31/07/13

Lecture 2: what is this thing called ecology?

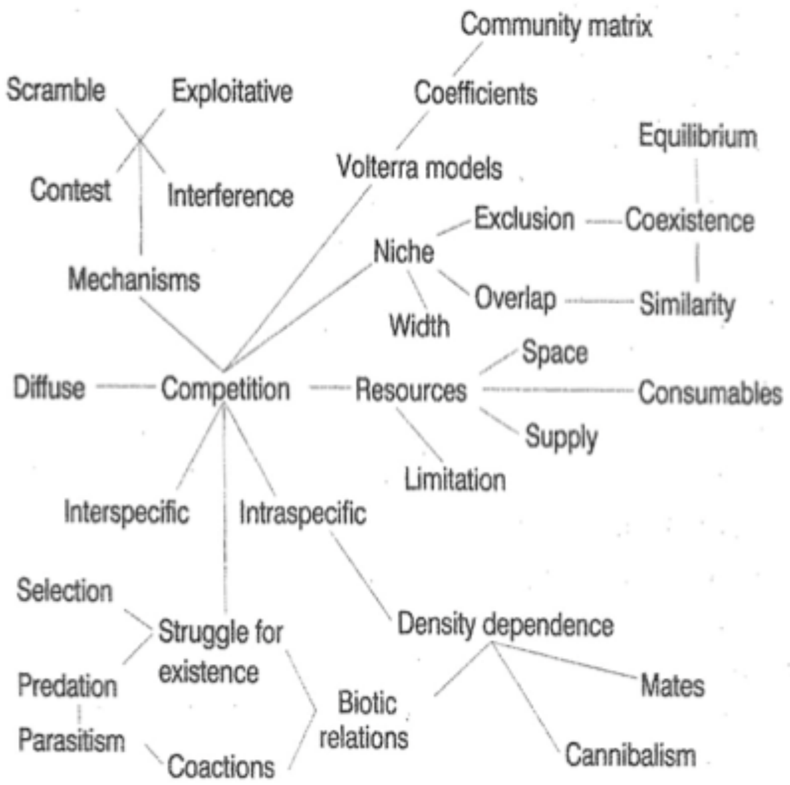
Ecology:
- Study of interactions between organisms and their environment
- Krebs (1972) study of the interactions that determine the distribution and abundance of organism
- Ricklefs and miller (2000) study of the relations of organisms to one another and the their surroundings

What are ecologists?
- Not easily defined based on skills or expertise
  - Theoretical, empirical, resource managers
- Ecologists work in a field that encompasses an immense range of organizational, spatial and temporal scales
- Ecologists inquire about the condition or state of a system, about function or mechanisms, and about the evolutionary basis of a pattern

There are limitations to the scales studied which then effect the outcomes.

Concept clusters
- multiplications of definitions
- Multiplications of linkages
- Multiplication of scales
- How do we navigate through the maze?

EG: competition concept cluster

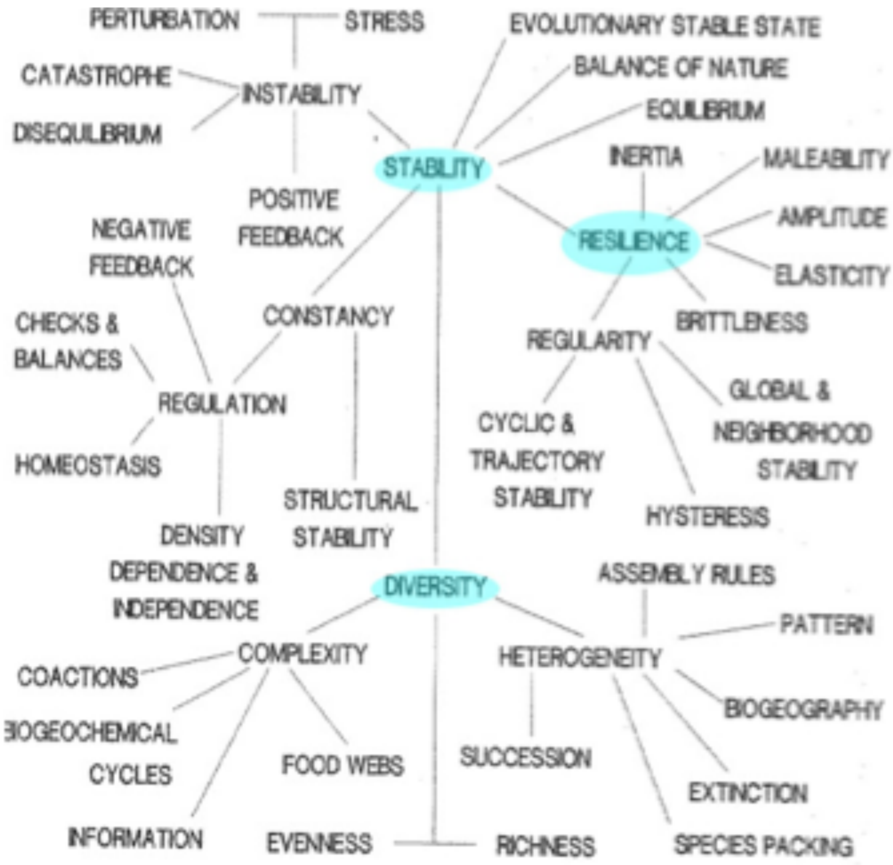


How can we strengthen the science of ecology?
Belovsky et al. 2004

- 1. Address long standing unresolved issues rather than addressing apparently new novel issues
- 2. Read the past literature (1900s) before launching in to a new research direction – the decadal recycling of research ideas. E.g. Algal Functional- Form Hypothesis
- 3. Integrate empirical and theoretical ecology
- 4. Integrate natural history and experimentation
- 5. Research multiple causation of ecological patterns
- 6. Study dynamics rather than get bogged down into equilibria – disequilibria arguments. They are end members of a gradient in ecological dynamics
- 7.Work on broad spatial scale long time series data sets.
- 8.Work on standardizing data collection - you may have a single purpose but if there is some consideration of future use then a single study can be a valuable data point in a universal study.
- 9. Do not be driven by methodology and statistics.

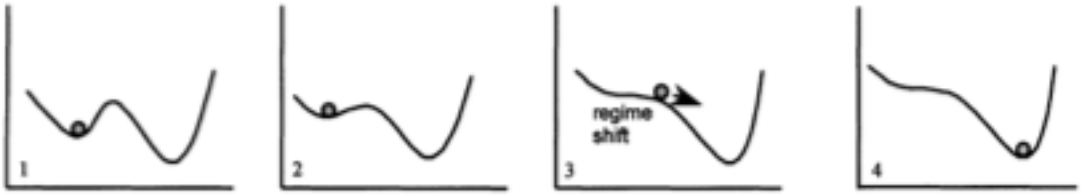
• 10. Foster the application of your Ecology to informing environmental decision making.

Resilience Clusters Concept



Resilience:

• Resilience – The ability of a population/system to resist damage and recover from disturbance events or "The magnitude of disturbance that a system can experience before it shifts into a different state (stability domain) with difference controls on structure and function" (Holling 1973). "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity and feedbacks" (Folke et al. 2004).
• Resistance – the ease/difficulty of population change in response to a disturbance event
• Recovery – The extent to which a system can recover to pre-disturbance state following a disturbance event
• Reversibility/Elasticity – The rate at which a system/population returns to pre-disturbance state



clear-water lakes	phosphorous accumulation in agricultural soil and lake mud	flooding, warming, overexploitation of predators	turbid-water lakes
coral-dominated reefs	overfishing, coastal eutrophication	disease, bleaching hurricane	algae-dominated reefs
grassland	fire prevention	good rains, continuous heavy grazing	shrub-bushland
grassland	hunting of herbivores	disease	woodland
kelp forests	functional elimination of apex predators	thermal event, storm, disease,	sea urchin dominance
pine forest	microclimate and soil changes, loss of pine regeneration	decreased fire frequency, increased fire intensity	oak forest
seagrass beds	removal of grazers, lack of hurricanes, salinity moderation, spatial homogenization	thermal event	phytoplankton blooms
tropical lake with submerged vegetation	nutrient accumulation during dry spells	nutrient release with water table rise	floating-plant dominance

Figure 2 Alternate states in a diversity of ecosystems (1, 4) and the causes (2) and triggers (3) behind loss of resilience and regime shifts. For more examples, see Thresholds Database

two theories of resilience:
1) as more and more pollution, or other stresses is put on an ecosystem, the 'tipping point' becomes lower so that effects of a large disturbance are felt more when a large disturbance occurs.
2) as systems are degraded, the less resilient species are replaced by more resilient species so that the tipping point increases.

Learning outcomes

- Ecology as a science is young, and is driven by clusters of concepts
- The transition between private thinking and prediction is key to solid ecology

- Resilience determines how systems will absorb and recover from changing environmental conditions

7/8/13

Lecture 3: Demography:

Demography: The study of the size & structure of populations

Population size: N or Ntx
- Where Ntx is the number of individuals present in the population at time x

1. Population size
- Population size increases by:
  - Natality – birth
  - Immigration – movement into a population
- Population size decreases by:
  - Mortality – death
  - Emigration – movement out of a population
  - Ntx =Ntx-1 +(B+I)–(D+E)

Population growth
- Is multiplicative not additive
  - The current population is multiplied by some (constant) fraction at each time step eg compounded
- λ (lambda) = net per capita rate of increase = R0 = net reproductive rate
  - λ = 1 indicates no change,
  - λ > 1 indicates population growth
  - λ < 1 indicates population decline

Models of population growth
- Geometric growth
  - Discrete generations
  - Good with annual reproductive event
  - $Nt = \lambda^{t} Nt_0$ or $N_t = R_0^{t} N_{t0}$
  - $\lambda = R_0$ = net per capita rate of increase or net reproductive rate
  - t = time and N_{t0} = population size at time 0
  - Application
  - Can use for annual breeders, sampled annually

– Average annual growth rate = $\sqrt[t]{(Nt/N0)}$

Example 1

Wolves in the rocky mountains were sampled for three years following introduction. The population is increasing.

$N_t = \lambda^t Nt_0$

$\sqrt[t]{(N_t/N_0)}$

Year	N
1998	275
1999	322
2000	433

λ
1.17
1.34

λ1998-2000
$= \sqrt[t]{(N_{2000}/N_{1998})}$
$= \sqrt[2]{(433/275)} = \sqrt{(1.575)} = 1.25$

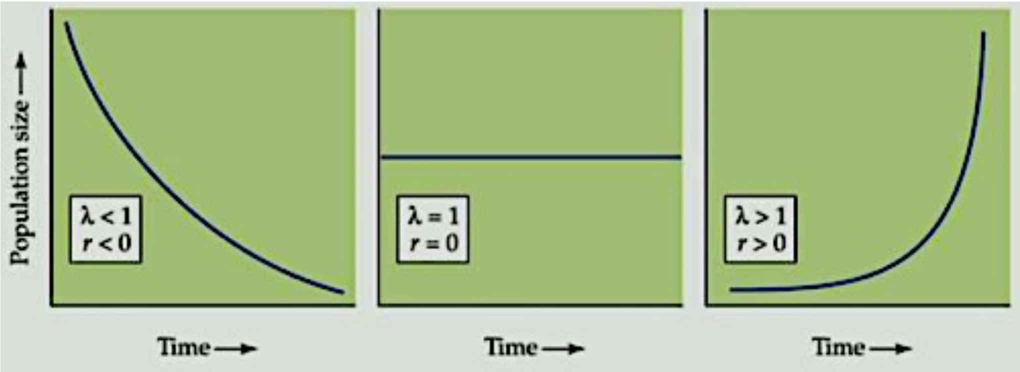
- Exponential growth
  - Overlapping generations
  - Rate of increase at time interval is proportional to population size (*N*)
  - $dN/dt = rN$ (or $Nt = N_0e^{rt}$)
    - where; dN/dt = change in population size;
    - r = instrinsic rate of increase (= per capita rate of increase and equals birth rate minus death rate);
    - N = population size.
    - No = original population size
    - Nt = population size at time
    - t = time
    - r = *per capita* instantaneous rate of increase = $\log_e \lambda$

What does instantaneous rate mean?

- λ (or R_0) is a finite rate
  - Calculated over a given time period (usually per year)
- r is an instantaneous rate
  - Calculated over a very small time period
- Finite rate = $e^{\text{instantaneous rate}}$, or
- Instantaneous rate = loge (finite rate) = ln λ

Why use instantaneous rates?

- Better reflects how biological system operate
- Has more intuitive values

- Mathematically easier to handle
- 

	Decreases	No change	Increases
Finite rates	0 to 1.00	1.00	1.00 to ∞
Instantaneous rates	-∞ to 0.00	0.00	0.00 to ∞

The wolves in example 1 began as a population of 275 in 1998. Given their average net per capita increase (λ) of 1.25, when will the population reach 1000?

- Use $N_t=N_0e^{rt}$ rearranged as $N_t/N_0=e^{rt}$
  - $1000/275 = 3.636 = e^{rt}$ where $r = \ln \lambda = 0.223$
- Log both sides
  - $\ln(3.636)=1.29 = \ln(e^{rt})=rt =t(\ln \lambda)=t(0.223)$
- Rearrange and solve for t
  - $t = 1.29/0.223 = 5.78$
- Wolf population will reach 1000 sometime in 2003-4

2. Population structure
- Populations are not one homogenous mass but made up of individuals of different sexes, sizes and ages.
- Different stages and ages usually have different growth, survival and reproductive rates.
- Structure of population will therefore effect population growth

Demographic parameters required to project population size over time
- Birthrate–individuals born over a time period
- Mortality rate–individuals dying over a time period
- Survival rate–individuals surviving over a time period
- Sex-ratio–the proportion of the population that is male or female

- Age-structure–the number of individuals of the various age classes at a given time

Life cycles

Individuals:

- Born
- Grow
- Become reproductive - Length and schedule of reproductive phase will influence population growth
- May live through a post reproductive stage
- Die

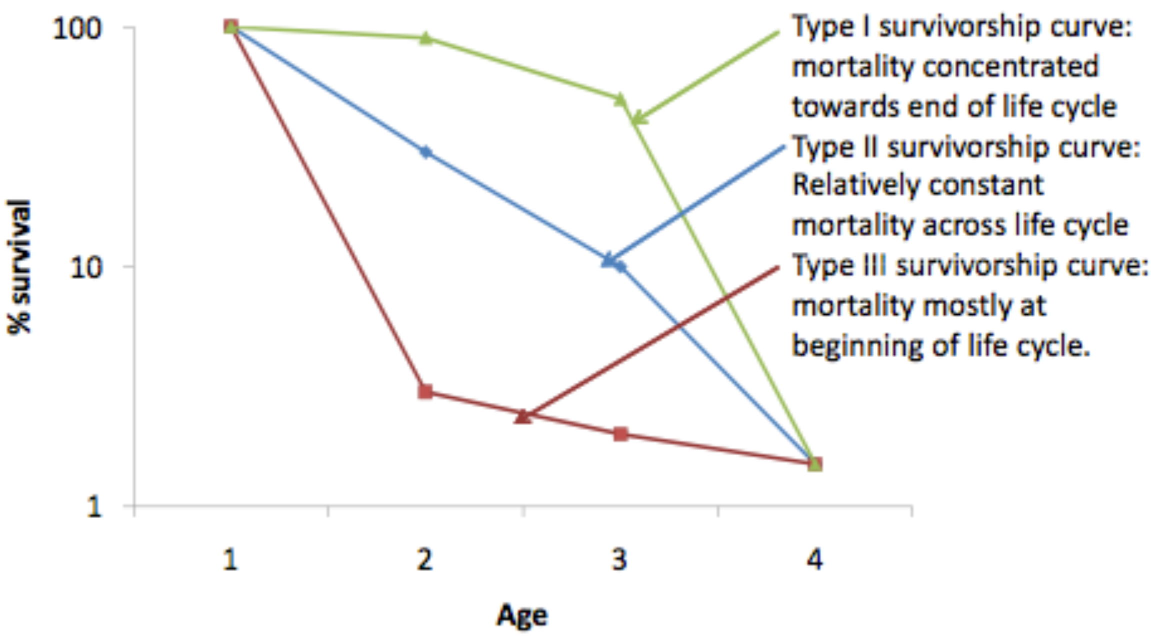
Estimating demographic parameters

- Life-table – summarises mortality & survival rates for each age class (cohort) in a population
- Calculated by following the fate of a cohort of animals (**dynamic life table**) or derived from census data (**static life table**)

Age (Years) x	Number surviving n_x	Proportion surviving l_x	Deaths in each age interval d_x	Mortality rate q_x
0–1	30	1.0	8	0.266
1–2	22	0.733	16	0.730
2–3	6	0.200	4	0.666
3–4	2	0.066	–	–

- Proportion surviving = Ix = nx / n0
- Number of deaths in an interval = dx = nx – n(x+1)
- Mortality rate = qx = dx / nx
- two problems with life tables
  - you need a lot of data
  - there are a few major assumptions that must be upheld.

Survivorship curves:



Estimating demographic parameters

- Fecundity table – summarizes rates of births taking into account variations in reproductive success with age.

Age (years) x	n_x	Proportion surviving l_x	Total offspring	Fertility b_x	Survival and reproduction l_xb_x
0–1	30	1.0	10	0.33	0.33
1–2	22	0.733	35	1.59	1.17
2–3	6	0.200	12	2.00	0.40
3–4	2	0.066	4	2.00	0.132

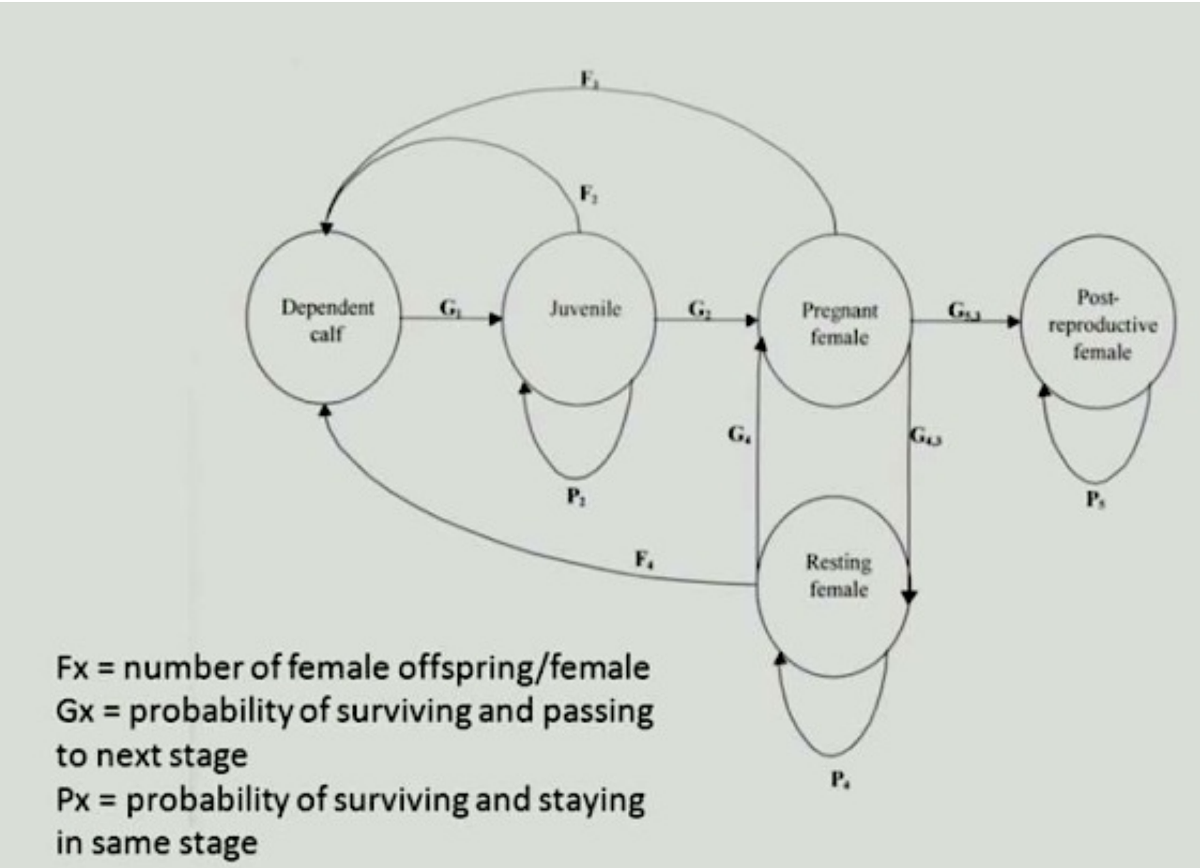
  - Mean no. females born in each age group (fertility) = bx = total offspring / nx
  - Survival & reproduction = lxbx = proportion surviving x fertility
  - Net reproductive rate = R0 = Σ (lxbx)
    - R0 = 1 females have replaced themselves
    - R < 1 population declining
    - R > 1 population increasing
      - Estimate of R0 (λ) by this method is more accurate and can be used in population models

Life Tables

- Cohort Life Tables
  - (dynamic or horizontal) life table is reliable but collation of data and construction beset by practical difficulties. Best done on laboratory

organisms, but also possible for plants. Large investment of time and money.

- Static Life Tables
  - (Time specific or vertical) life table confuses age-specific changes in birth and mortality rate and their variation from year to year.
  - Fixed cohort tables are rarely possible with natural populations.
  - Alternative is to examine the age structure of the whole population at one particular time.
  - Major assumption is numbers of births and age-specific survival rates remain the same from year to year (a stable age distribution, and a constant birth and death rate).
  - No ability to account for immigration and emigration.

- Stage-structured life cycles
  - Can utilize knowledge of stages to project population
  - Construct life cycle graph = flow diagram
  - For each stage, an individual may:
    - Survive and remain at that stage (P)
    - Survive and develop/grow to next stage (G)
    - Survive and reproduce (F)
    - 

Key points

- Population models can project population estimates forward in time
- Life tables can be used to answer critical questions about population growth and survival
- All population models discussed assume conditions will remain the same and thus are projections of current conditions, not predictions.