

Population Viability and Metapopulations

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EXTINCTION

- **What causes extinction?**
 - **Deterministic extinction**
 - probability of death > probability of birth
 - The “Big Five” Wilcove et al. 1998 - BioScience
 - Habitat alteration
 - Overharvest
 - Pollution
 - Introduced species
 - Disease

EXTINCTION

- **What causes extinction?**
 - **STOCHASTICITY** (randomness) becomes a major issue in small populations
 - **Stochastic extinction** = extinction due to random factors
 - Even though probability of birth may be \geq probability of death

Stochastic Extinction

- **Stochastic Catastrophe**
 - volcanic eruption vs. Martinique rice rat
- **Environmental Stochasticity**
 - e.g. drought, hard winters
 - severe storms nearly wiped out a whooping crane flock in FL, Feb. 2007
- **Demographic Stochasticity**
 - Fates of individuals can randomly vary
 - Birth
 - Sex ratio

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EXTINCTION and Stochasticity

- Expected birth and death rates are **probabilities**
 - if population size is large then the observed birth & death rates will be very close to the expected values
 - if population size is small, then the actual birth & death rates may be very different from expected

Stochastic Extinction and Small Populations

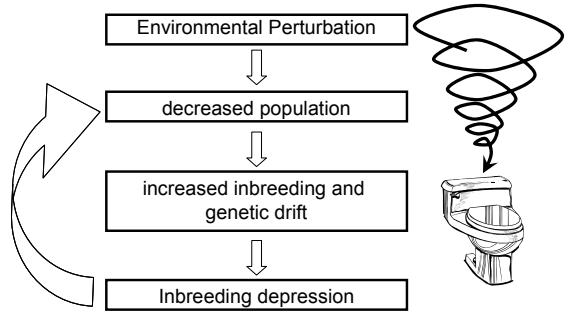
- If the probability of each female giving birth is 0.5 and there are only 3 adult females, then what is the probability of ZERO births?
 - = $1/2^3 = 1$ in 8
- What if there are 30 females?
 - = $1/2^{30} = 1$ in 1.1 billion
- Small populations often go extinct even if the expected $(b - d) \geq 0$

Stochastic Extinction (cont.)

- Genetic Stochasticity
 - GENETIC DRIFT →
 - RANDOM LOSS OF ALLELES
 - rare alleles may be important for long term adaptability
 - INBREEDING
 - Inbreeding depression (lower birth & survival rates)

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Genetic Vortex



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How Small is Too Small?

- **Minimum Viable Population (MVP)** -
- **Some general guidelines**
 - genetic stochasticity: effective population size > 50
 - demographic stochasticity: 50-100
 - environmental stochasticity: several hundred to few thousand

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THE HEATH HEN

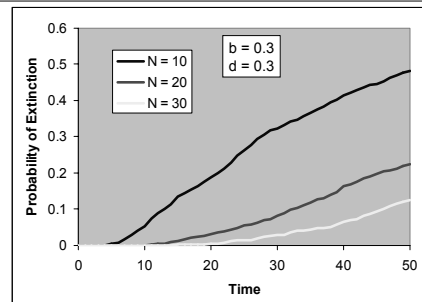
- Lived in Coastal Marshes along the Atlantic and numbered in 10,000s - 100,000s
- Hunting pressure from European settlers.
- Marshes converted to agriculture
- **1900** 100 individuals
- **1907** created refuges, protected habitat, removed predators
- **1916** population increased to 800.
fire wiped through island causing decrease in population
- **Winter 1916/17** 10 year low in snowshoe hare caused invasion of goshawks and snowy owls, increasing predation.
- **1917** 100 animals
- **1920** 200 animals
- **1921** diseased chickens brought to island spread to hens reduced population to 100 animals
- **1922-32** many infertile eggs (inbreeding depression, etc.)
change in sex ratio (10 males/female)
- **1932** EXTINCT

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Population Viability Analysis

- estimate birth, death, & migration rates
- plug these values into a population model
- predict probability of extinction under different conservation scenarios
 - Time scale
 - Population size
 - Metapopulation structure

Population Viability Analysis: Sample Output



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Metapopulation

- *group of spatially separated populations linked infrequently by dispersal*
- too little dispersal: populations are not linked (separate populations)
- too much dispersal: populations form a single large population

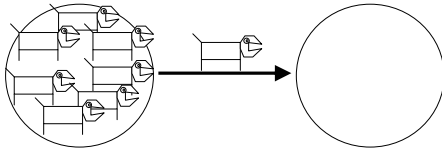
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Metapopulations and Extinction

- **Local extinction:** loss of all animals from one population (= **extirpation**)
 - each population has some probability of going extinct
- **Global extinction:** extinction of the whole metapopulation
 - metapopulation may persist despite local extinctions

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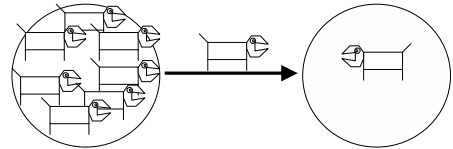
Metapopulations and Migration



- immigrants can recolonize a patch after local extinction

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Metapopulations and Migration

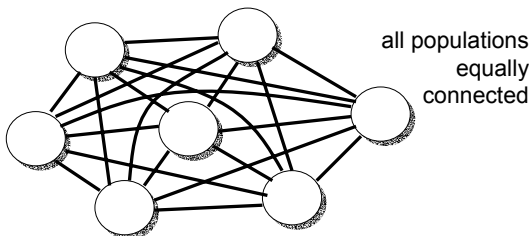


- “rescue effect” – immigration may prevent extinction in a patch with a small population

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Types of Metapopulations

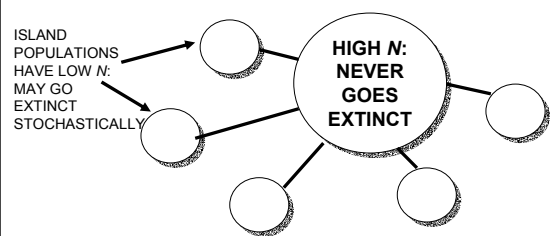
- “Classic” or “Levins” Metapopulation



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Types of Metapopulations

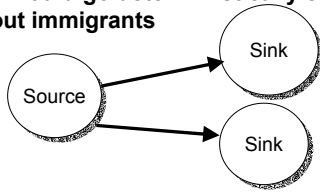
- Mainland-Island Metapopulation



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Types of Metapopulations

- **Source-Sink Metapopulation**
average $b > d$ in source patches (good habitat)
average $b < d$ in sink patches (poor habitat)
- sink would go deterministically extinct without immigrants



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Levins Metapopulation Model

- **Simplest model**
- **Assumptions**
 - all patches are the same
 - migration & extinction rates are constant
 - patches are either extinct or occupied at K
 - all patches are equally accessible
 - many patches
 - fate of each patch is independent of others

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Levins Metapopulation Model

- m = migration rate (probability of an animal moving from patch to patch)
- e = probability of local extinction
- p = proportion of occupied patches
- at equilibrium:

$$p = 1 - e/m$$

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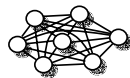
Increasing Connectivity

- habitat corridors
- wildlife overpasses / underpasses

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Implications for Reserve Design

- **SLOSS Debate (Single Large or Several Small)**
- **Single large reserve:**
 - low chance of local extinction (high N)
 - vulnerable to a single catastrophe
 - may not consist only of high-quality habitat
- **Several small reserves**
 - higher local extinction rate
 - less vulnerable to catastrophe
 - may be focused on good habitat
 - connectivity is crucial



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Things to Remember

- Understand how small populations are more subject to stochastic extinction
- Understand how the genetic vortex works
- Know what population viability analysis is
- Definition & types of metapopulations
- Importance of connectivity
- SLOSS Debate