Conserving populations

Individuals matter

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>Population characteristics affect N_e</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Age structure</td>
</tr>
<tr>
<td>• Reproductive status</td>
</tr>
<tr>
<td>• Sex ratio</td>
</tr>
<tr>
<td>• N_e = (4 × N_f × N_m) / (N_f + N_m)</td>
</tr>
<tr>
<td>• N = 41 adults capable of reproducing, but... N_f = 30 and N_m = 11, so...</td>
</tr>
<tr>
<td>• N_e = 32...so 22% fewer</td>
</tr>
<tr>
<td>• Mating systems</td>
</tr>
<tr>
<td>• Strictly monogamous: N_e = 22 using data above</td>
</tr>
<tr>
<td>• Polygamous: only dominants mate</td>
</tr>
</tbody>
</table>

Changes in numbers

- Some ‘simple’ descriptions

Exponential
\[
dN/dt = rN
\]

Which model of growth is more relevant to conservation?

Logistic
\[
dN/dt = rN((K-N)/K)
\]

Factors influencing population size

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

A case study

- The heath hen (*Tympanuchus cupido cupido*)

<p>| Table 8.1: An example of a life table for Federal’s ground squirrel (<em>Spermophilus federi</em>). Life tables, properly constructed from appropriate data, provide important measures of the age-specific demographic characteristics of plant and animal populations. |
|---|---|---|---|---|---|---|---|---|</p>
<table>
<thead>
<tr>
<th>Age (years)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>107</td>
<td>285</td>
<td>1,096</td>
<td>0.60</td>
<td>1.23</td>
<td>2540</td>
<td>227</td>
<td>1,089</td>
</tr>
<tr>
<td>1-2</td>
<td>1272</td>
<td>80</td>
<td>0.87</td>
<td>0.48</td>
<td>199</td>
<td>74</td>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>2-3</td>
<td>67</td>
<td>32</td>
<td>0.18</td>
<td>0.66</td>
<td>1.59</td>
<td>24</td>
<td>0.04</td>
<td>0.00</td>
</tr>
<tr>
<td>3-4</td>
<td>35</td>
<td>16</td>
<td>0.65</td>
<td>0.66</td>
<td>1.59</td>
<td>14</td>
<td>9</td>
<td>0.10</td>
</tr>
<tr>
<td>4-5</td>
<td>19</td>
<td>10</td>
<td>0.20</td>
<td>0.53</td>
<td>1.58</td>
<td>2</td>
<td>8</td>
<td>0.08</td>
</tr>
<tr>
<td>5-6</td>
<td>5</td>
<td>4</td>
<td>0.16</td>
<td>0.54</td>
<td>1.56</td>
<td>15</td>
<td>8</td>
<td>0.15</td>
</tr>
<tr>
<td>6-7</td>
<td>4</td>
<td>3</td>
<td>0.06</td>
<td>0.75</td>
<td>0.75</td>
<td>8</td>
<td>8</td>
<td>0.15</td>
</tr>
<tr>
<td>7-8</td>
<td>2</td>
<td>2</td>
<td>0.08</td>
<td>0.75</td>
<td>0.75</td>
<td>8</td>
<td>8</td>
<td>0.15</td>
</tr>
</tbody>
</table>

*Includes 122 females that captured in towings

*Includes 110 males that captured in towings

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)
  - Behavior matters

Warder Clyde Allee

Sage grouse

Fig. 12.4

Shaffer (1981)
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

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

- Catastrophes
  - Each year: 2% chance of 90% dying

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
VOREX

- 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

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)

- With enough data, they are often accurate
- 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