POPULATION DYNAMICS

• POPULATION SIZE
• REGULATION OF POPULATIONS
• POPULATION GROWTH RATES
• SPECIES INTERACTIONS

POPULATION DENSITY

• DENSITY = NUMBER OF INDIVIDUALS PER UNIT AREA OR VOLUME
• POPULATION GROWTH = CHANGE IN DENSITY OVER TIME

FOUR (4) FACTORS AFFECTING DENSITY

IMMIGRATION (+)

DENSITY

NATALITY (+)

MORTALITY (-)

EMIGRATION

FOUR (4) FACTORS AFFECTING DENSITY

• IMMIGRATION
• EMIGRATION
– ASSUME THESE TWO ARE EQUAL

DENSITY FUNCTIONS (CONT’D)

• NATALITY: PROCESS OF ADDING NEW INDIVIDUALS TO POPUL. VIA BIRTHS
  – FERTILITY = PERFORMANCE (ACTUAL?) BASED ON NUMBERS BORN (HUMANS)
  – FECUNDITY = POTENTIAL LEVEL OF PERFORMANCE BASED UPON MEAN GESTATION TIME (HUMAN POPUL.)

DENSITY FACTORS (CONT’D)

• MORTALITY: DECREASE IN NUMBER OF INDIVIDUALS BY DEATH RATE
  – PHYSIOLOGICAL LONGEVITY = MEAN LIFE SPAN UNDER OPTIMUM CONDITIONS
    • SENESCENCE DEATH = OLD AGE
  – ECOLOGICAL LONGEVITY = EMPIRICAL MEAN LIFE SPAN UNDER ANY GIVEN CONDITIONS
DENSITY MEASUREMENTS

• ABSOLUTE DENSITY: TOTAL COUNTS (DIFFICULT/SOME ERROR)
  – HUMAN POPULATION CENSUS
  – BIRDS: ALL SINGING MALES IN AREA
  – LARGE PLANTS IN GIVEN AREA (TREES)

DENSITY MEASUREMENTS (CONT’D)

• DENSITY ESTIMATES
  – USE OF QUADRATS (PLANTS, SMALL ANIMALS)
  – CAPTURE-RECAPTURE (MOBILE POPUL)
    • CLOSED: NOT CHANGE SIZE DURING SAMPLE PERIOD
    • OPEN: CHANGES IN SIZE DURING SAMPLE PERIOD
  • NOTE: REAL POPULATIONS ARE OPEN

DENSITY ESTIMATES (CONT’D)

• PETERSON INDEX: PROPORTIONAL COMPUTATION OF MARKED VS. UNMARKED INDIVIDUALS IN SAMPLE

MARKED IND = MARKED IN TOT. POPUL
TOTAL CAUGHT = TOTAL POPUL. SIZE

POPULATION GROWTH

• RATE OF GROWTH: CHANGE IN NUMBERS PER UNIT TIME

• EXPONENTIAL GROWTH (UNRESTRICTED ENVIRONMENT)
  – FUNCTION OF TWO (2) FACTORS
    • SIZE OF POPULATION AT TIME ZERO
    • CAPACITY OF POPULATION TO INCREASE (I.E., BIOTIC POTENTIAL) OR DECREASE IN SIZE OVER TIME

\[ r = b - d \]

\[ r = \frac{\text{net population growth rate per individual per unit time}}{\text{number of individuals}} \]

\[ N_{t+1} = r \times N_t \]
MEANS OF COMPUTING $r$

- LIFE TABLES
- SURVIVORSHIP CURVES

$r' = b - d$

EFFECTS OF $b - d$ ON POPULATION GROWTH

BACTERIUM CULTURE

- PLOT GROWTH OF POPULATION OVER TIME
- BIOTIC POTENTIAL NOT CHANGE
- SIZE OF POPULATION CHANGES EXPONENTIALLY
EXPONENTIAL GROWTH

- \( N_t = N_0 \ e^{rt} \)
- \( \frac{dN}{dt} = r \times N \)
- \( \frac{dN_{t+1}}{dt} = r \times N_t \)

- NOTE: DEPENDENT & INDEPENDENT VARIABLES IN CURVE
- CHANGE THROUGH TIME
- \( r \) IS CONSTANT FOR ANY PARTICULAR POINT IN TIME FOR GIVEN ENVIRONMENTAL CONDITIONS
- # IND > RAPIDLY; RATE OF CHANGE REMAINS CONSTANT

dN/dt = r * N

- \( r \) = BIOTIC POTENTIAL OR INTRINSIC RATE OF NATURAL INCREASE
- POPULATION GROWTH RATE DEFINED PER INDIVIDUAL (FEMALE)
  - ASSUME UNCROWDED CONDITIONS
  - STABLE AGE CLASS DISTRIBUTION
  - POTENTIAL GROWTH VS. ACTUAL
- \( r \) IS AN INNATE QUALITY OF A SPECIES JUST AS MEAN WT., SIZE, ETC

INNATE CAPACITY FOR NATURAL INCREASE

- SIMILAR TO MEAN LONGEVITY, NATALITY, GROWTH RATE
- FUNCTION OF:
  - ENVIRONMENTAL CONDITIONS
  - INTRINSIC NATURE OF SPECIES IN QUESTION
  - DIFFICULT TO MEASURE DUE TO DUE TO CHANGING ENVIRONMENTAL CONDITIONS
  - ATTEMPTS TO STANDARDIZE (OPTIMIZE)

dN/dt = r * N

- SHOULD BE CLEAR FROM EQUATION:
  - IF \( r = 1 \): NO CHANGE (GROWTH) IN POPULATION SIZE
  - IF \( r < 1 \): DECREASE IN SIZE
  - IF \( r > 1 \): INCREASE IN SIZE
  - ORDER OF MAGNITUDE OF \( r \) DETERMINES RATE OF CHANGE
  - IF \( r \) REMAINS CONSTANT, THEN RATE OF CHANGE IS CONSTANT
**ASSUMPTIONS**

- **UNREALISTIC**—BUT GOOD BEGINNING POINT FOR CONSIDERATION OF POPULATION MODELS
- **BIOTIC POTENTIAL DOES NOT REMAIN CONSTANT IN NATURE**
- **ATTEMPTS TO MEASURE IN NATURE NOT SIMPLE**
- **r VARIES WITH ENVIRONMENTAL CONDITIONS, AGE DIST., GENETIC COMPOSITION, SOCIAL STRUCTURE, ETC.**

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**LOGISTIC GROWTH:**

$$dN/dt = r \cdot N (K - N/K)$$

- **K = CARRYING CAPACITY**
  - MAXIMUM NUMBER OF INDIVIDUALS THAT CAN BE SUPPORTED
  - (INDEFINITELY—ASSUMING EVERYTHING REMAINS THE SAME) IN A GIVEN AREA (ENVIRONMENT)

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**LOGISTIC GROWTH:**

$$dN/dt = r \cdot N (K - N/K)$$

- **(K-N/K) IS A MEASURE OF ENVIRONMENTAL RESISTANCE**
  - DIRECT EFFECT OF CROWDING
- **REPRESENTS AN INVERSE MEASURE OF ENVIRONMENTAL RESISTANCE**
  - WHEN ENVIR. RESIST. IS LOW, VALUE OF (K-N/K) APPROACHES VALUE OF 1
- **VARIOUS FACTORS AFFECT K**
  - ANYTHING WHICH AFFECTS BIRTH RATE OR DEATH RATE WILL IMPACT K

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**REGULATION OF POPULATION SIZE & RATE OF CHANGE**

- **DENSITY DEPENDENT FACTORS**
  - CROWDING EFFECT
- **DENSITY INDEPENDENT FACTORS**
  - OTHER ENVIRONMENTAL RESISTANCE FACTORS
- **CARRYING CAPACITY EFFECTS**
  - LOGISTIC GROWTH
DENSITY DEPENDENT FACTORS

• INTRINSIC—
  – POPULATION SIZE FACTORS

• EXTRINSIC—INTERACTIONS WITH OTHER PARTS OF COMMUNITY STRUCTURE
  – PREDATION
  – PARASITISM
  – DISEASE
  – STRESS (TERRITORIALITY)
  – INTRA & INTERSPECIFIC COMPETITION

DENSITY INDEPENDENT FACTORS

• MANY CATASTROPHIC EVENTS
  – OFTEN WEATHER RELATED

• MODIFICATION OF WEATHER CONDITIONS (REGIONAL?)

• FOOD QUALITY/QUANTITY

• NUTRIENT TYPE
  – QUALITY & QUANTITY

• HABITAT SELECTION

SPECIES INTERACTIONS

• SPACING PATTERNS
  – RANDOM
  – CLUMPED (AGGREGATION)
  – EVENLY SPACED—REGULAR—(HYPERDISPERSION)

• EVALUATE TYPE OF DISPERSION (DISTRIBUTION) BY POISSON STATISTICS

SPECIES DISTRIBUTION PATTERNS

- nearly uniform
- random
- clumped
SPECIES INTERACTIONS
- SPACING (PATTERNS OF DISTRIBUTION)
- PREDATOR-PREY INTERACTIONS
- INTERSPECIFIC COMPETITION
- EFFECTIVENESS OF COMPETITION
- LOTKA-VOLTERRA MODELS

TWO SPECIES INTERACTIONS
- PREDATOR-PREY INTERACTIONS
  - TIME LAGS
- COMPETITIVE INTERACTIONS
- INTRERSPECIFIC COMPETITION
- OCCURS WITH SYMPATRIC DISTRIBUTION OF TWO/MORE SPECIES IN SAME AREA

PREDATOR-PREY INTERACTIONS
- TIME LAG EFFECTS
- ARRAY OF FACTORS AFFECTING EACH SPECIES IN QUESTION INDEPENDENT OF DIRECT INTERSPECIFIC COMPETITION

INTERSPECIFIC COMPETITION
- WILL OCCUR WITH SYMPATRIC DISTRIBUTION OF TWO OR MORE SPECIES
- DEGREE OF INTERACTION (SEPARATION) MAY BE DEFINED WITH RESPECT TO SPECIFIC RESOURCES
  - FOOD SIZE PREFERENCE

EFFECTIVENESS OF COMPETITION
- ABILITY OF ONE SPECIES TO UTILIZE AVAILABLE RESOURCES THAN THE OTHER
  - KEY LIMITING RESOURCES, OR MANY OTHERS
- FUNCTION OF ENVIRONMENTAL CONDITIONS
- GENETIC/SOCIAL STRUCTURE FACTORS
- SUPPORTED BY LAB STUDIES
- TEMP VARIATION, HUMIDITY, FOOD QUAL & QUANTITY, ACCUM. WASTE PRODUCTS

COMPETITIVE EXCLUSION
- GAUSE:
  - NO TWO (2) SPECIES CAN EXIST (SURVIVE) ON SAME LIMITING RESOURCES…AT SAME TIME ALL OF THE TIME
- SPECIES WITH IDENTICAL RESOURCE REQUIREMENTS CANNOT CO-EXIST
- CONCEPT OF NICHE, NICHE OVERLAP
COMPETITIVE EXCLUSION PRINCIPLE (GAUSE)

• NO TWO (2) SPECIES CAN EXIST (SURVIVE) ON THE SAME LIMITING RESOURCE...AT THE SAME TIME, ALL OF THE TIME

• SPECIES WITH IDENTICAL RESOURCE REQUIREMENTS CANNOT CO-EXIST
  – LEADS TO CONCEPT OF NICHE, NICHE OVERLAP, ETC. (LATER DISCUSSIONS)

• CONCEPT OF NICHE, NICHE OVERLAP