Population Biology

- The study of populations
- Chapter 10
- Biotic Potential
- Emphasize on the consequences human population growth

Current Human Population Data

- [http://opr.princeton.edu/popclock/popupclock.html](http://opr.princeton.edu/popclock/popupclock.html)
  - 6.58 Billion and growing

<table>
<thead>
<tr>
<th>TIME UNIT</th>
<th>BIRTHS</th>
<th>DEATHS</th>
<th>NATURAL INCREASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>133,201,704</td>
<td>55,490,538</td>
<td>77,711,166</td>
</tr>
<tr>
<td>Month</td>
<td>11,100,142</td>
<td>4,624,272</td>
<td>6,475,871</td>
</tr>
<tr>
<td>Day</td>
<td>364,936</td>
<td>152,029</td>
<td>212,907</td>
</tr>
<tr>
<td>Hour</td>
<td>15,206</td>
<td>6,335</td>
<td>8,871</td>
</tr>
<tr>
<td>Minute</td>
<td>263</td>
<td>106</td>
<td>148</td>
</tr>
<tr>
<td>Second</td>
<td>0.5</td>
<td>0.3</td>
<td>0.2</td>
</tr>
</tbody>
</table>

US POPULATION GROWTH

About 301,000,000 and growing

A Mathematical Approach to Understanding Population Growth

1. The initial size of the population = \( N_0 \)
2. The number of Births = \( B \)
3. The number of Deaths = \( D \)
4. The number of Immigrants = \( I \)
5. The number of Emigrants = \( E \)
6. The size of the population at time “\( t \)” = \( N_t \)

The population at any time can be determined with the following equation

\[
N_t = N_0 + B - D + I - E
\]

\[
N_t = N_0 + B - D
\]
Rates vs Absolutes
A "rate" is a value divided by time
  The number of Births and Deaths per unit time is at least part a function of the size of the population.

Birth and Death rates are often calculated on a per capita bases i.e.

\[ b = B \text{unit time}^{-1} N^{-1} \text{(read- birth rate equals Births per year per individual)} \]
\[ d = D \text{unit time}^{-1} N^{-1} \text{(read- death rate equals Deaths per year per individual)} \]

Growth rates on per capita bases can ve calculated by subtracting \( d \) from \( b \), i.e. \( r = b - d \)
Where is per capita growth rate of the population.

Changes in \( N \) (assume \( I \) and \( E = 0 \))
\[ \Delta N = B - D \]
the number of B's and D's for some discrete unit of time can be estimated by --- \( B - D = rN \)

\[ \frac{dN}{dt} = (b - d) N = rN \]

Note:
1: \( r \) = the intrinsic rate of natural increase.
2: Does not predict \( N_t \) only \( \Delta N \)
3. \( \Delta N \) is a function of \( N \)
4. Assumes \( r \) represents per capita growth rate for some discrete time period.

**DISCRETE VS CONTINUOUS GROWTH**

Discrete assumes that the population growth only occurs periodically (annually or monthly).

Continuous means that the population is growing all the time.

Analogy to interests rates
if the \( r=0.05 \) new individuals per week per old individuals and we start with 100 individuals.
  Week 0 =100, Week 1= 105, week 52= 1264.28
  if \( r=1.05 \) new individ per 2 weeks per individ.
    Week 0=100, Week 2=105, week 52=355.57
  if \( r=1.05 \) new individ per 52 weeks per individ.
    Week 0=100, Week 2=100, week 52=105

Mathematically:
For discrete growth

\[ N_t = N_0 + N_0 e^{rt} \]

For Continuous growth

\[ N_t = N_0 e^{rt} \]
Properties of Exponential Growth

- Population will always increase by the same Percent in any two periods of time of the same length
  - Simplest example assume population doubles each year
    - $2 \rightarrow 4 \rightarrow 8 \rightarrow 16 \rightarrow 32 \rightarrow 64 \rightarrow 128 \rightarrow 256 \rightarrow 512$
    - If $r=0.05$
      - $2 \rightarrow 2.10 \rightarrow 2.21 \rightarrow 2.32 \rightarrow 2.43 \rightarrow 2.55 \rightarrow 2.68 \rightarrow 2.81$
  - Still J-shaped.