POPULATION GROWTH

Chapter 11

Chapter Concepts

- 1. With abundant resources, populations can grow at geometric or exponential rates.

- 2. As resources are depleted, ….?

Estimating Rates of An Annual Plant-ch 10

- *P. drummondi*
  - R_o = net reproductive rate; Avg. number of seeds produced by an individual in a population during its lifetime.

$$R_o = \sum l_x m_x$$

X= age interval in days.

l_x = ?

m_x=?

Estimating Rates of An Annual Plant-ch 10

- *P. drummondi*
- R_o = **net reproductive rate**;
  - Avg. number of seeds produced by an individual in a population during its lifetime.

$$R_o = \sum l_x m_x$$

X= age interval in days.

l_x = % pop surviving to each age (x).

m_x= avg. number seeds produced by each individual in each age category.

Estimating Rates of An Annual Plant-ch10

- Because *P. drummondii* has non-overlapping generations, can estimate growth rate.

- **Geometric Rate of Increase (λ):**

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

N_{t+1} = Size of population at future time.

N_t = Size of population at some earlier time.

Estimating Rates when Generations Overlap-ch10

- Common Mud Turtle (*K. subrubrum*)
  - About half turtles nest each year.
  - **Avg. generation time**:

$$T = \sum x l_x m_x / R_o$$

X=age in years

Per Capita Rate of Increase:

$$r = \ln R_o / T$$

ln =base natural logarithms

Geometric Growth

- When <u>generations do not overlap</u>, growth can be modeled geometrically.

$$N_t = N_o \lambda^t$$

N_t = # individuals at time t.

N_o = initial # of individuals.

λ = geometric rate of increase.

t = # of time intervals or generations.

Exponential Growth

- Continuous population growth in an unlimited env. can be modeled exponentially.

$$dN/dt = rN$$

=the change in numbers with change in time

r =the per capita rate of increase

- As population size (N) increases,
  - rate of pop.increase (dN/dt) gets larger.

Exponential Growth

- For an exponentially growing pop., size at any time can be calculated as:

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

- N_t = # individuals at time t.
- N_0 = initial # of individuals.
- e = base of natural logarithms.
- r = per capita rate of increase.
- t = number of time intervals.

- Ex. Pollen records (Bennett 1983)

→ growth of postglacial pine pop in Britain.

assump: the rate of pollen deposition is prop to the size of tree pop around a lake

- Ex. Collared dove
  - Expand into W Europe, British Isles
  - 1955-72, exponential growth
  - > 1970 slow down, Env Limitation

Chapter Concepts

- 2. As resources are depleted, population growth rate slows and eventually stops: logistic population growth.

Logistic Population Growth

- **Sigmoid (S-shaped)** pop. growth curve.
- **Carrying Capacity (k)** is the number of individuals of a population the env. can support.
  - Finite amount of resources can only support a finite number of individuals.

- **Carrying Capacity (k)** is likely determined by a complex interplay among factors, e.g. food, parasitism, disease, and space….

- → Mathematical model helps..

Logistic Population Growth

$$dN/dt = r_m N(1-N/k)$$

- r_m = max. per capita rate of increase under ideal conditions.
- r_m =intrinsic rate of increase
- When N nears K, right side of the equation nears zero.
  - As pop. size increases, logistic growth rate becomes a small fraction of growth rate.
- Highest pop size when N=k/2.
- N/k = environmental resistance.

Chapter Concepts

- 3. The environment limits population growth by changing birth and death rates.

- $\gamma = b - d$

  b = birth rate

  d =death rate

Limits to Population Growth

- Environment limits population growth by altering birth and death rates.
  - Density-dependent factors:
    - Disease, Resource Competition
  - Density-independent factors:
    - Natural Disasters

Galapagos Finch Population Growth

- *Boag and Grant - Geospiza fortis* was numerically dominant finch (1,200).

- Highly variable rainfall at Galapagos Is. → pop fluctuated greatly

- After drought of 1977, pop. fell to 300.
  - Food plants failed to produce seed crop.
  - 1983 – 10x normal rainfall caused population to grow (1,100) due to abundance of seeds and caterpillars.

- Ex. Grant & Grant

  large cactus finch on Genovesa Is, 1978-88

  two droughts

Cactus Finches and Cactus Reproduction

- *Grant and Grant* documented several ways finches utilized cacti:
  - Open flower buds in dry season to eat pollen.
  - Consume nectar and pollen from mature flowers.
  - Eat seed coating (aril).
  - Eat seeds
  - Eat insects from rotting cactus pads.

Cactus Finches and Cactus Reproduction

- Finches tend to destroy stigmas, thus flowers cannot be fertilized.
  - Wet season activity may reduce seeds available to finches during the dry season.
  - *Opuntia helleri* main source for cactus finches
    - Negatively impacted by El Nino (1983).
      - Stigma snapping delayed recovery.
        - Interplay of biotic and abiotic factors.

Chapter Concepts

- 4. On avg., small organisms have higher (r) and more variable pops. – while large organisms have lower (r) and less variable pops.

Intrinsic Rates of Increase

- On average, small organisms have higher rates of per capita increase and more variable populations than large organisms.

Pop. Growth by Small Marine Invertebrates

- Populations of marine pelagic tunicate (*Thalia democratica*) grow at exponential rates in response to phytoplankton plumes.
  - Numerical response can increase pop. size dramatically due to extremely high reproductive rates.

Growth of A Whale Population

- Pacific Gray Whale (*Eschrichtius robustus*) divided into Western and Eastern Pacific subpopulations.
- *Rice and Wolman* estimated avg. annual mortality rate of .089 and calculated annual birth rate of 0.13. (from life table)
  - 0.13-.089 = .041
    - Gray Whale pop. Growing at 4.1% per yr.

Growth of A Whale Population

- *Reilly et.al.* used annual migration counts from 1967-1980 to obtain 2.5% growth rate.
- Thus from 1967-1980, pattern of growth in California Gray Whale pop fit exponential model:

$$N_t = N_o\ {}^{e0.025t}$$

By 1993, pop reached 21,000=prewhaling level

Applications to human population

- Distribution is highly clumped at large scales
- Asia
  - China & India
- Coastal area

Populaiton dynamics

- Vary widely from region to region, and country to country
- Exam: age distributions, birth rates & death rates of 3 countries.

- In 1997
- Lithuania, b=0.014, d=0.013, r=0.001
- Hungary, b=0.011, d=0.015, r= -0.004
- Rwanda, r=0.018
- Predict their pop dynamic trends?

END