The Metapopulation Story: Insights for Management

Levins' Model Assumptions

• All patches identical in size and quality
• Infinite number of patches
• No spatial structure
• All patches equally connected
• No time lags - population instantaneous with colonization
• Complete spatial asynchrony
  "blinking light" model

Metapopulation—Theory or Hypothesis?

1. Theory: A hypothesis that has survived repeated efforts to falsify it "to the extent that we have some faith in predictions from it" Nichols 2001:12
2. Hypothesis: a story about how the world works
3. Model: an abstraction or simplification of the real world; models as tools for the evaluation of hypotheses
  "All models are wrong, but some are useful"

Models Provide Insight, Not Proof

"The primary value of models is heuristic…"
"Models are most useful when they are used to challenge existing formulations, rather than to validate or verify them"
Oreskes et al. 1994

Paradigm Shifts and Motivation for Metapopulation Concept

Theory of Island Biogeography

Importance of Habitat Fragmentation

Critique of TIB for Habitat Islands

Emerging Field of Cons. Bio

Theory of Small Population Dynamics

Emerging Field of Landscape Ecology

Contributions of Metapopulation Concept to Conservation

Starters:
• almost all of the influential papers have been via mathematical modeling (theoretical)
• empirical evidence is scant
concept is strong in guiding management

Doak and Mills 1994 Ecology 75:615-626
Contributions of Metapopulation Concept to Conservation

And a favorite dogma of conservation biology

But…….

(1) Are metapopulation models useful in depicting real populations?

(1) Can we determine when metapopulation dynamics are important for real populations?

(3) Should we create metapopulations for vulnerable species?

Doak and Mills 1994 Ecology 75:615-626

Are metapopulation models useful in depicting real populations?

Empirical evidence for metapopulation dynamics

Harrison and Taylor 1997

???????

Can we determine when metapopulation dynamics are important for real populations?

Data needs?

Ability to distinguish among alternative explanations?

Doak and Mills 1994 Ecology 75:615-626

Should we create metapopulations?

• much of the motivation for metapopulation concepts
• Spotted owl example, etc.
• Insight provided from modeling exercises with existing data
  • highlight sensitivity
  • identify information gaps that are most needed
  • bring in stakeholders

Doak and Mills 1994 Ecology 75:615-626

Utility of Metapopulation Models in Conservation

“All models are wrong. Some are useful”

Metapopulation theory via models:

• renewed interest in understanding dispersal
  • in matrix
  • in corridors/stepping stones
• heighten awareness of risks to populations
• identified parameters we must think about for persistence
• facilitated criticism of metapop models leading to heightened awareness for within-patch issues (alternative explanation for patch occupancy)
• that are more amenable to management
• increased concern about need for connectivity

Doak and Mills 1994 Ecology 75:615-626

Cautions in Applying Dogmatic Ecological Theories

• cool concepts get quickly accepted, often without evidence
• hypothetical nature of ecological theories get confused with the more widely accepted definition of theory as arising from repeated attempts to falsify hyp
• “…latest fads in ecology are co-opted by conservationists eager to use them in applied setting”
• conservation is often by case study, and not generalization
• de-emphasizes the less theoretical but often more pragmatic focus on the myriad factors affecting population declines
Multiple Factors Affect Local Dynamics

- Increased predation
- Habitat loss
- Pesticides
- Isolation
- Ground squirrel control
- Disturbance

But a Good Theoretical Perspective Provides Important Guidance and Constructive Thinking

Caughley’s Two Threads of Conservation Biology

Small-Population Paradigm
- Decreasing Population
- 

Declining Species Paradigm
- 

The Enlightened Applied Ecologists
- Yes, a burrowing owl... Red XL indeed!
- Exactly as predicted...

Great, that gives us \( S = 0.81 \pm 0.02 \), just what I needed for my Individual-Based Model!

Stability Properties of the Spotted Owl Metapopulation in Southern CA

Noon and Mc Kelvey 1992

One of the primary early examples of applying metapopulation models to guide management

Stability Properties of the Spotted Owl Metapopulation in Southern CA

Used demographic data collected at study sites AND assumptions about behavior and relationships among traits

Used several models to ASSIST in the design of a reserve strategy:
1. Individual-territory model
2. Territory-cluster model
3. Spatially explicit landscape model

Stability Properties of the Spotted Owl Metapopulation in Southern CA

Spatially Explicit Landscape Model

- uses real landscape
- links survival and reproduction to current habitat location
- made assumptions of relationship of demographic rates with size and distribution of habitat patches
- simulates movement based on set of movement rules
Stability Properties of the Spotted Owl Metapopulation in Southern CA

Conclusions From Simulations

- authors noted results should NOT be interpreted as estimates of extinction likelihoods – too many uncertainties and assumptions
- uncertainties included dispersal abilities through matrix and long-term demographic rates
- interpreting model results visually (on the real landscape map) allowed insights into locations that were particularly vulnerable
- identified sensitivity of results to assumptions
- identified parameters requiring greater understanding
- clarified potential relationships otherwise not envisioned

Stability Properties of the Spotted Owl Metapopulation in Southern CA

Ultimately, model results guided the development of a conservation strategy and identified uncertainties of different approaches

The model allowed evaluation of potential management strategies, but the modelers did not prescribe specific directions from their effort—An appropriate use of modeling in natural resource management

• identified populations most influential in metapopulation persistence under the model and reductions in habitat in these areas were most critical