Population Growth Worksheet

Environmental Studies 148 Lecture Notes

1) Population Growth
  A) **Exponential** – growth without limits
    i) Definition:
        the unrestricted increase in a population (also called the **biotic potential** of a population)

    ii) Formula: Non-overlapping Generations: $N_t = N_{t-1} + rN_{t-1}$
    iii) Overlapping Generations: $\frac{dN}{dt} = rN$

       (This is the *instantaneous* rate of change → *dN/dt* stands for the instantaneous change in N at a given time).

    iv) Calculating r from population sizes: $r = \frac{(N_t - N_{t-1})}{N_{t-1}}$

    v) Example:

Exponential Growth of Rabbits: r = 0.3 (Adapted from Campbell, *et al, Biology Concepts and Connections* 6th ed.)		
Time (Months)	N (population size now)	rN (change in population size = baby rabbits)
0	20	6
1	26	8
2	34	10
3	44	13
4	57	17
5	74	22
6	96	29
7	125	38
8	163	49
9	212	64
10	276	83
11	359	108
12	467	140

  B) Carrying capacity
    i) Definition:

the maximum number of individuals of any species that can be supported
by a particular ecosystem on a sustainable basis
ii) Carrying capacity is symbolized as **K**

C) Logistic growth – growth limited by a carrying capacity

i) Formula: $\dfrac{dN}{dt} = rN\left(1 - \dfrac{N}{K}\right)$

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ii) Example:

Effect of K on Growth Rate as N approaches K. K= 1,000, r = 0.1 (Adapted from Campbell, *et al, Biology Concepts and Connections* 6th ed.)					
N	rN	$\dfrac{N}{K}$	$1-\dfrac{N}{K}$	$\dfrac{dN}{dt} = rN\left(1 - \dfrac{N}{K}\right)$	baby rabbits
10	1	0.01	0.99	0.99	
100	10	0.1	0.9	9.00	
400	40	0.4	0.6	24.00	
500	50	0.5	0.5	25.00	
600	60	0.6	0.4	24.00	
700	70	0.7	0.3	21.00	
900	95	0.9	0.05	0.25	
1,000	100	1.0	0.00	0.00	

iii) Points to remember:
    (a) Population growth slows and ceases as population density increases
    (b) Increasing population density results in a decrease in birth rate, an
        increase in death rate, or both
    (c) Produces "s" shaped curve

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iv) **Environmental resistance** –
factors that tend to reduce population growth rates:

    (a) Density dependent – factors linked to population size (disease, lack of
        food)
    (b) **Density-independent –** factors that limit growth that are not linked to
        population size. Often environmental (droughts, floods, habitat
        destruction)

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D) Population Overshoots ("Boom and Bust" Cycles)
    i) Some populations fluctuate in density with regularity
        (a) Food shortages
        (b) Predator-prey interactions

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E) When might you want to calculate these things?

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    i) Conservation biology

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    ii) Managing invasive species

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    iii) Sustainable harvest

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    iv) Human population growth

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2) "r-selected" and "K-selected" species
    A) Refers to **life-history** strategy, or how organism schedules its reproduction.

    B) "r" is from the population growth equation. "K" is from carrying capacity.

    C) General comparisons:

r-selected species	K-selected species
Short life	Long Life
Rapid Growth	Slower Growth
Early Maturity	Late Maturity
Many, Small Offspring	Few, Larger Offspring
Little Parental Care	High Parental Investment
Favored in unstable environments	Favored in stable environments
Early succession	Late succession
"generalists"	"specialists"

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    D) These traits are subject to selection!
        i) Example: guppies, pike-cichlids, and killifish

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        ii) Example: Dwarf wheat → tradeoff between straw (stem) and grain production

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        iii) Implications for fishing industry?