Conserving populations

Individuals matter

Human chromosome #3

Population characteristics affect $N_e$

- Age structure
  - Reproductive status
- Sex ratio
  - $N_e = (4 \times N_f \times N_m) / (N_f + N_m)$
  - $N = 35$ adults capable of reproducing, but... $N_f = 26$ and $N_m = 9$, so...
  - $N_e = 27...so 23\%$ fewer
- Mating systems
  - Strictly monogamous: $N_e = 18$ using data above
  - Polygamous: only dominants mate

Factors influencing population size

- Density dependent
- Density independent
- AND
  - Deterministic
  - Stochastic
- Which type of factor 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:

<table>
<thead>
<tr>
<th>Sex</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>$N_f$</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>$N_m$</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>$N_e$</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

Changes in numbers

- Some ‘simple’ descriptions

  **Exponential**
  \[
  \frac{dN}{dt} = rN
  \]

  **Logistic**
  \[
  \frac{dN}{dt} = rN(1-N/K)
  \]

Which model of growth is more relevant to conservation?

A case study

- The heath hen ($Tympanuchus cupido cupido$)

<table>
<thead>
<tr>
<th>Age (weeks)</th>
<th>$x_1$</th>
<th>$x_2$</th>
<th>$x_3$</th>
<th>$x_4$</th>
<th>$x_5$</th>
<th>$x_6$</th>
<th>$x_7$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>100</td>
<td>250</td>
<td>150</td>
<td>250</td>
<td>150</td>
<td>250</td>
<td>150</td>
</tr>
<tr>
<td>2-3</td>
<td>120</td>
<td>150</td>
<td>250</td>
<td>150</td>
<td>250</td>
<td>150</td>
<td>250</td>
</tr>
</tbody>
</table>

*Includes 172 females from captive rearing

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” Shafer (1981)
  - Genetic stochasticity
  - Environmental stochasticity
  - Demographic stochasticity
  - Natural catastrophes

Genetic stochasticity
- Canine distemper from nearby domestic dogs
- Bottleneck (9♀, 1♂)
- The Ngorongoro Crater lions

Brief interlude: Metapopulations
- What are they?
  - What do you have to measure?
  - Patch quality?
- Related idea: source-sinks

Environmental stochasticity
- The bay checkerspot has been studied for > 30 yr (Paul Ehrlich)
- Good example of a metapopulation

Demographic stochasticity
- Example
  - Allee effect (1931)
- Sage grouse

Warder Clyde Allee

Fig. 12.6

Fig. 12.4
Natural catastrophes

- Disturbances

After the 2009 fire at Lewis Ocean Bay HP

The extinction vortex

- Putting the 4 horsemen together

The upshot

- Chance events matter when N drops
- If we’re serious about examining extinction risks, then random variation must be included
- How do we do this?

Deterministic vs. stochastic modeling

- Modeling of $r$

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)

Some examples of stochasticity

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

Possingham et al. (2001)

Population viability analysis (PVA)

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

Possingham et al. (2001)
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 ______
  - Realistic?

An example

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

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

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