Conserving populations
Individuals matter

Population characteristics affect $N_e$

- **Age structure**
  - Reproductive status

- **Sex ratio**
  - $N_e = (4 \times N_f \times N_m) / (N_f + N_m)$
    - $N = 40$ adults capable of reproducing, but... $N_f = 30$ and $N_m = 10$, so...
    - $N_e = 30$...so 25% fewer

- **Mating systems**
  - Strictly monogamous: $N_e = 20$ using data above
  - Polygamous: only dominants mate

Factors influencing population size

- **Density dependent**
- **Density independent**
- **AND**
  - Deterministic
  - Stochastic
- **Which type of factors is easier to manage?**

Some population characteristics

- **Demography in action**
- **Changes in N**
  - **Age structure**
  - **Sex ratio**
  - **Many of which can be described in a**:

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Changes in numbers

- **Some ‘simple’ descriptions**
  - **Exponential**
    - $\frac{dN}{dt} = rtN$
  - **Logistic**
    - $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$

Which model of growth is more relevant to conservation?

A case study

- **The heath hen** (*Tympanuchus cupido cupido*)
The heath hen

- 1876: Once common in eastern US, overhunting and habitat destruction restricted it to Martha’s Vineyard
- 1900: 100 individuals left
- 1907: 50 individuals left; refuge established
- 1915: recovery to 2,000 individuals
- 1916: fire destroys most habitat and nests; predators (goshawks) converge
- 1920: some recovery followed by disease from domesticated turkeys; 100 individuals
- 1932: extinction following rising sterility and loss of all females

Once population declined, what type of factors cemented its decline?

Important sources of uncertainty for populations

- “Four Horsemen of the Extinction Apocalypse” Shaffer (1981)
- Genetic stochasticity
- Environmental stochasticity
- Demographic stochasticity
- Natural catastrophes

Genetic stochasticity

Canine distemper from nearby domestic dogs

Bottleneck (9♀, 1♂)

The Ngorongoro Crater lions

Environmental stochasticity

The bay checkerspot has been studied for > 30 yr (Paul Ehrlich)

Good example of a metapopulation

Brief interlude: Metapopulations

- What are they?
- What do you have to measure?
- Patch quality?

Related idea: source-sinks

Fig. 12.6

Demographic stochasticity

- Example
- Allee effect (1931)

Warder Clyde Allee

Sage grouse

Fig. 12.4
Natural catastrophes

- Disturbances

After the 2009 fire at Lewis Ocean Bay HP

The extinction vortex

- Putting the 4 horsemen together

Deterministic vs. stochastic modeling

- Modeling of $r$

Some examples of stochasticity

- Each year: 30% chance of dying
- 50% of survivors give birth
- Demographic stochasticity
- Each year: 2% chance of 90% dying

Population viability analysis (PVA)

- Modeling the chance of extinction given certain conditions
- Helps determine MVPs
- VORTEX as a stochastic model for PVA
- Bob Lacy

Fig. 3. The trend of a modelled population whose successive rates of increase $r$ are drawn at random from a normal distribution with zero mean and unit variance. Caughley (1994)
VORTEX

- Combination of deterministic and stochastic factors affecting a population
- Incorporates each of the “4 horsemen”
- Can model metapopulations
- A powerful program that depends on several assumptions, but is especially reliant on lots of accurate data
  - Realistic?

An example

Modeling points to remember

- “All models are wrong. Some models are useful.”
  - George Box
- "To err is human, but to really foul things up you need a computer."
  - Paul Ehrlich

Some PVA problems

- Models populations, not communities or ecosystems
- No clear and standard criteria to judge success
- Variability in output can be large
- It’s not diagnostic of the specific causes of extinction, although it can provide clues

So, why bother? (1)

- ‘Parameterizing’ a model forces you to be explicit about what you DO and DO NOT know about a population
  - As such, it can provide guidance about the direction of your research program
- PVA is used frequently to set conservation goals in ESA recovery plans

So, why bother? (2)

- Brook et al. (2000) split long-term data sets for 21 populations in half
- Used the 1st half to make PVAs in different programs & the 2nd half to test their accuracy

Minimum data set = 10 yr