Population Ecology 2016 HW 1

1. $$N(t) = N(0)e^{rt}$$

$$\frac{N(t)}{N(0)} = e^{rt}$$

$$\ln\left(\frac{N(t)}{N(0)}\right) = \ln\left(e^{rt}\right)$$

$$\ln\left(\frac{N(t)}{N(0)}\right) = rt$$

$$\boxed{\frac{\ln\left(N(t)/N(0)\right)}{r} = t}$$

Evans and Smith (1952) calculated r for the human louse $\approx$ r = 0.1/day. Assume N(0) = 10 lice

For N(t) = 100, $t = \dfrac{\ln(100/10)}{0.1/\text{day}} = $ 23 days

For N(t) = 1,000, $t = \dfrac{\ln(1000/10)}{0.1/\text{day}} = $ 46 days

For N(t) = 100,000,000, $t = \dfrac{\ln(10^8/10)}{0.1/\text{day}} = $ 161 days

For N(t) = 100,000,000,000, $t = \dfrac{\ln(10^{11}/10)}{0.1/\text{day}} = $ 230 days

Does this result surprise me?

No. This is not a surprising result, given the density-independent growth we are assuming. In reality, the population must be limited by a number of factors, since humanity has not been overrun by lice. Some of these might include host disturbance (e.g. lice prevention), intraspecific competition among lice, and dispersal limitation for lice among humans (their primary habitat).

2. Assume exponential population growth

$$N(t) = N(0)e^{rt}$$

$$N(0) = 6.9 \times 10^{9} \text{ in } 2009$$

Let t = doubling time = 50 years; solve for r

$$N(t) = N(50 \text{ years}) = 2N(0) = N(0)e^{r(50)}$$

$$2 = e^{r(50)}$$

$$\ln 2 = 50(r)$$

$$\boxed{r = \frac{\ln(2)}{50 \text{ years}} = 0.014/\text{year}}$$

Now solve for population size in 2050, i.e. $t = 41$ years

$$N(41 \text{ years}) = 6.9 \times 10^{9} \text{ people } e^{(\frac{0.014}{\text{year}})(41 \text{ years})}$$

$$\approx 1.2 \times 10^{10} \text{ people}$$

$\therefore$ The projected population in 2050 is about 12 billion.

3. We will model annual plant population growth using geometric growth with $R = r+1$

$R = 1.12$

$$N_T = R^T N_0$$

To estimate doubling time, let $N_T = 2N_0$

$$\therefore\ 2\cancel{N_0} = R^T \cancel{N_0}$$

$$2 = R^T$$ Take natural log of both sides

$$\ln(2) = \ln(R^T)$$

$$\ln(2) = T\ln(R)$$

$$T = \frac{\ln(2)}{\ln(R)} = \frac{\ln(2)}{\ln(1.12)} \approx 6 \text{ years}$$

$\boxed{\text{The approximate doubling time is 6 years}}$

4. Previous classes have thought of many mechanisms that may introduce density dependence into the population death rate within urban areas. Examples below:

Higher population sizes have been shown to lead to increased rates of suicides.

Higher population size could result in more competition for resources, resulting in death by aggression or starvation.

Higher population size could influence death rates through automobile accidents.

Urban areas should have more deaths due to crime relative to rural areas.

Infectious disease rates that depend on human-human contact should be more prevalent in urban areas and result in density-dependent death rates.