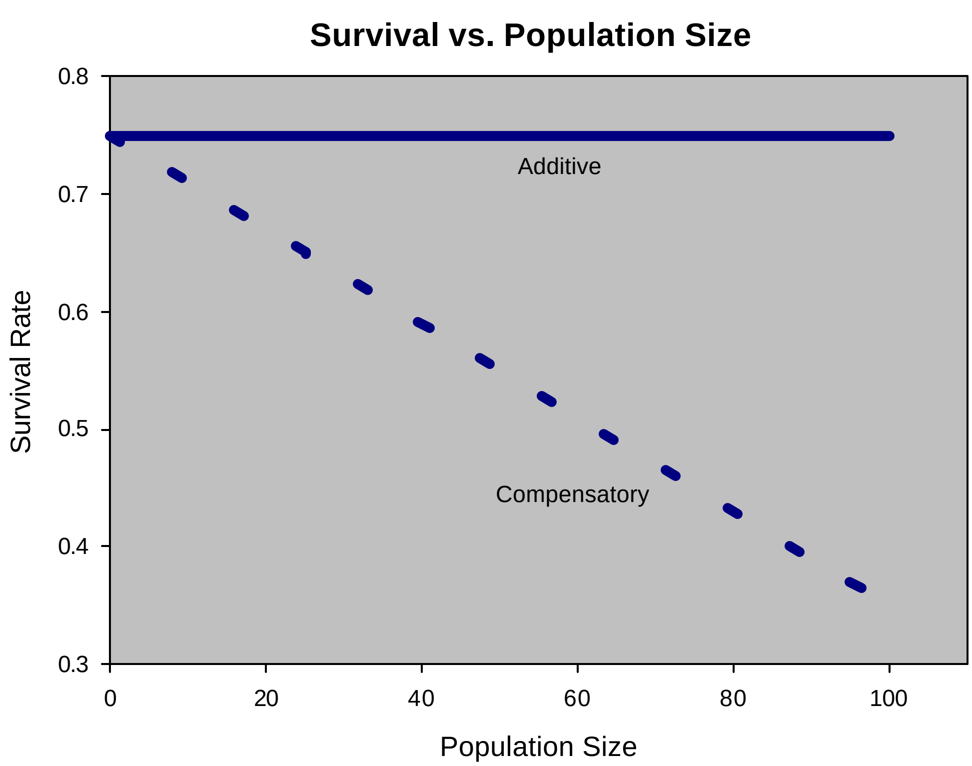
WLF 419 - Waterfowl and Wetlands Ecology and Management
Lecture 16 – Harvest Theory
Next Time – Harvest Management

Paul Errington, one of the most elegant writers in wildlife management, studied population dynamics of muskrats and bobwhite quail during the 30's and 40's. Based on his observations of these and other species, Paul introduced several concepts:

- Winter Threshold Hypothesis
  - Winter carrying capacity
  - Above carrying capacity is **doomed surplus**
  - Harvest doomed surplus w/o affecting survival
  - Principle of Inversity - DD reproduction
    - restrict talk to effects of exploitation on survival

What type of relationship must exist between survival and population size must exist for the DOOMED SURPLUS hypothesis to have any merit?

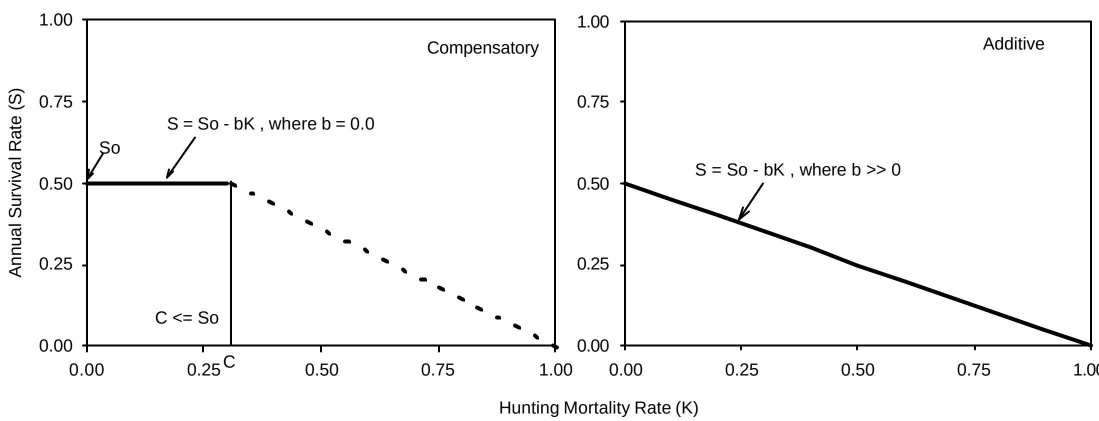


P Conceptual Models of the Effects of Exploitation on Survival
P Mechanism underlying hypotheses about effect of exploitation
P Empirical Evidence (Research Challenges)
P Adaptive Harvest Management

Additive and Compensatory

- P Hypotheses
  - P Compensatory - hunting mortality increases there is a compensatory decrease in nonhunting mortality such that hunting mortality has no effect on annual survival
  - P Additive - as hunting mortality increases annual survival probability decreases or hunting mortality is in addition to nonhunting mortality

Figure 3. Relationship between K and S.



Summary

- P **under compensatory - S is constant up to K<=C**
- P **under additive - any increase in K results in a decrease in S**

How can this happen?

- P Phenomenological vs. Mechanistic Models
  - P Mechanism is increase in posthunting survival
  - P Can we model posthunting season survival under density dependence

P Hypothetical Example with DD survival

P Assumption

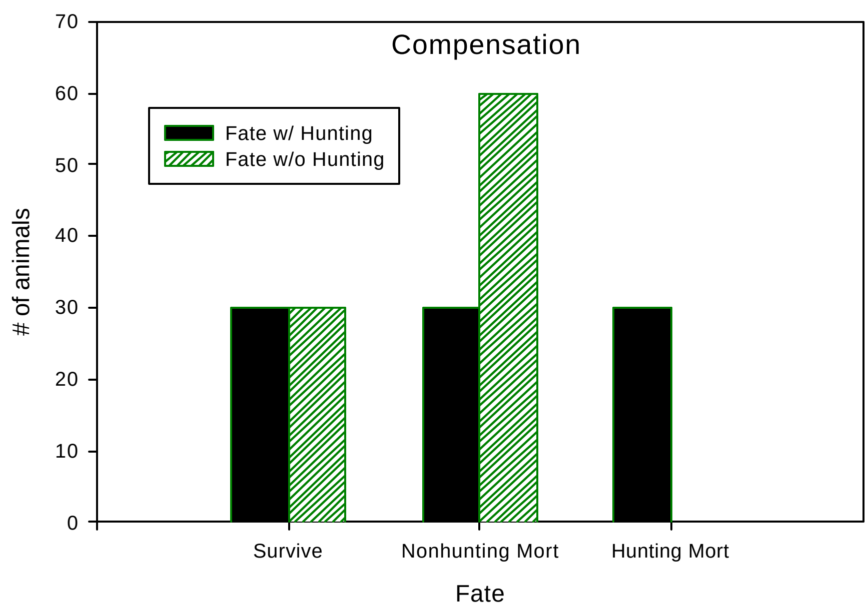
- Separation of hunting and nonhunting mortality
- Model posthunting survival with S=S'-bN

P Compensation w/ harvest

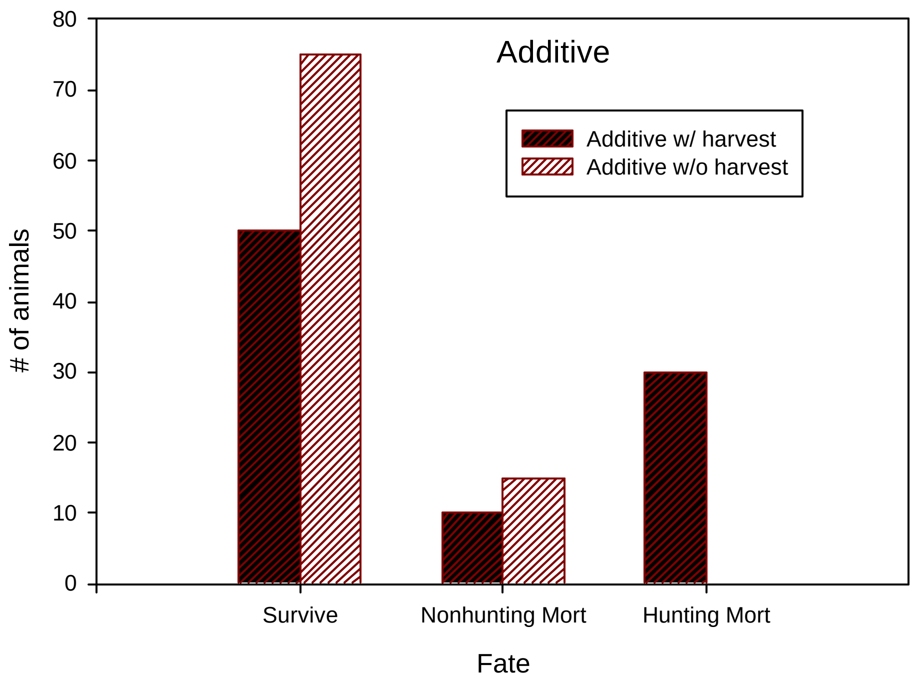
- 90 animals at start of hunting season
- Compensation (DD) b>0, b=0.0055556
- So=0.83333
- Harvest 30 animals
- What is survival of remaining 60
  - S=0.83333-0.0055556(60)=0.50
    - 30 survive posthunting

P Compensation w/o harvest

- all condition the same except no harvest
- How many survive the year?
  - S=0.83333-0.0055556(90)=0.3333
    - 30 animals survive year



- **P** Additive w/ Harvest
  - All same conditions except b=0
  - How many survive post hunting
    - 0.8333(60)=50
- **P** Additive w/o Harvest
    - 0.8333(90)=75



S=(1-k)(1-(Bo+B1(N-kN))

Empirical Evidence

- **P** Hypotheses
  - Ho: No relationship between K and S (comp) or Ha: neg relationship (add)
  - Ho: No relationship between K and V (add) or Ha: Neg relationship
  - Ho: No relationship between density and V (add), Ha: positive rel (comp)

- **Muskrats (Clark - Iowa)**
  - Hypothesis 1 not rejected
  - Muskrat Vo high = 0.75

- **Waterfowl**
  - Extensively studied
  - generally Hypothesis 1 by indexing K
  - generally support compensation
  - or compensation beyond threshold
  - species specific Vo mallard =0.35, Canada geese=0.15

- **Mule Deer calves - Colorado, Bartmann**
  - One of the few experimental studies - describe
  - Removed individuals from one popn and compared to popn w/ no removals
    - No difference in annual survival between populations
  - Removed individuals were placed at varying densities
    - mortality increased with densities

- Confounding of K and Density
  - Harvest Acting Beyond Threshold

Compensatory	Additive
Density-Dependence	Free of Density-Dependence
So low	So high
Pattern and Process -->	
Supported by Empirical Studies	Harvest Beyond Threshold
Confounding of K and Density -->	
Adaptive Harvest Management -->	

Definitions

- K = Kill Rate = probability that an animal will die as a result of hunting during the hunting season
- V = Nonhunting Mortality Rate = probability that an animal will die during the nonhunting period, (1-V) = So, and Vo=V when K=0
- S = Survival Rate = # of animals alive at beginning of year i+1, of those alive at the beginning of year i
- C = Threshold Value for K, K <=Vo

- Assumptions
    - Anniversary date is start of hunting
    - Finite Rates - instantaneous requires competing risk theory w/ little improvement in model performance, but S = exp -instantaneous mortality rate or ln(S) = -instantaneous mortality rate
    - Separate Hunting and Nonhunting Mortality, so S=1-K-V, M=K+V
    - Complication - individuals that die from hunting are no longer “available” to die from nonhunting mortality
- Relationship between K and S
    - S = So(1-bK)
        - Additive - if K and S are completely related what b would you predict (1.0)
        - Compensation - if So completely compensates for K what b would you predict (0.0), for K<=C
        - Fig. 2 - additive model is not linear as K approaches 1
    - Table Values
        - Vo=0.3

K	Additive		Compensation	
	S	V	S	V
0.0 (0)	0.7	0.30 (30/100)	0.7	0.3 (30/100)
0.1 (10)	0.63	0.27 (63/90)	0.7	0.2 (20/100)
0.2 (20)	0.56	0.24 (56/80)	0.7	0.1 (10/100)
0.3 (30)	0.49	0.21 (49/70)	0.7	0.0 (0/100)
0.4 (40)	0.42	0.18 (42/60)	0.6	0.0 (0/100)
	=So(1-bK)	V=1-S-K (V/N)	=So for K<=C	=Vo-K for K<=C