Population characteristics affect $N_e$

- **Age structure**
  - Reproductive status

- **Sex ratio**
  - $N_e = \left( 4 \times N_f \times N_m \right) / \left( N_f + N_m \right)$
    - $N = 35$ 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?

Exponential
$$\frac{dN}{dt} = rN$$

Logistic
$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

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” 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

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

Demographic stochasticity
- Example
  - Allee effect (1931)

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

Fig. 12.6
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

- Each year: 2% chance of 90% dying

Exponential

$$dN/dt = rN$$

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

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