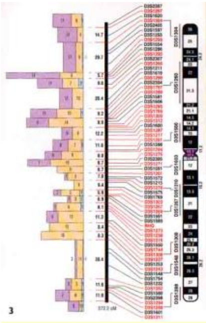


Human chromosome #3

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 8.1. An example of a life table for Belding's ground squirrel (*Spermophilus beldingi*). Life tables, properly constructed from appropriate data, provide important summaries of the age-specific demographic characteristics of plant and animal populations.

	Females					Males				
Age (year)	n_x	d_x	l_x	q_x	e_x	n_x	d_x	l_x	q_x	e_x
0–1	337	207	1.000	0.61	1.33	349	227	1.000	0.65	1.07
1–2	252[a]	125	0.386	0.50	1.56	248[b]	140	0.350	0.56	1.12
2–3	127	60	0.197	0.47	1.60	108	74	0.152	0.69	0.93
3–4	67	32	0.106	0.48	1.59	34	23	0.048	0.68	0.89
4–5	35	16	0.054	0.46	1.59	11	9	0.015	0.82	0.68
5–6	19	10	0.029	0.53	1.50	2	0	0.003	1.00	0.50
6–7	9	4	0.014	0.44	1.61	0	–	–	–	–
7–8	5	1	0.008	0.20	1.50	–	–	–	–	–
8–9	4	3	0.006	0.75	0.75	–	–	–	–	–
9–10	1	1	0.002	1.00	0.50	–	–	–	–	–

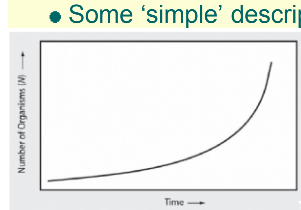
[a] Includes 122 females first captured as yearlings
[b] Includes 126 males first captured as yearlings
Source: Sherman and Morton (1984). Reprinted with permission of the Ecological Society of America.

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

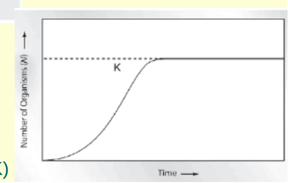
Changes in numbers

- Some 'simple' descriptions



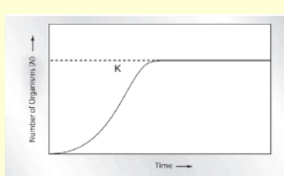
Exponential
dN/dt = rN

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 factor is easier to manage?

A case study

- The heath hen (*Tympanuchus cupido cupido*)

The heath hen

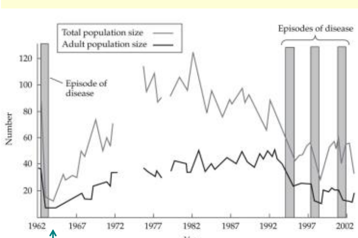
- 1876: Once common in eastern US, overhunting and habitat destruction restricted it to Martha's Vineyard
- 1900: 100 individuals left
- 1907: 50 individuals left; refuge established
- 1915: recovery to 2,000 individuals
- 1916: fire destroys most habitat and nests; predators (goshawks) converge
- 1920: 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

Vasnetsov

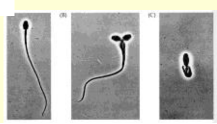
Genetic stochasticity



Canine distemper from nearby domestic dogs

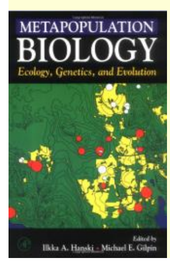
Bottleneck (9♀, 1♂)

The Ngorongoro Crater lions



Brief interlude: Metapopulations

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



Barred vs. N. spotted

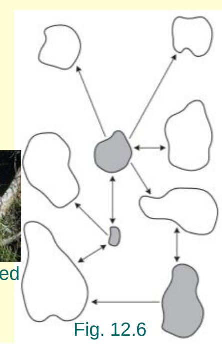
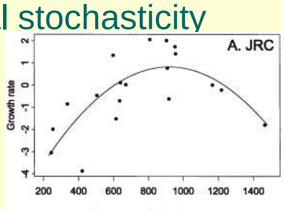
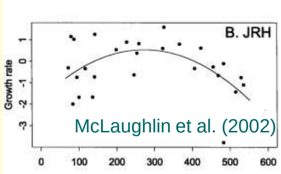


Fig. 12.6

Environmental stochasticity

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





McLaughlin et al. (2002)

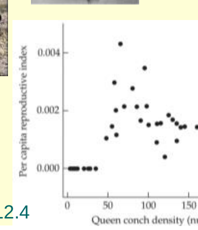
Demographic stochasticity

- Example
  - Allee effect (1931)

Warder Clyde Allee

Sage grouse

Fig. 12.4



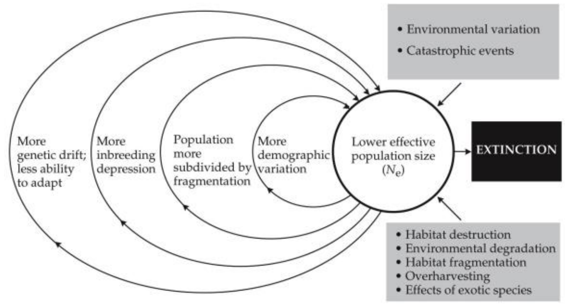
Natural catastrophes

- Disturbances

After the 2009 fire at Lewis Ocean Bay HP

The extinction vortex

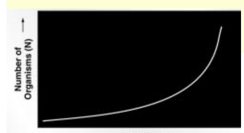
- Putting the 4 horsemen together



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



Exponential
dN/dt = rN

- Modeling of *r*

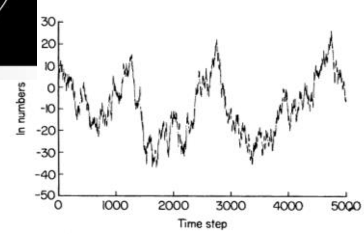
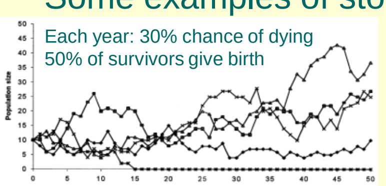


Fig. 3. The trend of a modelled population whose successive rates of increase *r* are drawn at random from a normal distribution with zero mean and unit variance.

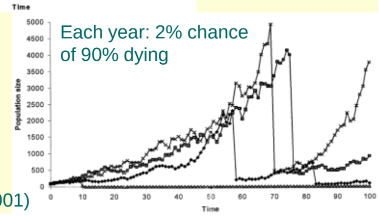
Caughley (1994)

Some examples of stochasticity



Demographic stochasticity

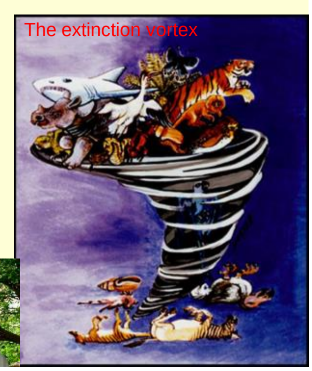
Catastrophes



Possingham et al. (2001)

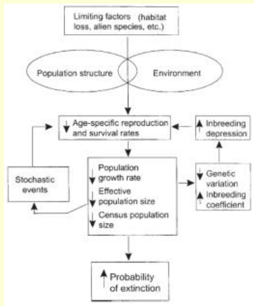
Population viability analysis (PVA)

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



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

Population trajectory for the Phantom Canyon population of *Aletes humilis*. The projection based on field data shows a nearly 50% decline over 50 years. Line ❷ is the average trajectory taken over 100 simulations, and lines ❶ and ❸ are the 95% confidence limits.

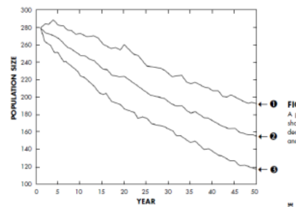
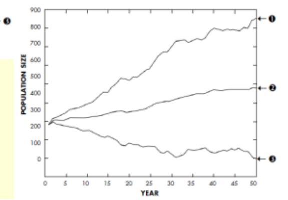


FIGURE 4.4
A projection model "experiment" of doubling seedling recruitment via transplantation each year shows the average population increases in size over 50 years (although some replicates still decline - see lower confidence limit). Line ❷ is the average trajectory taken over 100 simulations, and lines ❶ and ❸ are the 95% confidence limits.



Modeling points to remember

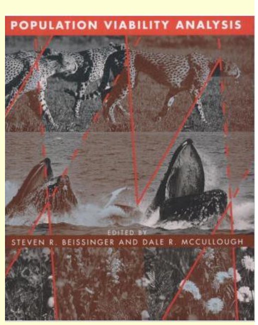
- "All models are wrong. Some models are useful."
  - George Box
- "To err is human, but to really foul things up you need a computer."
  - Paul Ehrlich

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

letters to nature

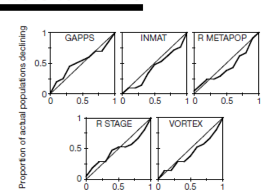


Figure 1 Plot of the PVA-predicted probability of population decline (quasi-extinction risk) versus the actual proportion of the 21 real populations that decline below the corresponding threshold size. These threshold sizes represent different percentage declines in different populations, but are always associated with the same level of risk. For example, half (10.5) of the 21 historical populations should have actually declined below the size assigned a 50% probability by the PVA. For each of the five PVA software packages, a perfect fit with reality lies on the 45° line.

Minimum data set = 10 yr