Population Regulation

Intrinsic Factors

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1. Define stability.

2. What are some features of a stable population?

3. How might a conservation biologist define population stability?

4. Draw a population time series that fluctuates and is stable.

5. What does it mean to say that the growth rate of a population is density dependent?

6. What are some features of a stable community?

7. Which community is most stable, one with many species, or one with few species?

8. If you could rewind evolution to the first organism, and let life evolve for a second time, would humans occur? Is evolution a stable process?
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The "Balance of Nature" Metaphor and Equilibrium in Population Ecology

K. M. Cuddington, Biology and Philosophy 16:463-479

- "Shorthand for a paradigm which view[s] nature as a beneficent force."
- "Used to define those types of equilibrium which are deemed natural."
- "Embody[es] our beliefs about the predictability and resilience of nature."
- "A central theme of ancient natural history."
- "All things were believed to be interconnected to preserve an order."
- "Pre-ordained by a divine power, randomness and extinction of species were not normally considered possibilities."
The "Balance of Nature" Metaphor and Equilibrium in Population Ecology

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- "Nature operates to strike a balance between disparate forces."
- "Natural populations have a more or less constant numbers or individuals."
- "Natural systems have a more or less constant number of species."
- "Communities of species maintain a "delicate balance" of relationships."
- "Result is a system that experiences community persistence."
“The reason ecologists today are uninterested in chaotic dynamics and multiple stable attractors is the same reason that Volterra rejected the idea of stable oscillations whose amplitude depended on initial conditions, and Nicholson and Bailey could not conceive of population extinction as a natural outcome of a predator-prey interaction.”

“The balance of nature metaphor does not cohere well with this type of equilibrium behavior, which is both predicted by population models and found in natural populations.”

“A stable equilibrium density, on the other hand, does cohere well with the notion of balance, and is well accepted by ecologists.”
The “Balance of Nature” and “Population Control”

P. R. Ehrlich and L. C. Birch, American Naturalist, 1967

- “Balance of Nature’ idea is commonly held by biologists.”
- “Harmony between organisms so that a state of dynamic equilibrium exists.”
- “Number of individuals of each species in the community is relatively constant.”
- “Significant changes in numbers occur only when something upsets natural ‘balance.’”
- “Perpetuated by popular magazines and nature films / Part of the lore of man–in–the–street.”
- “Difficult to explain why it persists in the writings of ecologists.”
Typical Argument for the “Balance of Nature”

P. R. Ehrlich and L. C. Birch, American Naturalist, 1967

- “Species $X$ has existed for thousands or perhaps millions of generations.”
- “Its numbers have never increased to infinity or decreased to zero.”
- “The same is true of the millions of other species still extant.”
- “During the next 100 years, the numbers of all of these species will fluctuate.”
- “None will increase indefinitely, and only a few will become extinct.”
- “Such ‘observations’ are basis for the statement that
  - population size is ‘controlled’ or ‘regulated’ and
  - that drastic changes in size are the results of upsetting the ‘balance of nature.’”
• “On the average, the species just replaces its numbers in successive generations.”

• “On the average, the numbers of individuals over a long period of time are constant.”

• E&B point to an extreme version from Slobodkin (1962, p. 46). “Despite this enormous variation in reproductive patterns, each female adult animal alive now—in every species, in almost every location—will be replaced by precisely one female alive a generation from now. If this were not the case, the size of animal populations would be changing permanently and strikingly at a much greater rate than any existing evidence indicates.”
Typical Argument for the “Balance of Nature” – Continued

P. R. Ehrlich and L. C. Birch, American Naturalist, 1967

- “Slobodkin’s statement may well be the most thoroughly falsified hypothesis still current in population biology” (emphasis added).
- “The literature fails to disclose a single case of a natural population behaving in the manner described.”
Population regulation is a fundamental process related to most phenomena in ecology, including evolutionary ecology.

Population regulation is defined as, “Bounded fluctuations in abundance, in contrast to the unbounded fluctuations of random walk populations.”

“Regulation arises as a result of potentially stabilizing density–dependent processes.”

“Regulation is essential to long–term species persistence.”

“Finding the stabilizing mechanisms that lead to regulation remains the central question in population dynamics” (emphasis added).
Coin population experiment.

Survival probability = 0.5

Fecundity = 2
Random Walking Coin Population

Survival probability = 0.5, fecundity = 2
A Basis for Models of “Population Control”

P. R. Ehrlich and L. C. Birch, American Naturalist, 1967

Reasonable Set of Propositions

- “First proposition: All populations are constantly changing in size”
- “No female animal alive now, in any species or in any location, will be replaced by precisely one female alive a generation from now”
- “A thorough search of the literature has failed to turn up a single case of exact replacement in a natural population”
- “This surely is a safer hypothesis than one which has been falsified in every single test known to us”
A Basis for Models of “Population Control” – Continued

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- “Second proposition: The environments of organisms are constantly changing, with changes on different time scales (diurnal, seasonal, long–term, etc.) going on simultaneously.”
A Basis for Models of “Population Control” – Continued

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- Third proposition: “The local population, within which there is relatively free movement of individuals, must be recognized and investigated if changes in population size are to be understood.”
- “The first step ... must be a study of the structure of the species population.”
- “Local populations must be identified by mapping, marking individuals, etc.; and some measure of the amount of migration among these populations must be obtained.”
- “The answer to the question at the ‘species level’ will be found in investigation of these local populations and the interactions among them.”
“Fourth proposition: The influences of various components of the environment on population size will vary.”

“Components (weather, resources, etc.) will act differently on populations of different densities, on different populations of the same species, on populations of different species, and so on.”
A Basis for Models of “Population Control” – Continued

P. R. Ehrlich and L. C. Birch, American Naturalist, 1967

• Simplified models are needed to understand what determines the numbers of organisms
  • “Such models are highly misleading if they are based on false assumptions”
  • “Any realistic model must take into account the four propositions stated above”
  • “The necessary model will be stochastic, not deterministic”