# theoretical ecology

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This is a brief collection of notes on theoretical ecology from ECL232 taught by Alan.

## 1 Summary

## 2 Sections

- Introduction
- Stability
- Time delays
  - Nicholson (1957) and May (1975) time delays in Huffaker data
- Age structure
  - simple renewal equation which focuses on births

$$B(t) = \int B(t-x)l(x)m(x)dx$$

  - here $B(t-x)$ is number of individuals born x years ago, $l(x)$ is survival of ind to age x, and $m(x)$ is reproduction at age x
  - look for solution where $B(t) = B(0)exp(rt)$
  - PDE approach would use method of characteristics (boundary condition turns out to be renewal equatioin)
- Two species competition (Lotka, Volterra, Gausa)
  - Lotka has simple set of competitors
  - **well-known idea that intra>inter species competition for coexistence**
  - Gausa (1935) - yeast experiments with single and mixed species setups
    - paramecian trials - one species outcompetes the other in mixed trial
  - Forms of competition: resources, competition-colonization tradeoff, extinctino events, Cornell gradient of physcial controls hypothesis, R* theory
  - Volterra extended Lotka by including density dependence
- Two species predation
  - can conduct experiments with refuges or immigration of prey
- Host-parasitoid (Nicholson-Bailey)
- Basic epidemiology
  - Kermack and McKendrick - SIR models
  - plague in Bombay in 1905
  - need $N_0 > l/K$ for epidemic to occur
  - definition of $R_0$
  - do multi-strain dynamics lead to death of host?
  - Anderson and May
- Spatial structure
  - Theory of Island Biogeography (MacArthur and Wilson 1967)
    - tried to explain the number of species found on islands, does not always scale with area

    - argued that number of species on island depended on colonization and extinction rates on those islands, crossing of these curves is an equilbrium
    - also predicts that islands farther from mainland should have lower equilrbium
  - implicent (fraction of space occupied) vs explicent (explicit, simulation based approaches)
  - metapopulations - Frituary butterflies, Huffaker's mites
    - persistence globally, not locally
  - Hastings (1977) - empty, prey only, prey and predator implicent model
  - KPP (1937), Fisher (1937) - spread of genes, Skellum (1951) - muskrat in Europe
- Diffusion equatin and spread (Andow et al. 1990)
- Chaos and complex dynamics
  - complex models have strong, overcommpensentory dynamics
  - overcompensentory - when density is large, next year is less
  - compensentory - saturing curve for N(t+1) vs N(t)
  - cobwebbing
  - chaos - expponetial divergence between nearby initial conditions
  - bifurcation diagrams
  - Lyapunov exponent - rate of expansion of ball arouund a solition (if positive then you have chaos)
  - strange attractor - has dimension that is not an integer
  - Constantino et al (1997) - chaotic dynamics in Tribolium using LPA model and experimental setup to manipulate parameter
  - Beninca et al (2008) - long term plankton experiment where predictiniliy decreases over time
- Regime shifts
  - alternative state for deserts, lakes, and coral reefs
  - critical slowing down occurs near bifurcation point (before transition)
  - historical data and **prosecutor's fallacy**
  - Takens Theorem - can reconstruct whole dynamics of system using single variable
  - need lots of data, hard to detect transition
  - Ludwig et al (1978)
  - look at type I vs type II errors and receiver operator curves (true pos vs false pos)
- Integro-difference approaches
  - important when reaction-diffusion assumptions not met
  - really fat tails creates moments that are infinite
  - van Kirk and Lewis (1997) is a classic paper
- **Stochasticity**
  - do answers change when you add stochasticity?
  - Melbourne and Hasting (2008) - stochastic Ricker model with environmental noise, demographic heterogeneity, demographic stochasticity, and random survival process, sex determination
  - more complicated, stochastic models create earlier time to extinction
  - my conjection - more complicated models will predict earlier timing of extinction
- Marine reserves
  - integro diff equations are one approach
  - Botsford et al 2001, Hastins and Botsford 2006
  - bioeconomic models
  - future prospects: appropriate values of variability, multi-species, bioeconomic models
- Invasive species
  - many different mathematical approaches
  - Spartina example