BIOl 410 Tutorial 2

Population growth

- Geometric population growth
- Exponential population growth
- Density dependence
- Logistic population growth

- Start Rstudio
- Set a working directory
  - setwd(“H:/BIOL_410_R")
  - NOTE: create folder first
- Confirm the new working directory
  - getwd()
- Create a new R-script and save to the working directory (use naming that makes sense: i.e. BIOL_410_tutorial_2)

Geometric population growth

$$N_{t+1} = N_t \cdot \lambda$$

```
# Model 1: Geometric population growth
years <- c(2015:2020)
Nt <- rep(0,length(years)) # holding vector for population
N <- 12      # initial population size
B <- 0.8     # birth rate per individual
D <- 0.2     # death rate per individual
R <- B - D   # per individual discrete population growth rate
lambda <- 1 + R # Finite rate of increase
for(year in years){
    t <- match(year, years)
    Nt[t] <- N + N*B - N*D
    #Nt[t] <- N + N*R
    #Nt[t] <- lambda*N
    N     <- Nt[t]
}

plot(years, Nt, ylab = "N")
```

Geometric population growth

- If the birth rate of the population is reduced by half, how long will it take to reach a population size of 200?
  - What is the populations new discrete population growth rate?
- If both the birth and the death rate are reduced by half, how long before the population reaches 200?
  - What is the new R?

Geometric population growth

$$N_t = N_0 \cdot \lambda^t$$

```
# Model 2: Geometric population growth, recursive equation
years <- c(2015:2020)
t <- c(1:length(years))
N0 <- 12    # initial population size
B <- 0.8    # birth rate per individual
D <- 0.2    # death rate per individual
R <- B - D  # per individual discrete population growth rate
lambda <- 1 + R # Finite rate of increase
N <- (lambda^t)*N0

plot(years, N, type="l")
```

Geometric population growth

- If the initial population size starts at 4 (instead of 12), how long does it take for the population to grow to above 200 individuals?

- Notes:

```
plot(years,N,type="l",ylim=c(0,400))
points(years,N,col="red")
```

Exponential population growth

$$N_t = N_0 e^{rt}$$

```
# Model 3: Exponential growth, conversion of lambda
years <- c(2015:2020)
t <- c(1:length(years))
N0 <- 12    # initial population size
B <- 0.8    # birth rate per individual
D <- 0.2    # death rate per individual
R <- B - D  # per individual discrete population growth rate
lambda <- 1 + R   # Finite rate of increase
r <- log(lambda)  # Intrinsic growth rate
N0 <- 12

N <- N0*exp(r*t)

points(years, N,col="red“,type=“l”)
```

Exponential population growth

- Compare population growth using the geometric model to the above version of the exponential growth model (i.e. for the same value of B and D).

Exponential population growth

$$N_t = N_0 e^{rt}$$

```
# Model 4: Exponential growth, instantaneous growth
years <- c(2015:2020)
t <- c(1:length(years))
N0 <- 12    # initial population size
b <- 0.8    # instantaneous birth rate
d <- 0.2    # instantaneous death rate
r <- b - d  # instantaneous rate of population increase

N <- N0*exp(r*t)

points(years, N, col="blue", type ="l")
```

Exponential population growth

- The doubling time of an exponentially growing population is given by

$$t_{double} = \frac{\ln(2)}{r}$$

- Calculate the doubling time for the previous exponentially growing population
- Double the populations intrinsic rate of increase (by altering b or d) and recalculate the doubling time

Exponential population growth

- The human population is expected to double in approximately 50 years.
- Assuming exponential population growth calculate r for the human population.
- If the current population size is 7.3 billion (2015), calculate the projected population size in 2030.

Exponential growth

- For five consecutive days the population of a flatworm is recorded as 100, 158, 315, 398, 794.
- Using this data, and assuming exponential growth, estimate r, and plot the projected population growth from an initial population size of 100.

```
worms <- c(100,158,315,398,794)
days <- c(1:5)
plot(days,worms)
```

Exponential growth

- Estimating r from data
- Plot the logarithm of population size vs time
- The slope of a best fit line approximates r under exponential growth

Logistic population growth

$$N_t = \frac{K}{1 + [(K - N_0)/N_0]e^{-rt}}$$

```
# Model 5: Logistic population growth
years <- c(2015:2030)
t <- seq(1,length(years),0.01)
N0 <- 1     # initial population size
b <- 0.8    # instantaneous birth rate
d <- 0.2    # instantaneous death rate
r <- b - d  # instantaneous rate of population increase
K <- 60

N <- K/(1+((K-N0)/N0)*exp(-r*t))
plot(t, N, type ="l")
```

Logistic population growth

- A population of butterflies is growing according to the logistic equation. Assuming a carrying capacity of 500, and a intrinsic rate of increase (r) of 0.1, what is the maximum rate of growth of the population?