

## Ecology:

The study of how organisms interact with the environment and each other.

We often look at different aspects of ecology such as:

- population ecology - population growth, dynamics, predation.
- community ecology - how do organisms interact with each other (competition & more)
- ecosystems - what impact do organisms have on the environment or vice versa. How does energy move through a system, food webs, etc.
- conservation biology - how can we best preserve organisms and their environment.

## Population ecology:

First, a population. This can have variable definitions, but in ecology usually it's a number of individuals in the same place:

- deer population in Northern Virginia
- mouse population on George Mason
- etc.
- but we can often mean larger groupings - human population, for example.

## Population density.

- One of the first things we want to know is how many individuals are in the area we're looking at.
- defined as # of individuals / unit area
- e.g., 100 people / square kilometer.
- often we need to estimate this using sampling techniques such as mark-recapture:
  - catch as many individuals as possible. Mark them.
  - do it again, in the same area. If most individuals caught the second time are unmarked, this indicates a larger population than if they're mostly marked.
  - we don't need to know the equations for this.
- Density often changes continually due to **[Fig., not in text]**:

- birth, death, immigration, emigration (obviously true for human populations as well).

Dispersal patterns [Fig. 36.2, p. 726].

- How are the organisms distributed?
  - clumped - occur in clumps, with few organisms between the clumps.
  - uniform - occur in a constant density (no matter where you look, there are about the same number).
  - random - they're wherever they want to be (no pattern).

Population growth.

- We use mathematical models to describe how fast a population can grow.
- Suppose we come up with the following hypothesis:
  - a single bacterium multiplies. Now we have two.
  - 20 minutes later each of those divides, and so we have four.
  - 40 minutes later, each of these four divides, so we have eight:
    - basically what we have is  $2^x$ , where  $x$  is the number of times they divide (“^” means “exponent, so  $2^x$  means 2 raised to the  $x$  power).
    - so at the end of 36 hours, we would have:
 
$$2^{108} = 324,518,553,658,426,726,783,156,020,576,256$$
    - or, as your book puts it, enough bacteria to cover the earth one foot deep (108 = 3 x 36, since the bacteria reproduce three times an hour).
    - obviously, something stops this from happening
      - Darwin realized this, and this helped him formulate evolution (by means of natural selection).
- This leads to the exponential growth model.

$$\frac{\text{change in population}}{\text{change in time}} = (\text{birth rate} - \text{death rate}) N$$

this is the same equation as in your text ( $G = rN$ ), but it's a little more

obvious what's going on.

$$\begin{aligned} \text{birth rate} - \text{death rate} &= r \\ \text{current population size} &= N \end{aligned}$$

(note that if birth rate > death rate, population will grow (ideally))

since we're not doing math (or deep ecology), let's leave it at that. If you plot this, you get a J shaped curve [**Fig., similar to 36.4A, p. 728**]

- the bacterial growth example can be used with this equation, and the overhead plots this.

- But most populations don't actually grow exponentially (they might for just a short period of time).

So we have the logistic growth model:

$$\frac{\text{change in population}}{\text{change in time}} = r N \frac{(K - N)}{K}$$

- again, this is not a math class, so we won't go into the details. But notice that if  $K = N$ , then the left hand side of the equation = 0.

- there is no population growth if  $K = N$ .

-  $K$  is often called the carrying capacity. The environment simply can't support more organisms than  $K$ .

- a lot of research is done to figure out what  $K$  is

-  $K$  can vary (in good years it might be higher, in bad years lower).

- remember that this is a model, and real life may not be what the model says it should be.

- plotting this gives a curve like that in [**Fig. similar to 36.4B, p. 729**]

- But supposing we have a decent model, what determines  $K$ ?

- food (there is only so much food to go around).

- territory (e.g., many song birds don't like to be too close to each other) [**Fig. 36.5A, p. 730**]

- number of nesting sites (similar to the previous one).

- predation (if there are too many organisms of one kind, a predator will start to eat more and more).

- weather - dry, hot, or extremely cold conditions can all increase the number of deaths (and reduce K) [Fig. 36.5B, p. 730].

An illustration of how some of these come together can be seen in moose on Isle Royale (in lake Superior) [Fig., not in text].

- Some populations can become cyclical (have up and down cycles) [Fig. 36.5C, p. 731].

- lynx & hare (still trying to figure out exactly what's going on here).

- fact: when there are a lot of hares, there are a lot of lynx, and vice versa.

- could be caused by:

- hares increasing until they run out of food, then dying off.  
- (grasses will have been reduced).

- lynx feeding on hares - as they feed on more and more hares, the hare population crashes, and so the lynx population crashes.

- Life tables & survivorship.

- Insurance companies do a LOT of this...

- [Fig. (table) 36.3, p. 727]

- from life tables, we can get survivorship curves [Fig. 36.3, p. 727]

- these illustrate the percentage of organisms alive as age increases.

- types I, II, & III

- This gives rise to the concept of r & K selection

- organisms with r selection produce many offspring, and hope some survive.

- they don't put a lot of resources into individual offspring

- have a very high potential rate of increase.

- e.g. roaches, weeds

- organisms with K selection produce fewer offspring, but put a lot more resources into each offspring.

- have lower potentials for maximum rate of increase.

- e.g. humans, oak trees

Human population growth [**Fig., not in book & 36.9A, p. 735**]:

- a very important (and somewhat political) issue.
- basic problem is that the human population has started to grow exponentially.
  - due to:
    - much better health care (decreased death rate), nutrition & sanitation.
    - so death rate has declined, but in many parts of the world, birth rate has not declined [**Fig. 36.9B, p. 734**].
  - currently we're at 6.7 billion +, by 2050, we're expected to be over 9.3 billion.
- this puts an enormous strain on ecological resources:
  - need increased food production
  - increased use of fresh water
  - increased use of other resources - minerals, energy, raw materials, etc.
  - this is not sustainable.
- best estimates are that the carrying capacity for the earth (K) is somewhere between 10 and 15 billion people (some say we've already exceeded capacity).
- this is not the only problem - we also have a large disparity in the amount of resources we consume.
  - in the U.S., for example, we use far more resources than other societies (see, for example, the table on p. 766 (4th edition only)).
    - Comparing the U.S. with India, the average American uses:
      - 50 times more steel
      - 170 times more rubber and newsprint
      - 250 times more fuel
      - 300 times more plastic
      - [**Fig. 36.11, p. 737**]
- see [**Fig., not in text**]
  - it takes about 8.4 ha to support someone in the U.S.. Someone from India or Bangladesh can make do with 0.8 - 0.5 ha.

- adding this up for the world works out to about 2 ha / person (i.e., if we calculate the amount of ecologically productive land).

- this raises two important ethical questions for conservation:

1) do we really have to use so much?

- note the table in the book - other highly developed countries (Germany, Japan) use half as much energy as we do!

2) is it fair? don't we want the rest of the world to catch up to our level of development?

- but what happens to the world's resources then?

- the only way that we can reach the above mentioned carrying capacity is if the rest of the world does not consume resources the way we do.

- note the high gas prices - one reason is increased competition with China. We can't supply as much gas as we use to everyone on the planet.

- as other countries develop, the strain on resources becomes worse.

- we'll say more on this topic when we do conservation biology

- doubling times, growth pyramids, etc.

- using the above equations, we can calculate the approximate doubling time for human populations.

- doubling time - the time needed for the population to double.

- this is highest in the poorer tropical countries:

- Kenya doubles its population in about 20 years

- United States & Canada double their population in about 114 years.

- age structure

- this is the distribution of ages within a population:

- what % is between 0 and 5 years old, between 6 and 10 years old, etc.

- we arrange this data into "population pyramids" [**Fig., not in text**]

- only fast growing countries really have a “pyramid structure”.

- note that a population with a lot of children (e.g., Kenya) will continue to increase in size even if 1 child/family rules are implemented (very controversial). This is because **[Fig. 36.9C, p. 735]**:

- all those children get to have children, and so there is a time delay (population continues to grow until the current children begin to die).

- China, with its 1 child / family rule is still growing, and won't decrease in size until about 2030.