lemmings

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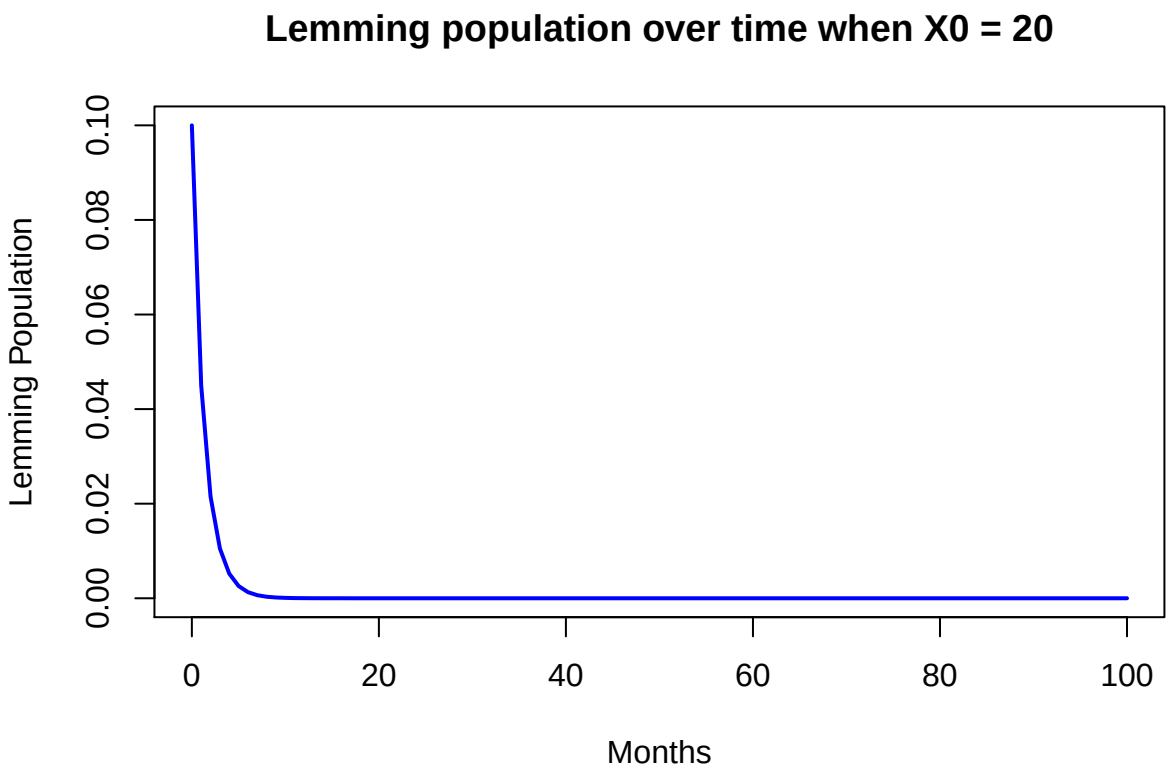
Exercise 1

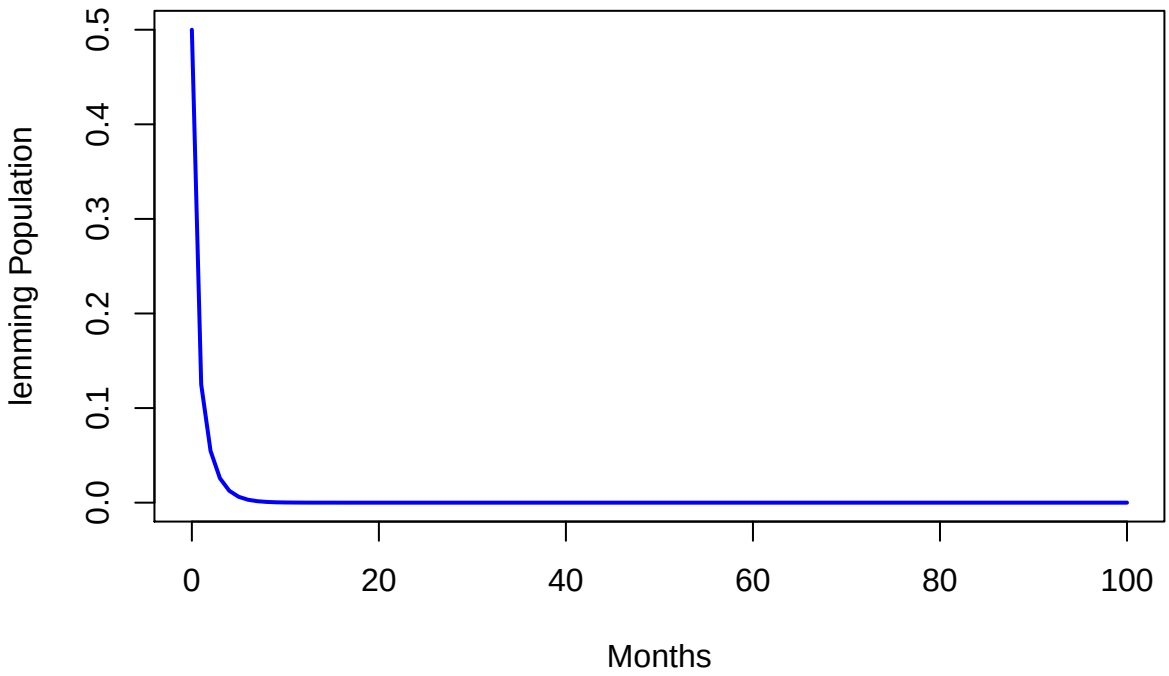
```
lemming_population <- function(r, X0, n) {
  Ls <- vector(length=n+1)
  # initialize the initial population
  Ls[1] <- X0
  for (i in 2:(n + 1)) {
    Ls[i] <- r * Ls[i - 1] * (1 - Ls[i - 1])
  }
  # output should be an array of n + 1 elements
  return(Ls)
}
```

Plotting graphs

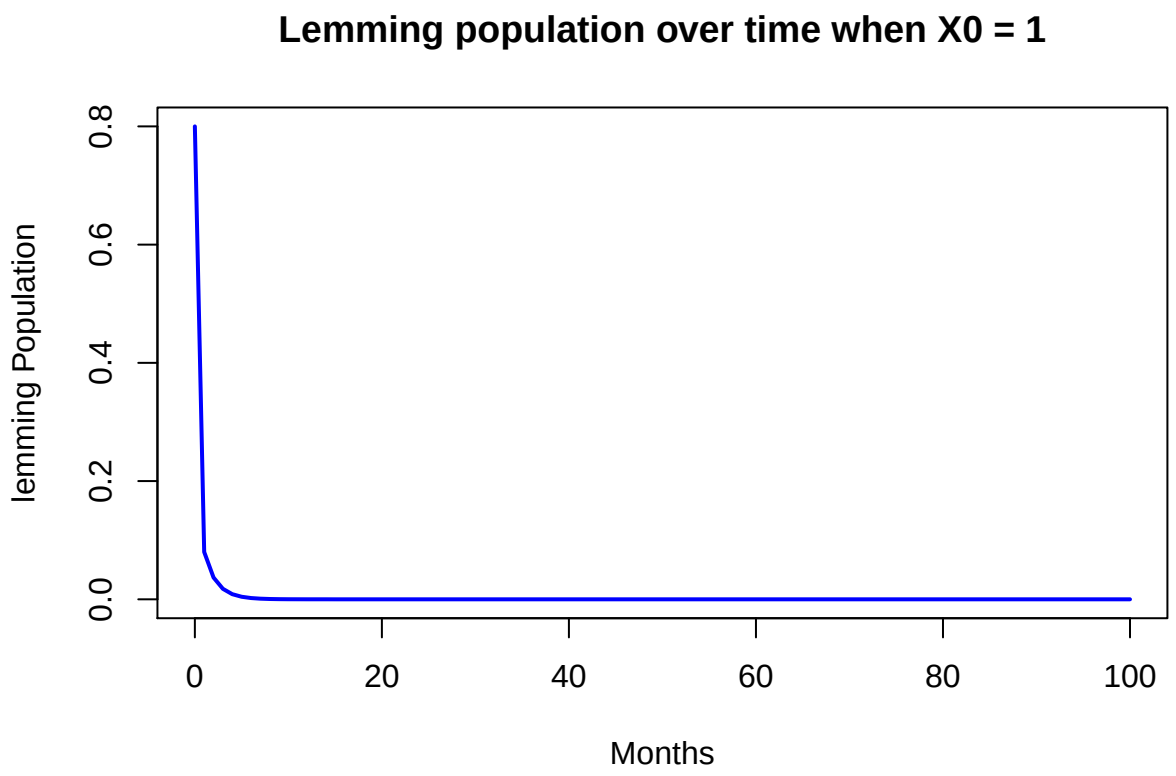
```
# 0 < r < 1
r <- 0.5
n <- 100
times <- seq(0, n)

X0 <- 0.1

lem_pop_1 <- lemming_population(r, X0, n)

X0 <- 0.5

lem_pop_2 <- lemming_population(r, X0, n)

X0 <- 0.8

lem_pop_3 <- lemming_population(r, X0, n)

plot(times, lem_pop_1,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "Lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_1)),
     main = "Lemming population over time when X0 = 20")
```



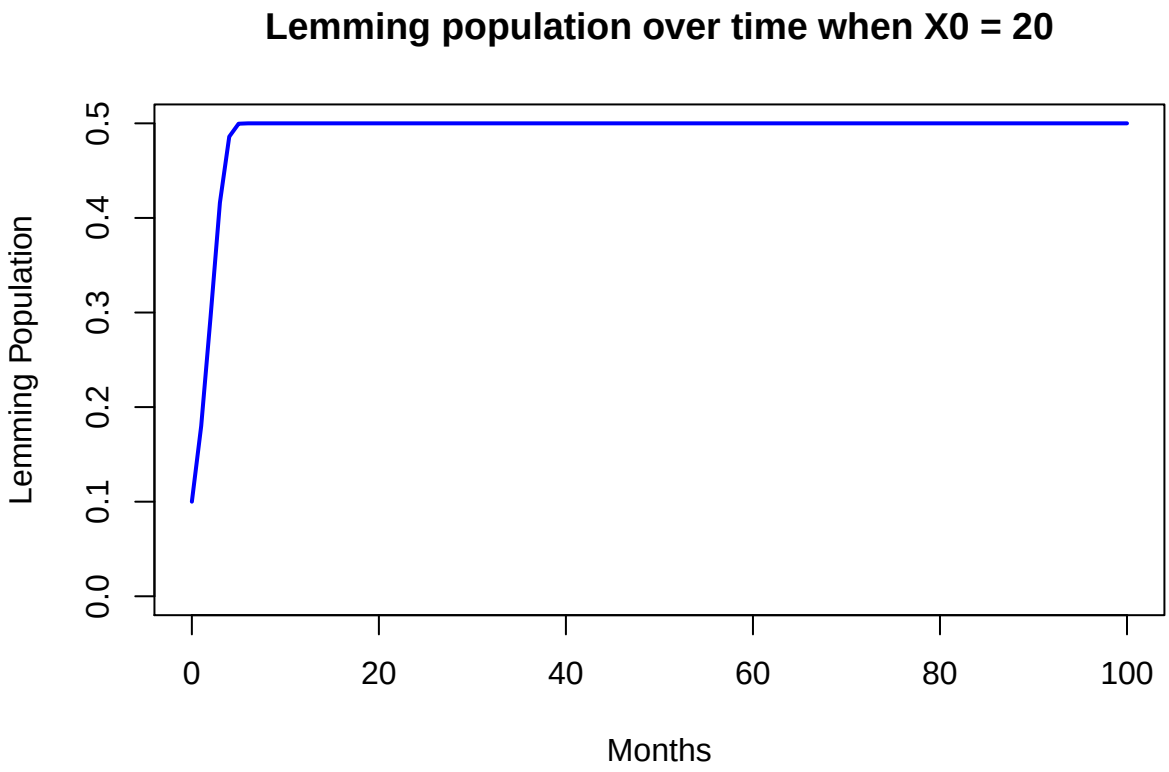

```
plot(times, lem_pop_2,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_2)),
     main = "Lemming population over time when X0 = 5")
```



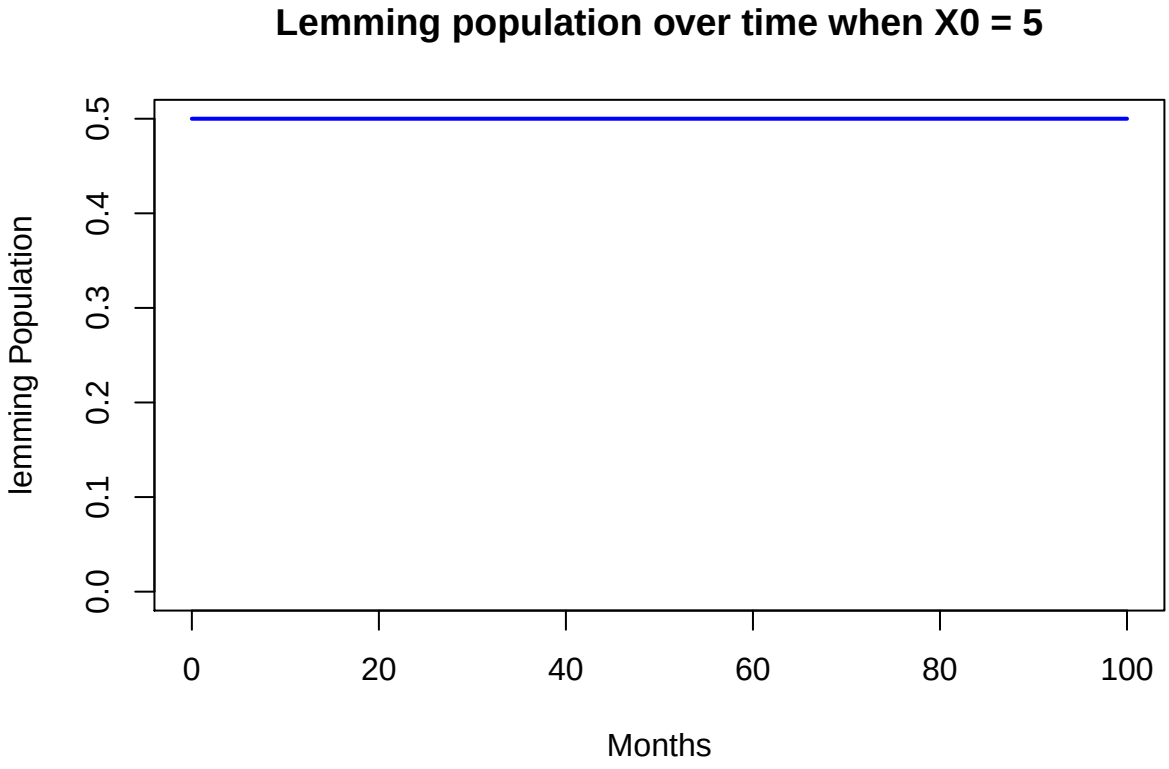
```r
plot(times, lem_pop_3,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_3)),
     main = "Lemming population over time when X0 = 1")
```



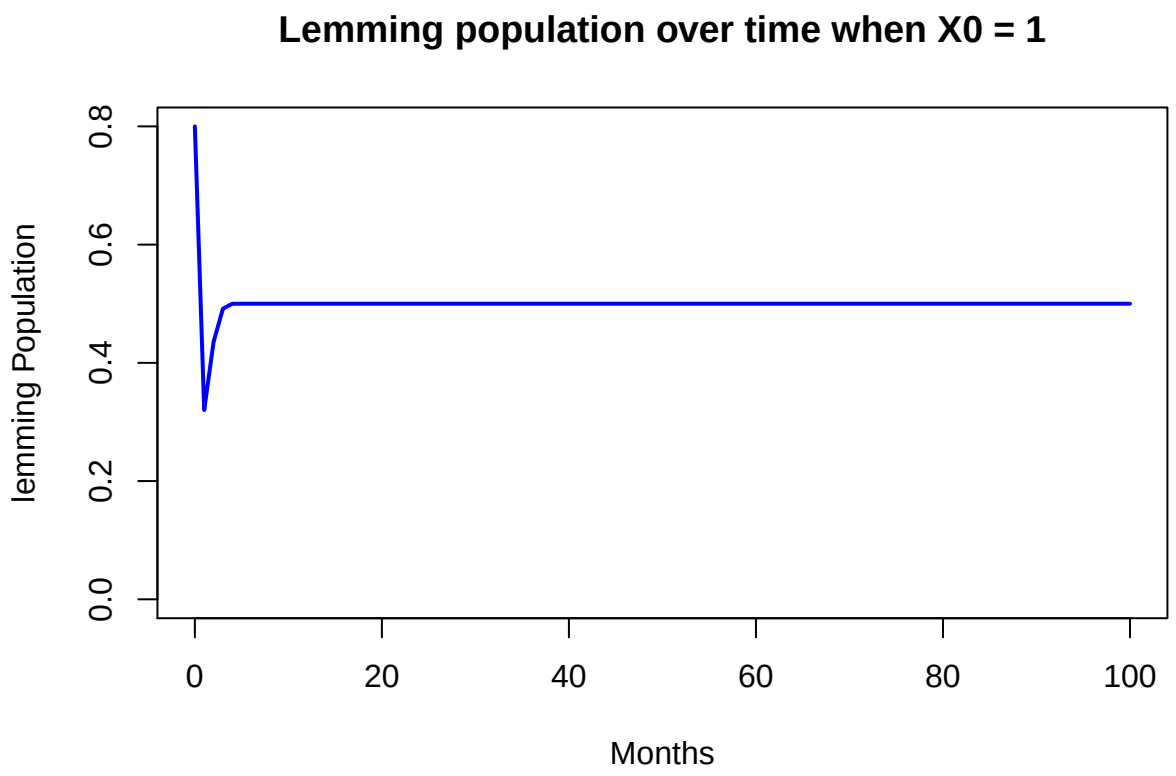

```r
# 1 < r < 3
r <- 2
n <- 100
times <- seq(0, n)

X0 <- 0.1

lem_pop_1 <- lemming_population(r, X0, n)

X0 <- 0.5

lem_pop_2 <- lemming_population(r, X0, n)

X0 <- 0.8

lem_pop_3 <- lemming_population(r, X0, n)

plot(times, lem_pop_1,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "Lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_1)),
     main = "Lemming population over time when X0 = 20")
```



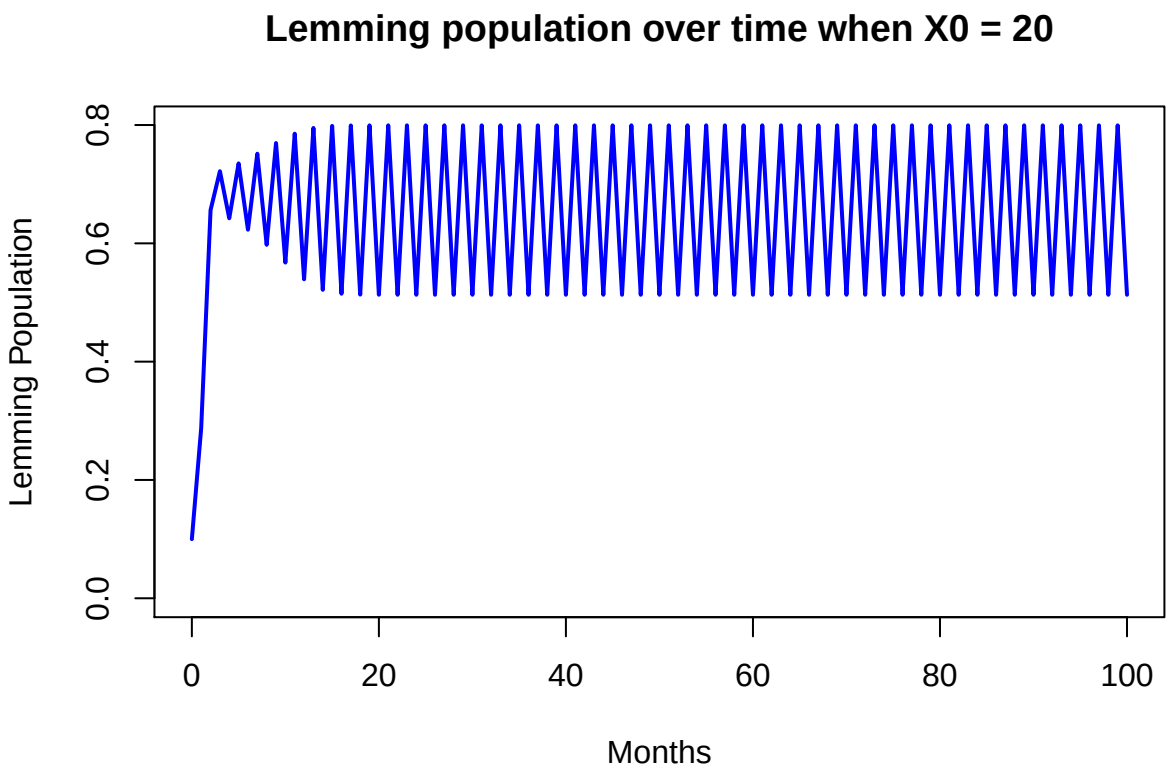

```
plot(times, lem_pop_2,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_2)),
     main = "Lemming population over time when X0 = 5")
```



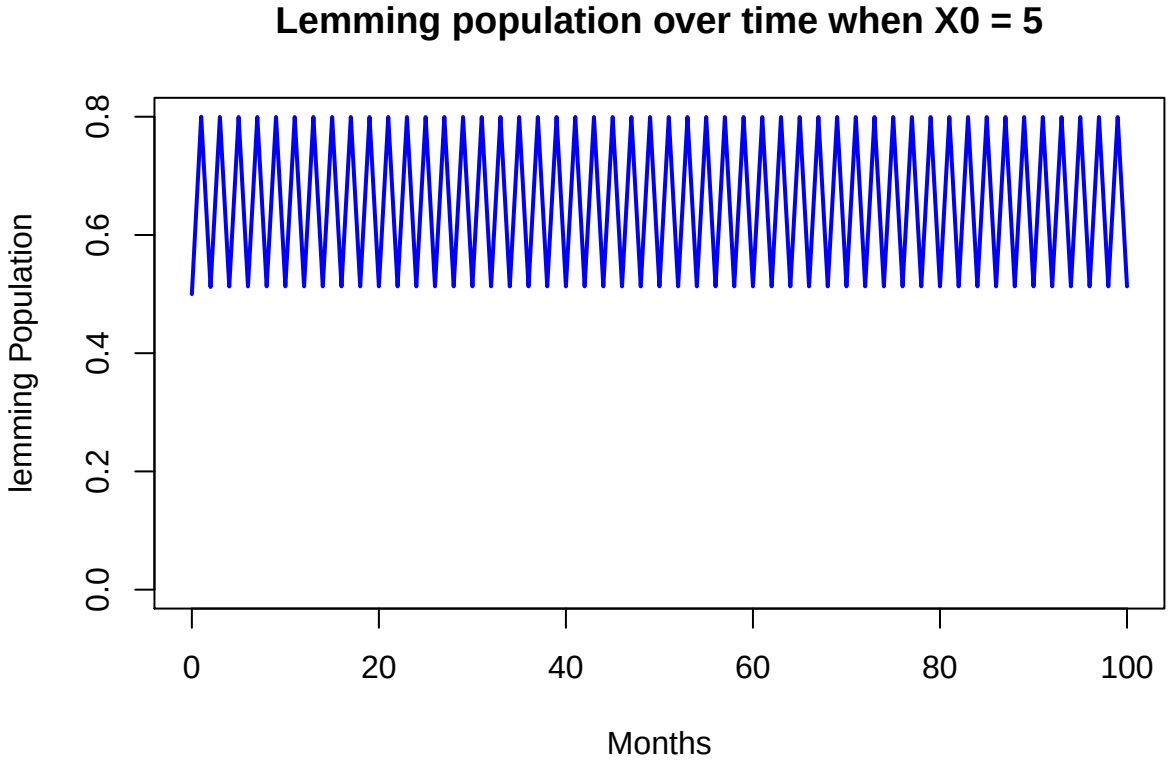
```r
plot(times, lem_pop_3,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_3)),
     main = "Lemming population over time when X0 = 1")
```



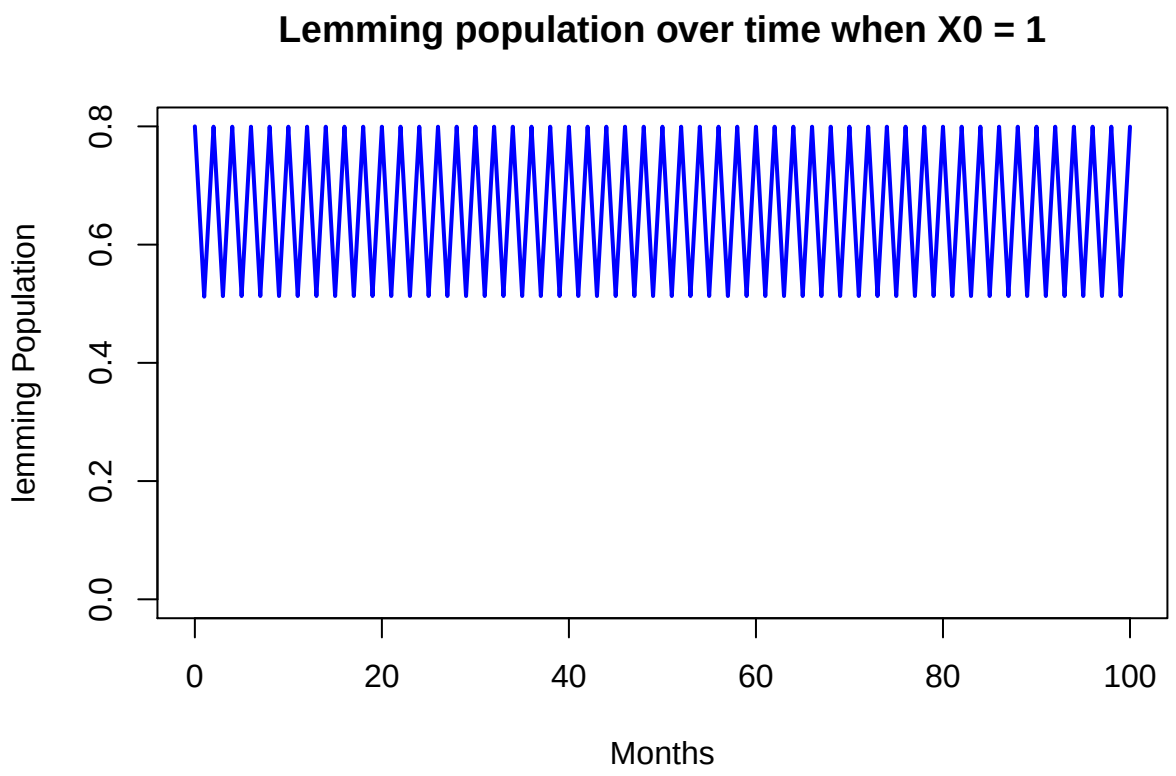

```r
# 3 < r < 3.449
r <- 3.2
n <- 100
times <- seq(0, n)

X0 <- 0.1

lem_pop_1 <- lemming_population(r, X0, n)

X0 <- 0.5

lem_pop_2 <- lemming_population(r, X0, n)

X0 <- 0.8

lem_pop_3 <- lemming_population(r, X0, n)

plot(times, lem_pop_1,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "Lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_1)),
     main = "Lemming population over time when X0 = 20")
```



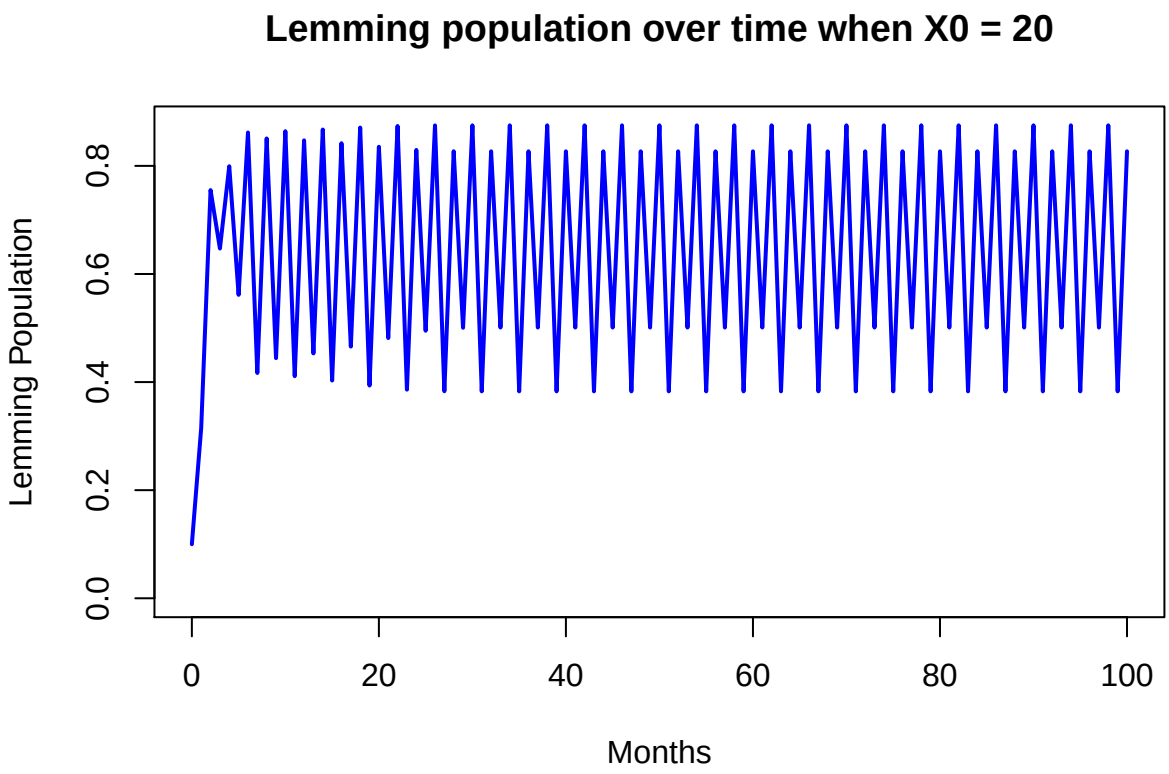

```r
plot(times, lem_pop_2,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_2)),
     main = "Lemming population over time when X0 = 5")
```



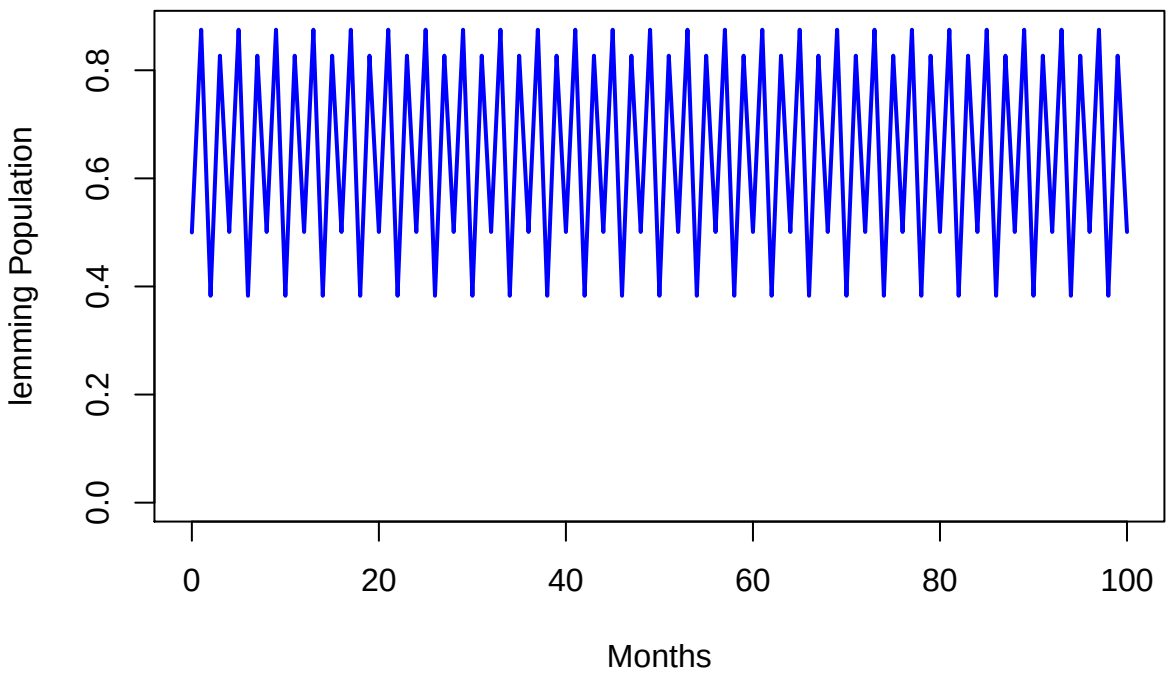
```r
plot(times, lem_pop_3,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_3)),
     main = "Lemming population over time when X0 = 1")
```



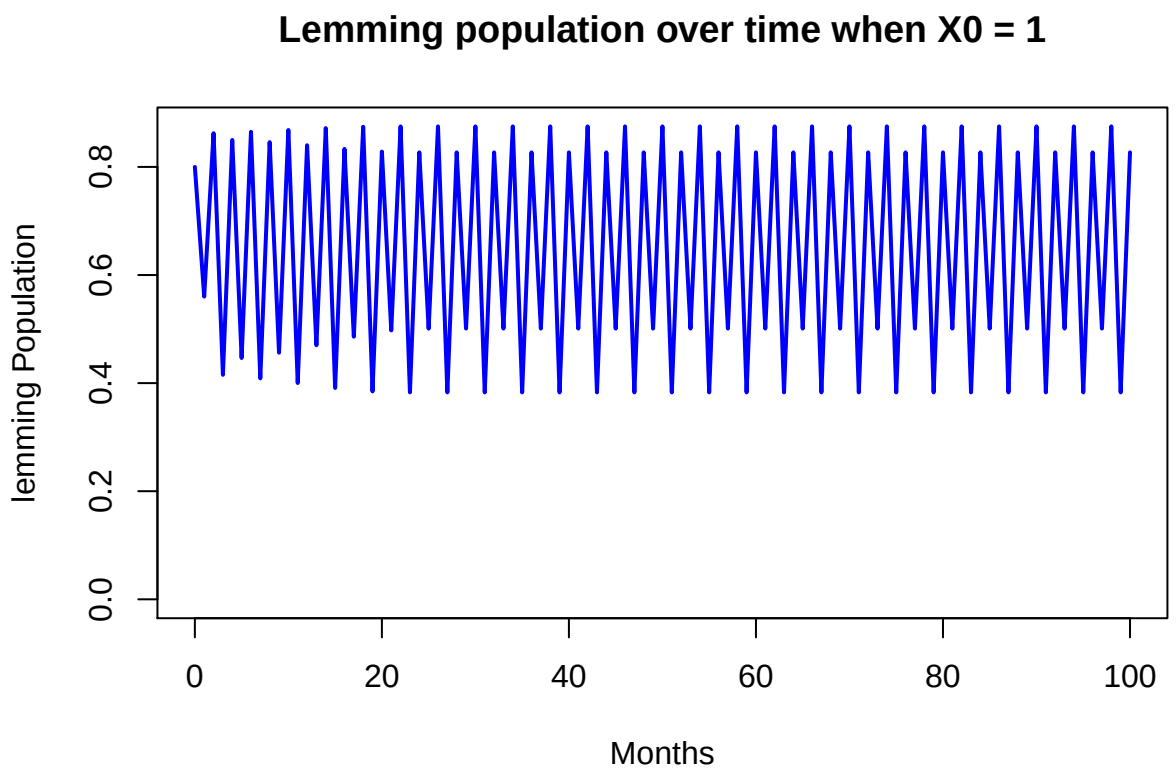

```r
# 3.449 < r < 3.54409
r <- 3.5
n <- 100
times <- seq(0, n)

X0 <- 0.1

lem_pop_1 <- lemming_population(r, X0, n)

X0 <- 0.5

lem_pop_2 <- lemming_population(r, X0, n)

X0 <- 0.8

lem_pop_3 <- lemming_population(r, X0, n)

plot(times, lem_pop_1,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "Lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_1)),
     main = "Lemming population over time when X0 = 20")
```



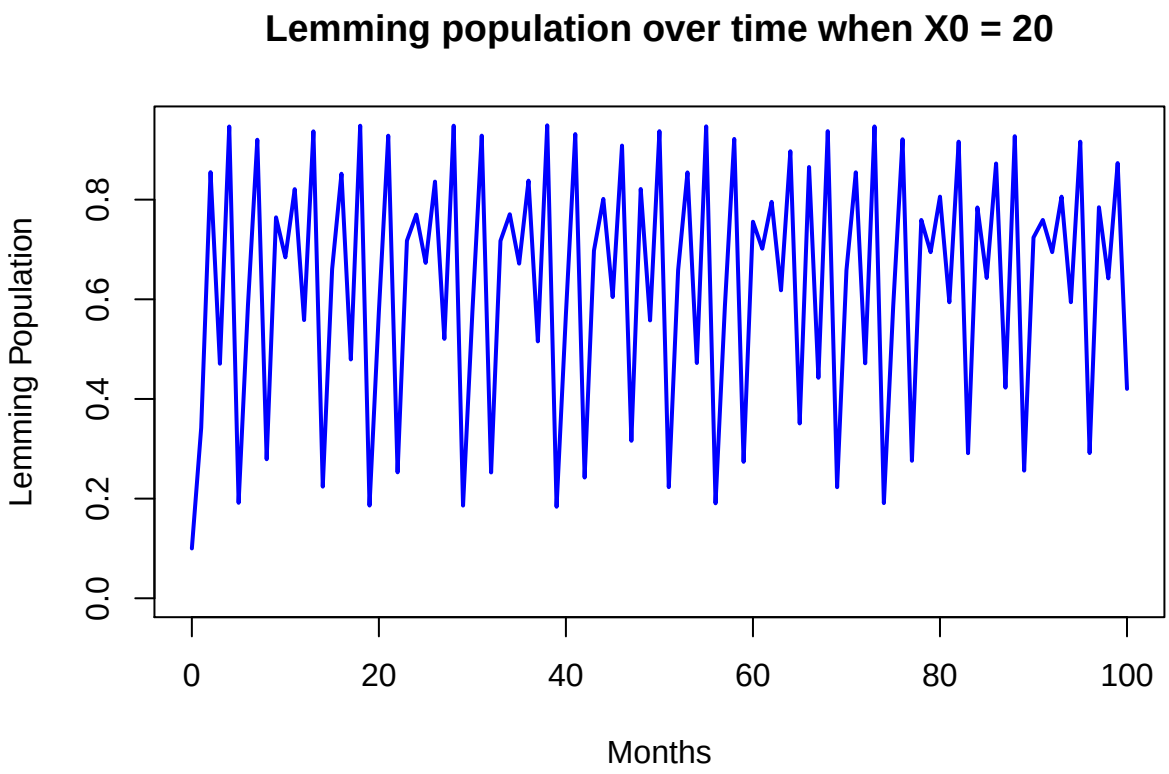

```
plot(times, lem_pop_2,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_2)),
     main = "Lemming population over time when X0 = 5")
```



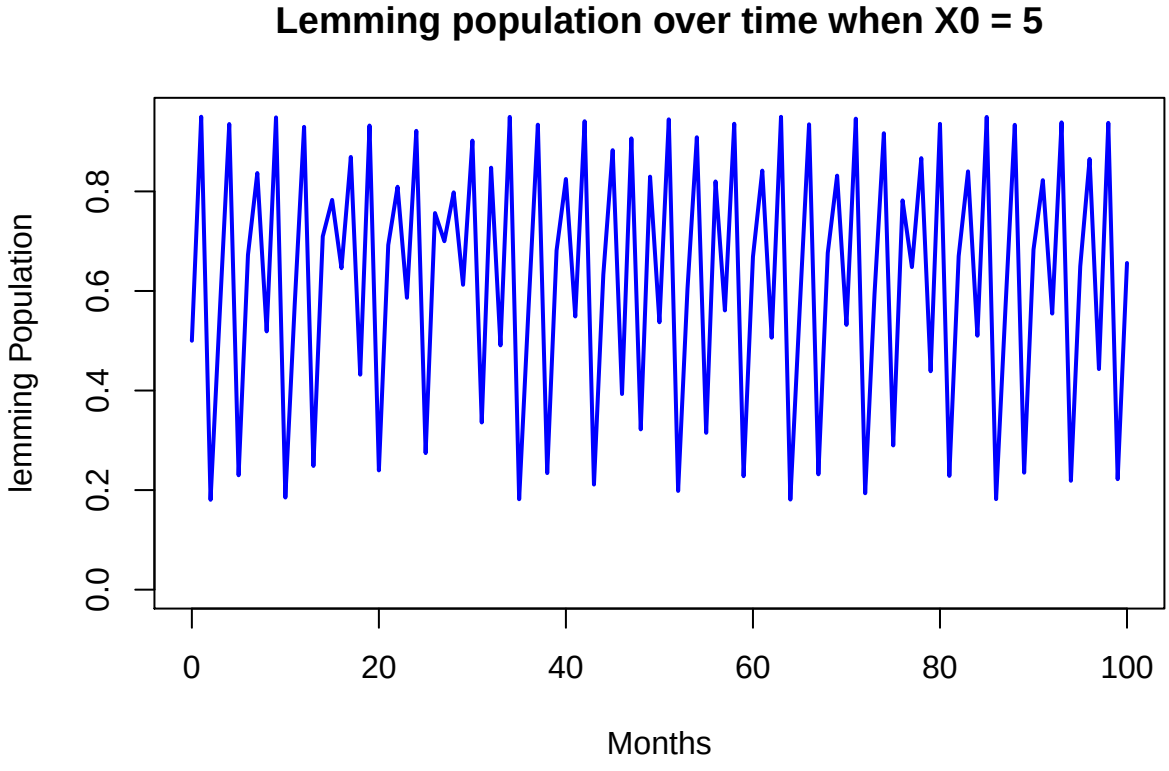
```r
plot(times, lem_pop_3,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_3)),
     main = "Lemming population over time when X0 = 1")
```



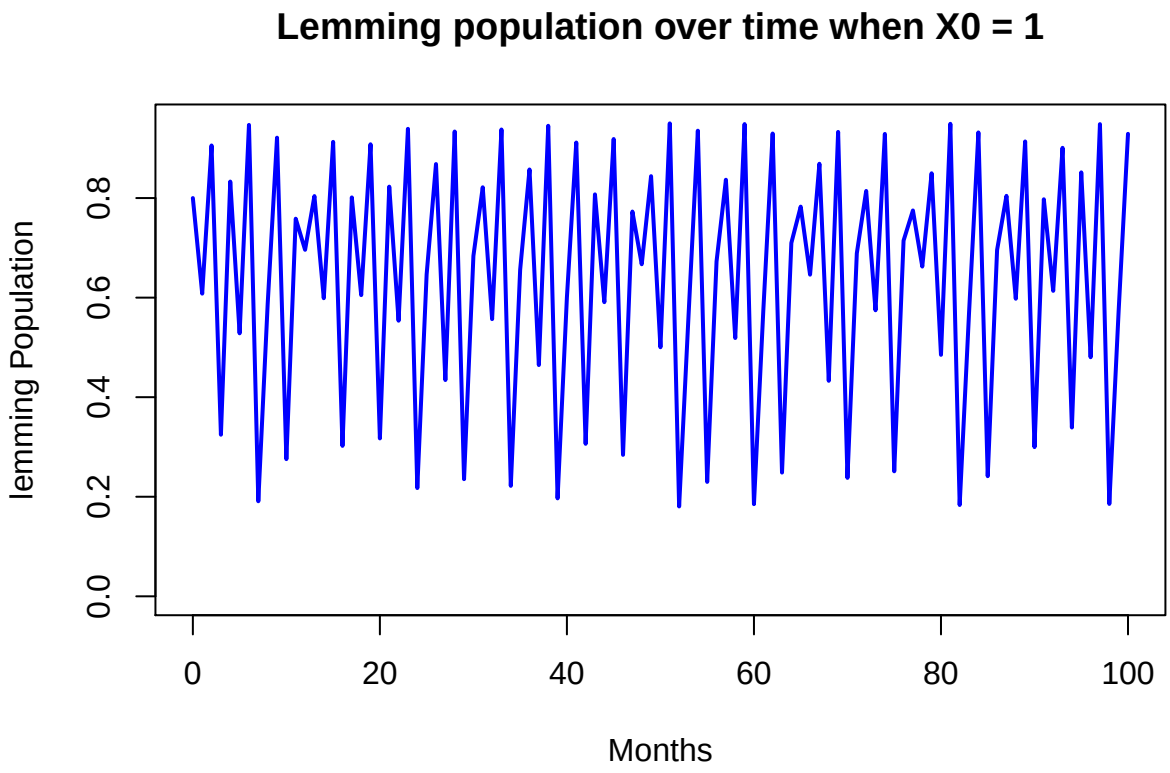

```r
# 3.6 < r < 4
r <- 3.8
n <- 100
times <- seq(0, n)

X0 <- 0.1

lem_pop_1 <- lemming_population(r, X0, n)

X0 <- 0.5

lem_pop_2 <- lemming_population(r, X0, n)

X0 <- 0.8

lem_pop_3 <- lemming_population(r, X0, n)

plot(times, lem_pop_1,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "Lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_1)),
     main = "Lemming population over time when X0 = 20")
```




```r
plot(times, lem_pop_2,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_2)),
     main = "Lemming population over time when X0 = 5")
```



```r
plot(times, lem_pop_3,
     type = "l", col = "blue" ,
     xlab = "Months", ylab = "lemming Population",
     lwd = 2, ylim = c(0, max(lem_pop_3)),
     main = "Lemming population over time when X0 = 1")
```



exercise 2

checking for sensitivity to intial conditions.

```r
# 3.6 < r < 4
r <- 3.8
n <- 100
times <- seq(0, n)
X0 <- 0.1

lem_pop_1 <- lemming_population(r, X0, n)

X0 <- X0 + 0.001

lem_pop_2 <- lemming_population(r, X0, n)

data_pop <- data.frame(times = times,
                       lem_pop_1 = lem_pop_1,
                       lem_pop_2 = lem_pop_2)

data_pop %>% ggplot(aes(x = times)) +
  geom_line(aes(y = lem_pop_1,
                color = "Lemming population 1")) +
  geom_line(aes(y = lem_pop_2,
```

```
              color = "Lemming Population 2")) +
scale_color_manual("Legend", values = c("red", "blue")) +
labs(x = "Time",
     y = "Population") +
ggtitle("Lemming population against time for subtle difference in initial population") +
theme(legend.position = c(.95, .95),
      legend.justification = c("right", "top")) +
scale_x_continuous(breaks = seq(0, n, 5)) +
scale_y_continuous(breaks = seq(0, 1, 0.05))
```