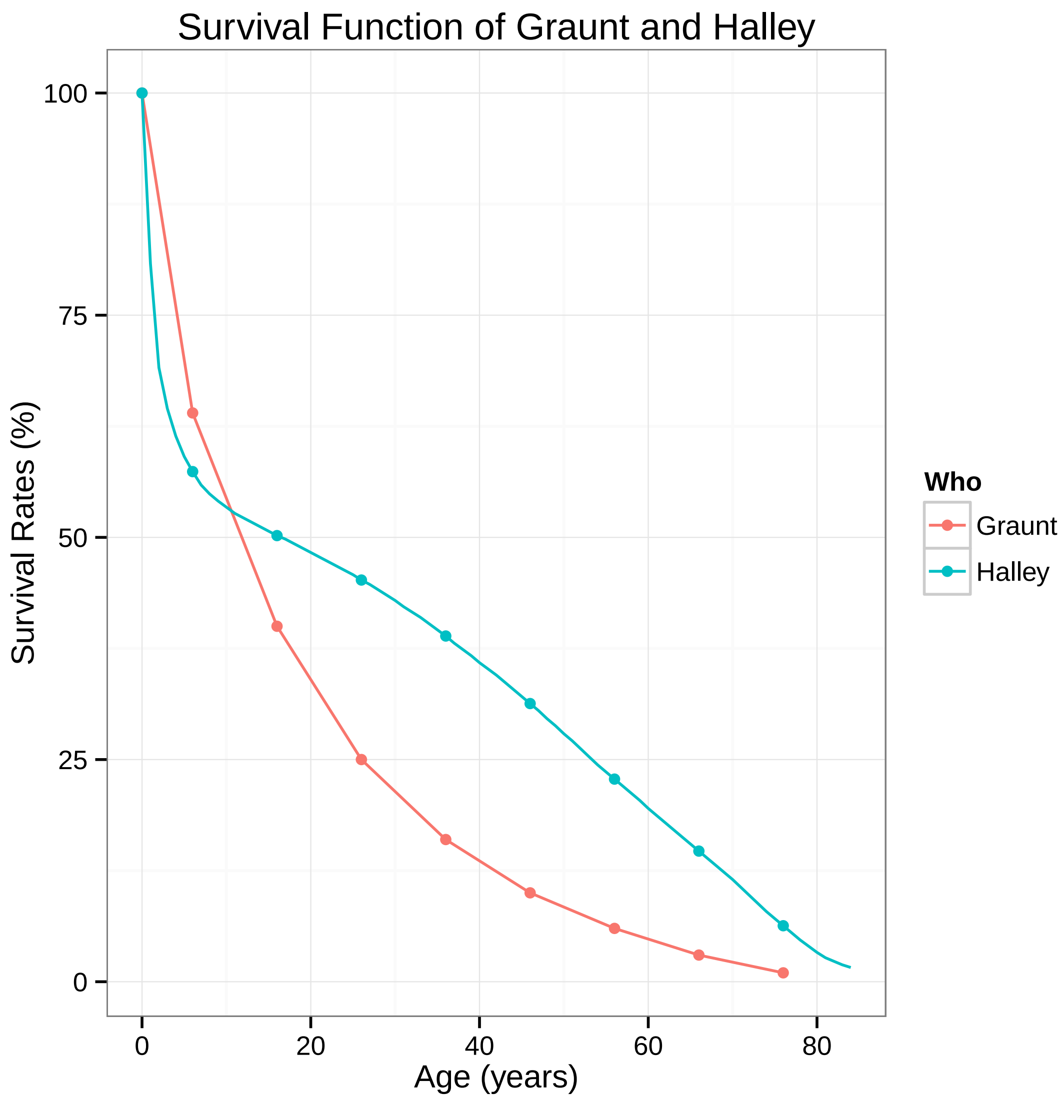
```
gh1 <- ggplot() +
  geom_line(data = graunt.halley.melt, aes(x = x, y = lx, colour = Who)) +
  theme.pdf
gh1
```



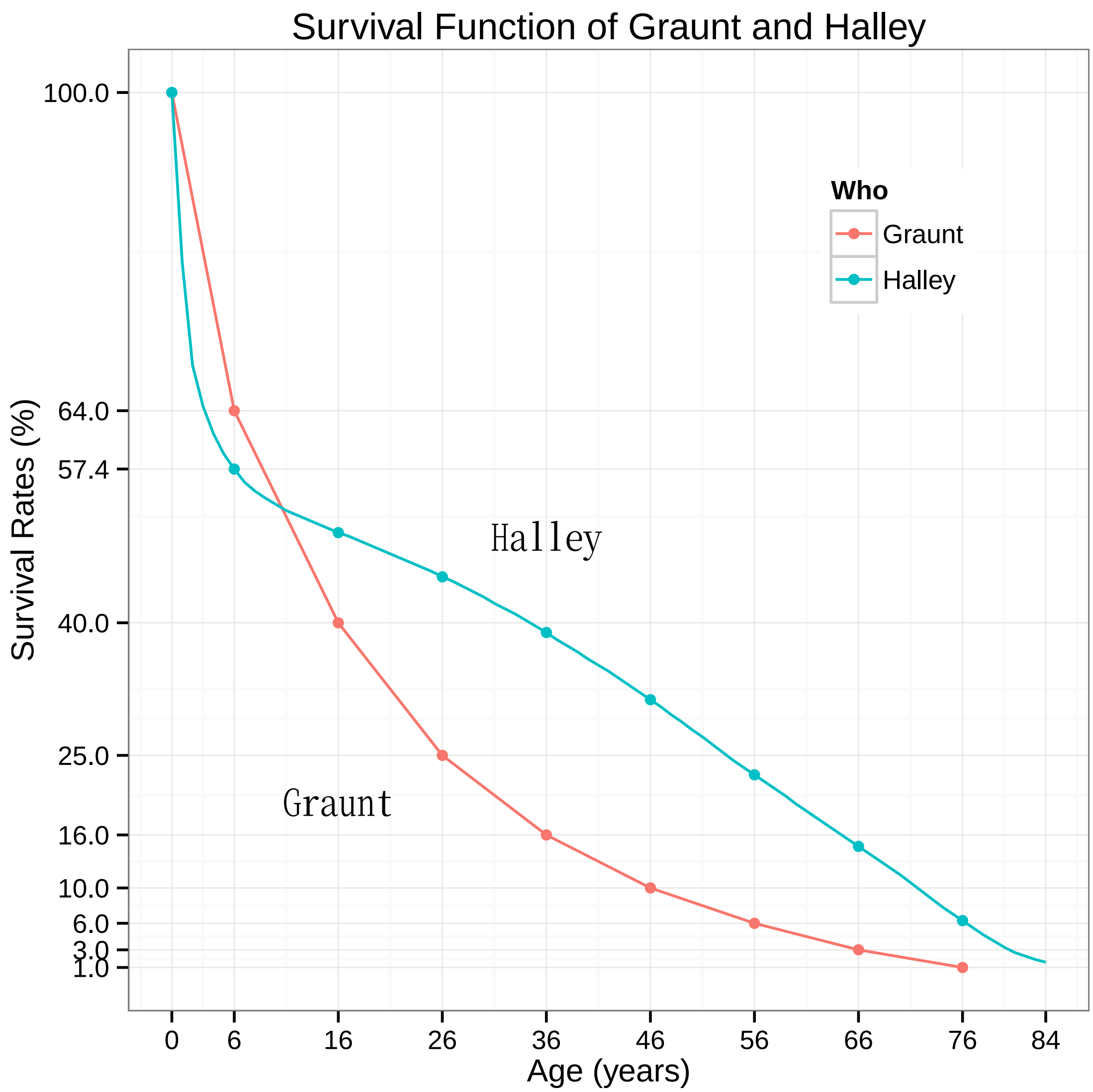

```
gh2 <- gh1 +
  geom_point(data = graunt.halley.melt.g, aes(x = x, y = lx, colour = Who))
gh2
```




```
gh3 <- gh2 +
  theme_bw() +
  theme.pdf +
  xlab(x.lab) +
    ylab(y.lab) +
  ggtitle(main.title.2)
gh3
```




```
gh4 <- gh3 +
  theme(legend.position = c(0.8, 0.8)) +
  annotate("text", x = c(16, 36), y = c(20, 50), label = c("Graunt", "Halley")) +
  scale_x_continuous(breaks = c(graunt$x, 84)) +
  scale_y_continuous(breaks = c(graunt$lx.17th, halley$px[halley$age == 6]))
gh4
```

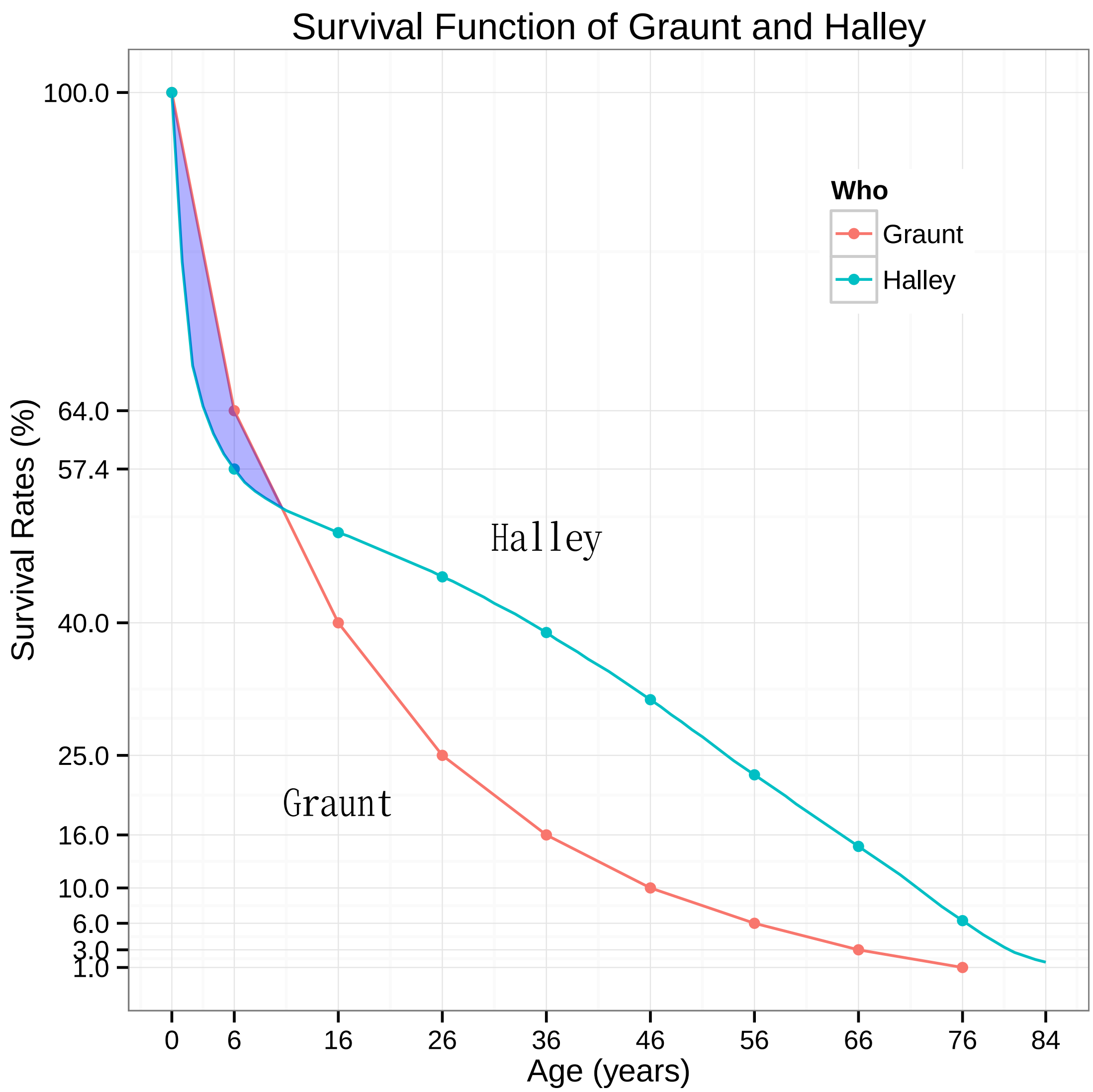



```r
ggsave("../pics/graunt_halley_ggplot.png", gh4)
```

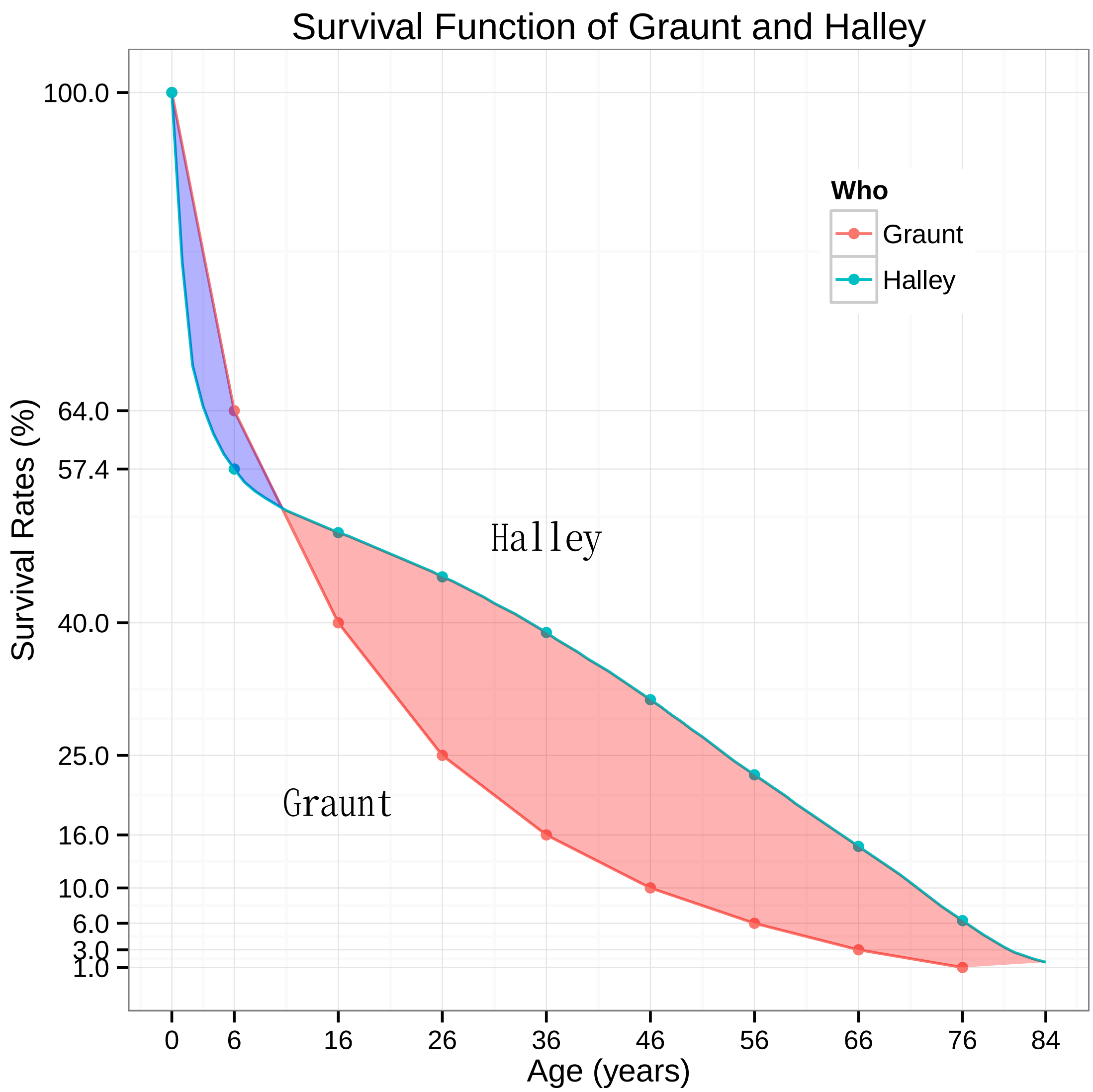
```
## Saving 6 x 6 in image
```

Polygon

```r
ghp4 <- gh4 +
  geom_polygon(data = data.frame(x = poly.1.x, y = poly.1.y), aes(x = x, y = y), alpha = 0.3, fill = "bl
ghp4
```




```
ghp5 <- ghp4 +
  geom_polygon(data = data.frame(x = poly.2.x, y = poly.2.y), aes(x = x, y = y), alpha = 0.3, fill = "re
ghp5
```




```
ggsave("../pics/graunt_halley_poly_ggplot.png", ghp5)
```

```
## Saving 6 x 6 in image
```

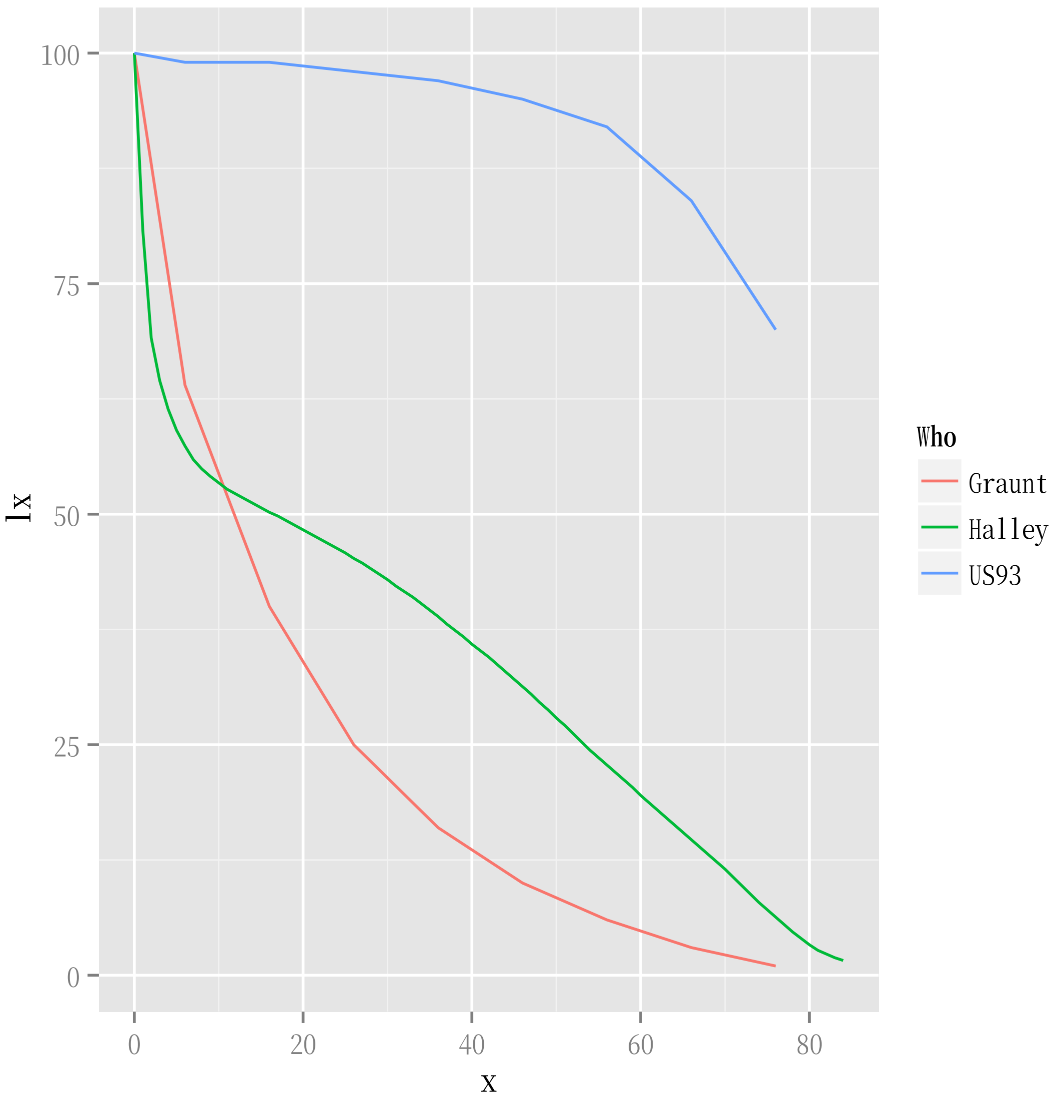
Graunt, Halley, and US93

Data Reshape

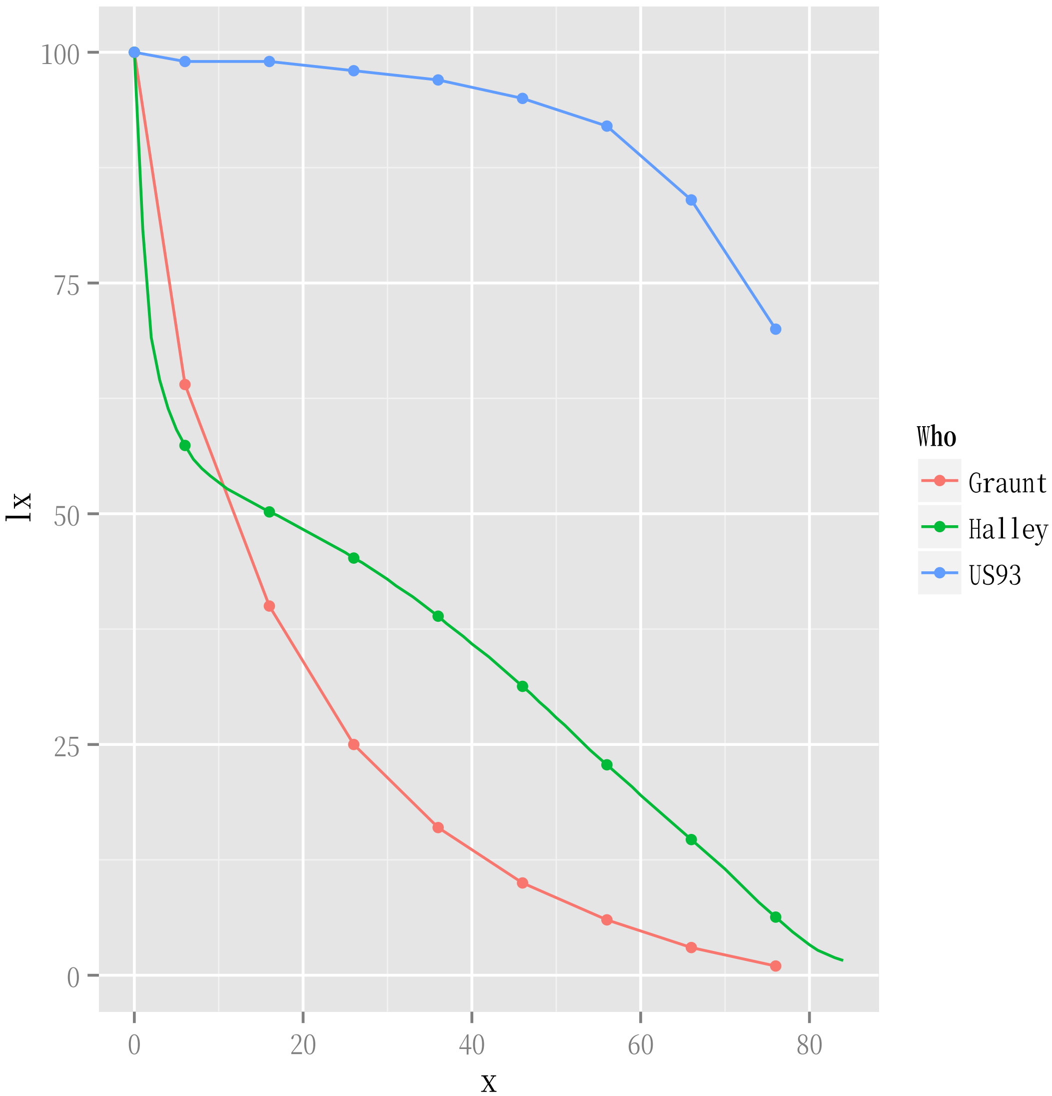
```
us93.2 <- us.93
names(us93.2) <- c("x", "US93")
ghu.melt <- melt(list(graunt.2, halley.2, us93.2), id.vars = "x", value.name = "lx", variable.name = "Wh
ghu.melt.g <- ghu.melt[ghu.melt$x %in% graunt$x, ]
main.title.3 <- "Survival Function Plots"
```

Survival Function Plots with ggplot

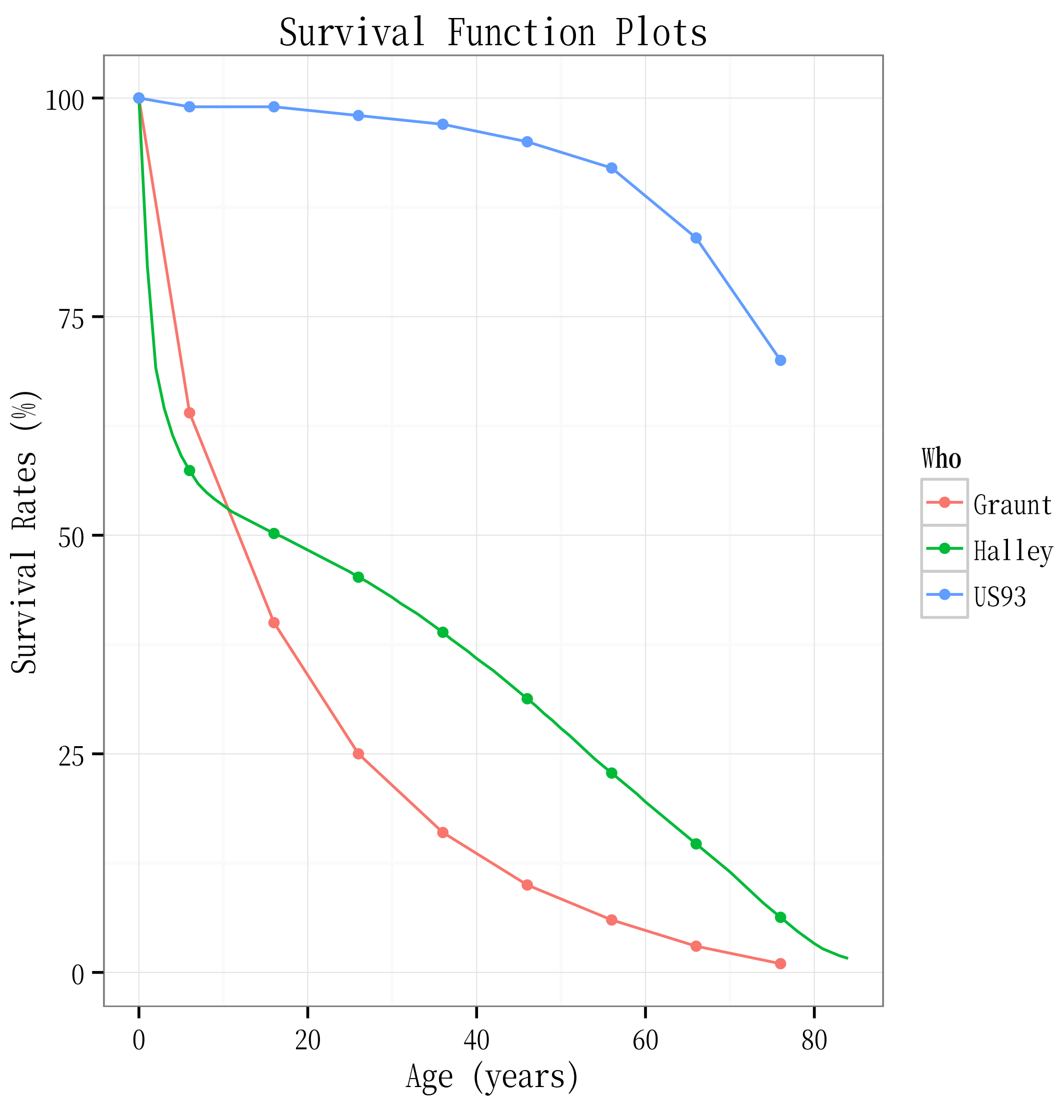
```
(ghu1 <- ggplot() +
  geom_line(data = ghu.melt, aes(x = x, y = lx, colour = Who)))
```



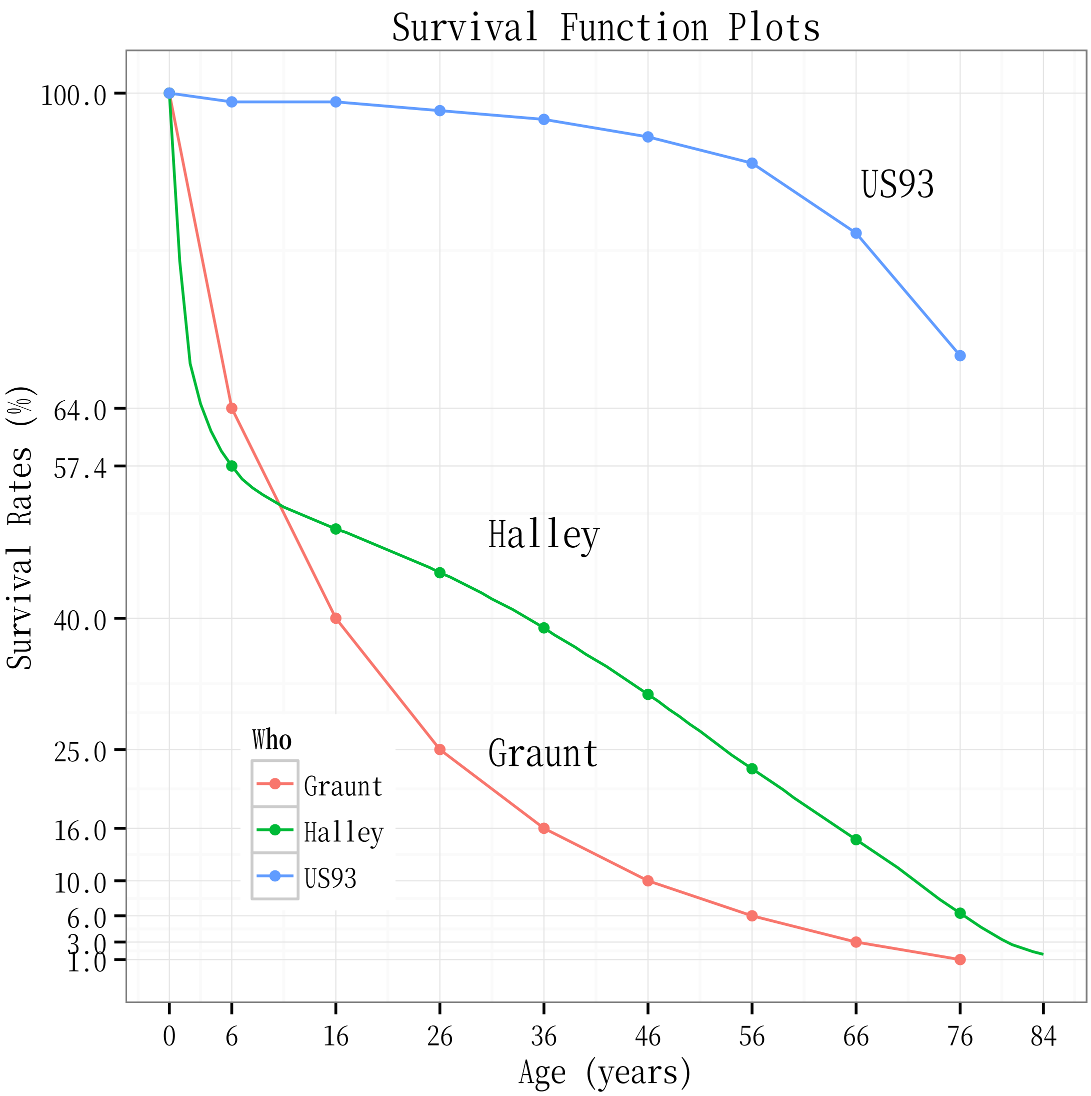

```
(ghu2 <- ghu1 +
  geom_point(data = ghu.melt.g, aes(x = x, y = lx, colour = Who)))
```




```
(ghu3 <- ghu2 +
  theme_bw() +
  xlab(x.lab) +
  ylab(y.lab) +
  ggtitle(main.title.3))
```




```
(ghu4 <- ghu3 +
  theme(legend.position = c(0.2, 0.2)) +
  annotate("text", x = c(36, 36, 70), y = c(25, 50, 90), label = c("Graunt", "Halley", "US93")) +
  scale_x_continuous(breaks = c(graunt$x, 84)) +
  scale_y_continuous(breaks = c(graunt$lx.17th, halley$px[halley$age == 6])))
```




```
ggsave("../pics/graunt_halley_us_ggplot.png", ghu4)
```

```
## Saving 6 x 6 in image
```

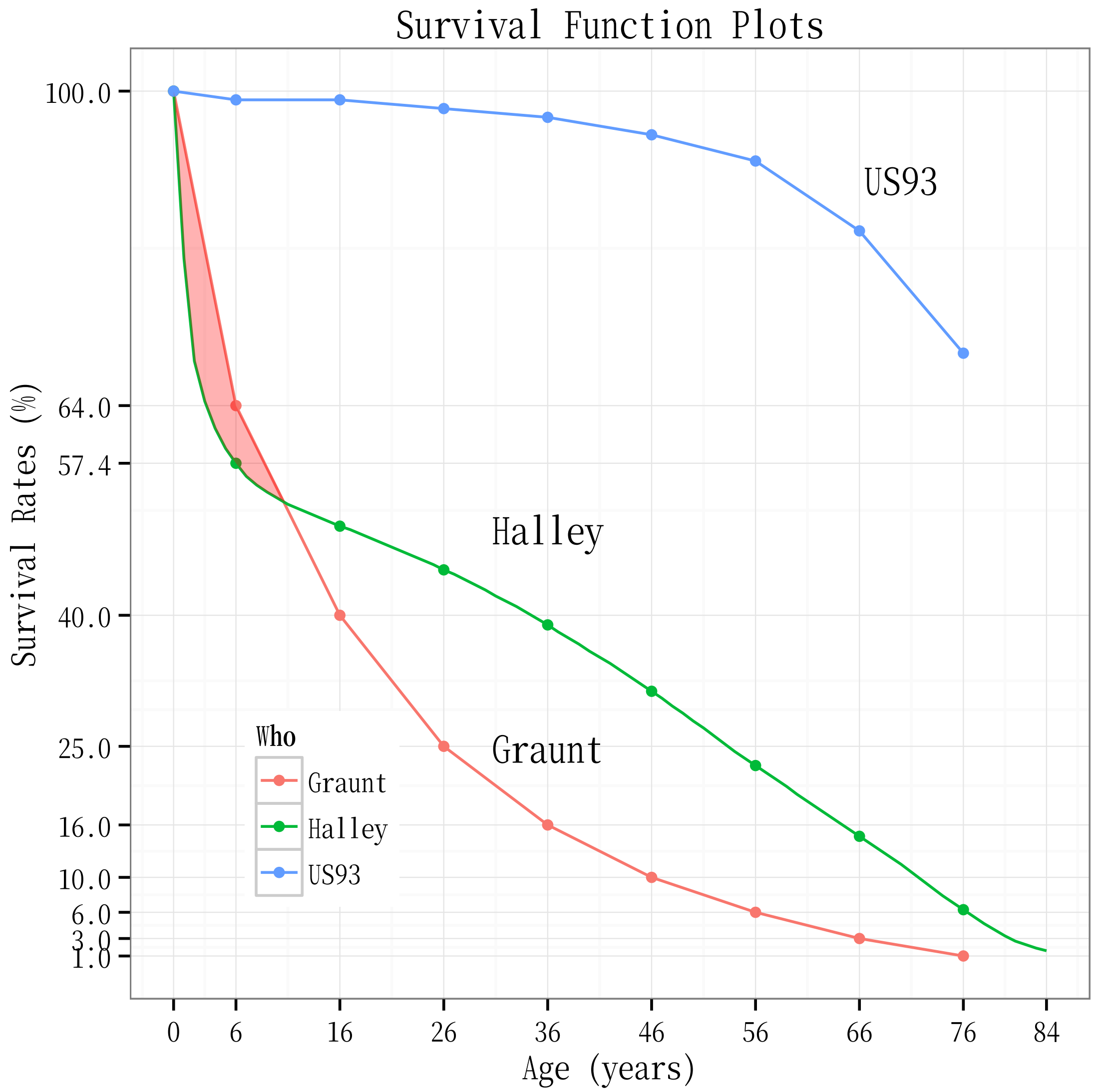
Polygon

Coordinates

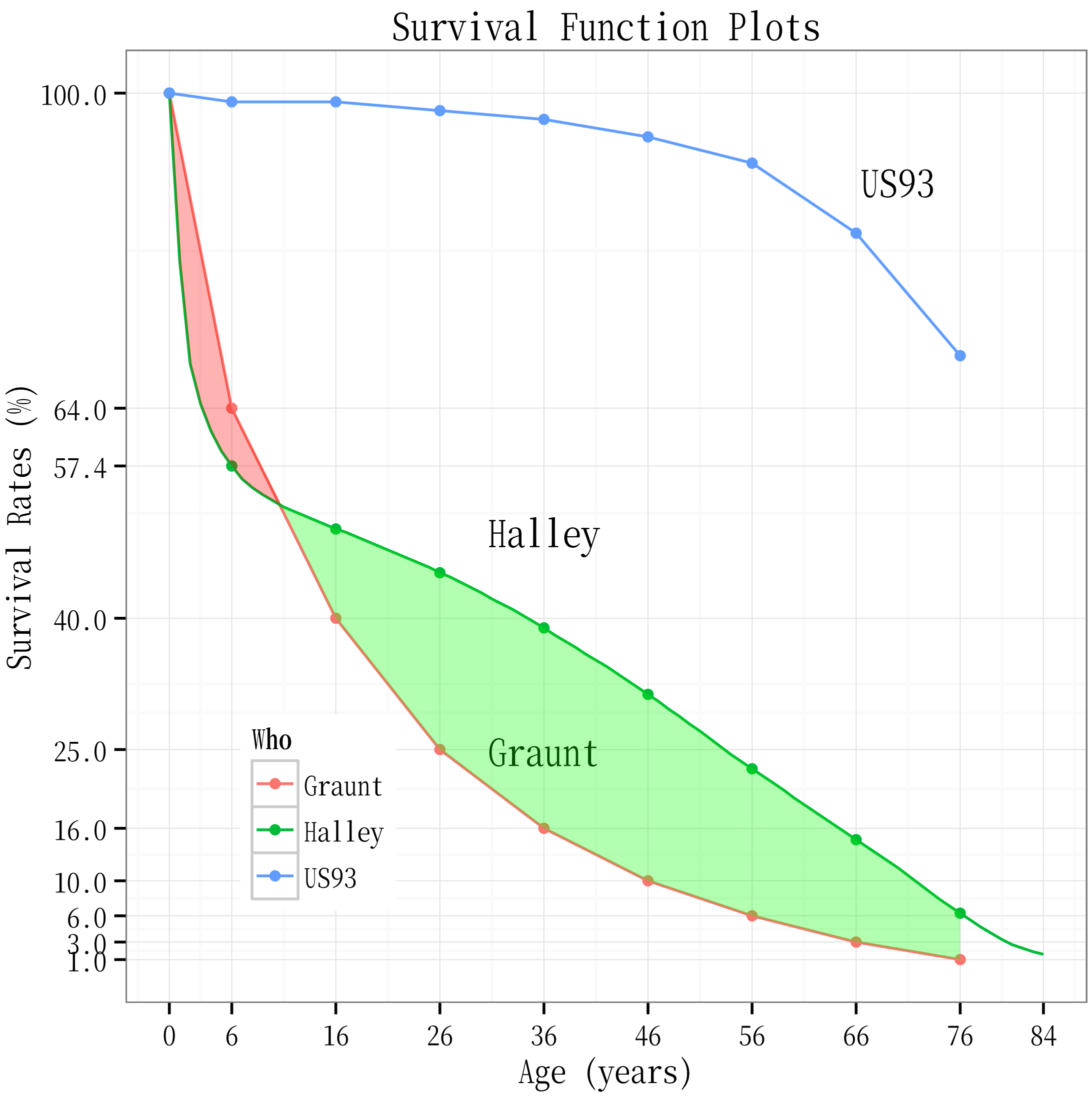
In order to make the graphs truncated at the age 76, restrict the age of Halley up to 76.

```
poly.lower.76 <- subset(poly.lower, poly.lower$x <= 76)
poly.3.x <- c(us93.2$x, halley.2$x[85:12], 10.8, graunt.2$x[2:1])
poly.3.y <- c(us93.2$US93, halley.2$Halley[85:12], 52.8, graunt.2$Graunt[2:1])
poly.us <- data.frame(x = poly.3.x, y = poly.3.y)
poly.us.76 <- subset(poly.us, poly.us$x <= 76)
```

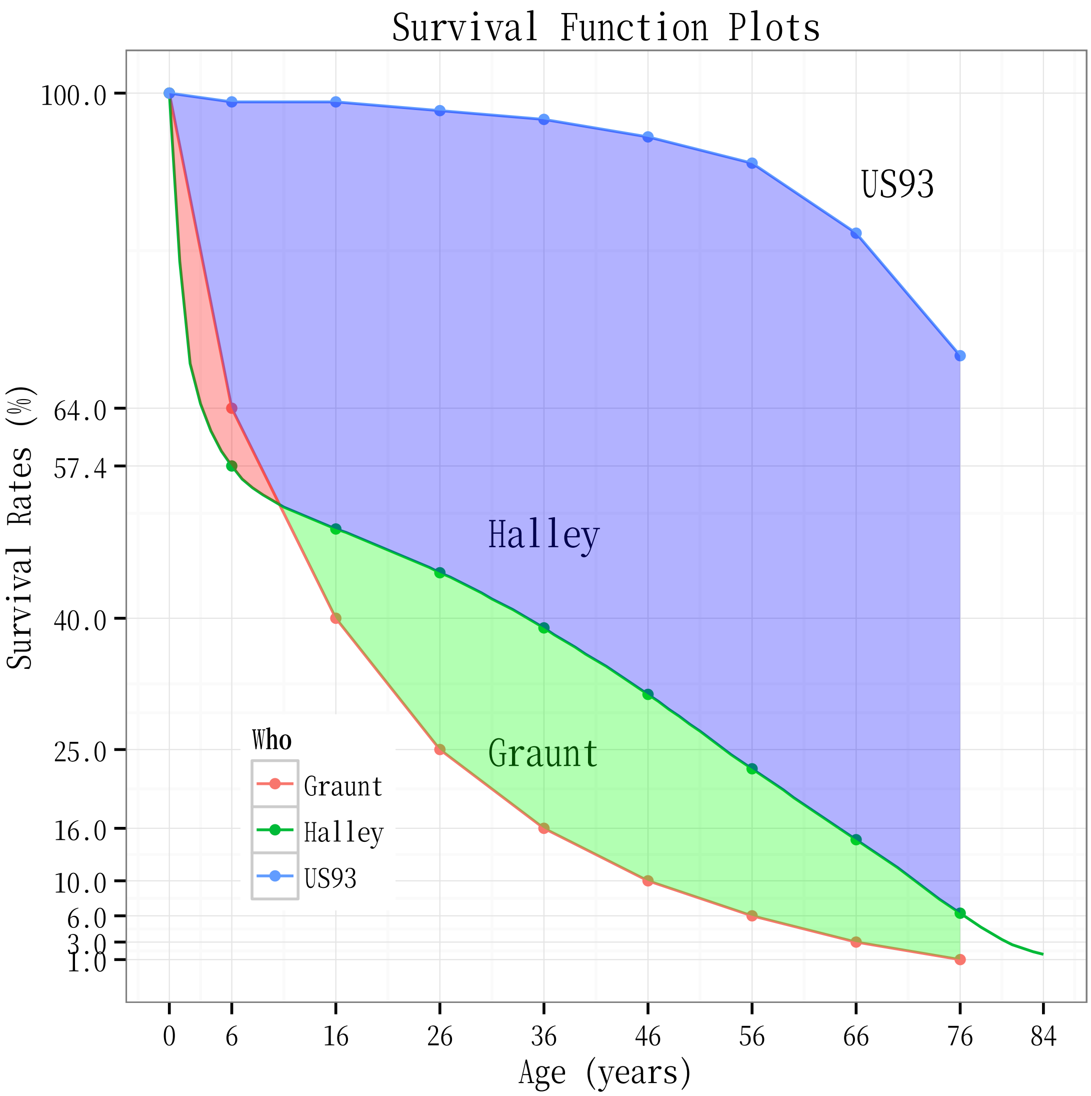
```
(ghup4 <- ghu4 +
  geom_polygon(data = poly.upper, aes(x = x, y = y), alpha = 0.3, fill = "red"))
```



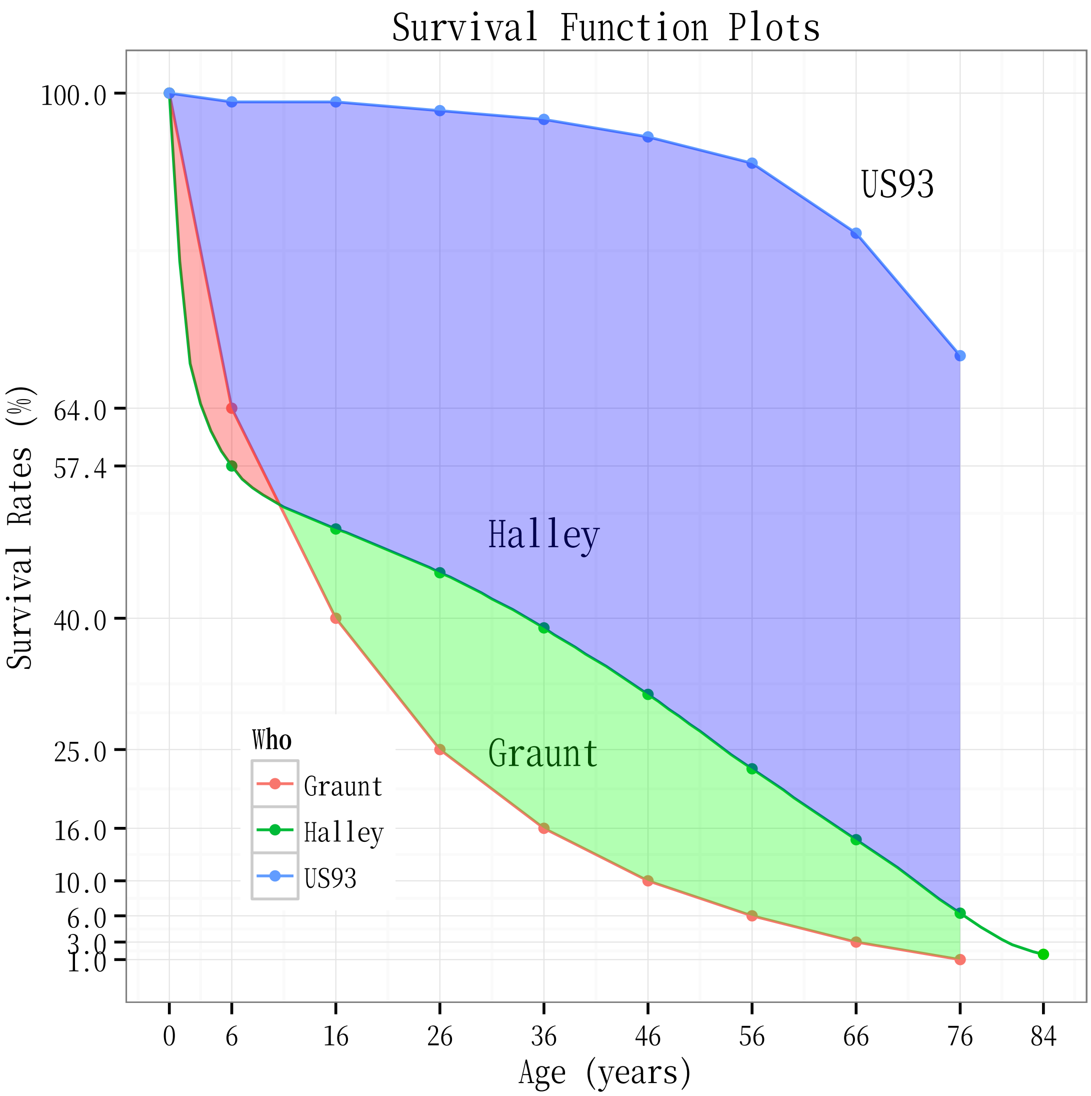

```
(ghup5 <- ghup4 +
  geom_polygon(data = poly.lower.76, aes(x = x, y = y), alpha = 0.3, fill = "green"))
```




```
(ghup6 <- ghup5 +
  geom_polygon(data = poly.us.76, aes(x = x, y = y), alpha = 0.3, fill = "blue"))
```




```
(ghup7 <- ghup6 +
  geom_point(data = data.frame(x = 84, y = halley$px[85]), aes(x = x, y = y),  colour = 3))
```




```r
ggsave("../pics/graunt_halley_us_poly_ggplot.png", ghup7)
```

```
## Saving 6 x 6 in image
```

dump() and source()

- Check out how to save and retrieve. Use `source()` and `load()` for retrieval.

```r
dump("area.R", file = "area.R")
save.image("graunt_halley_160329.rda")
```