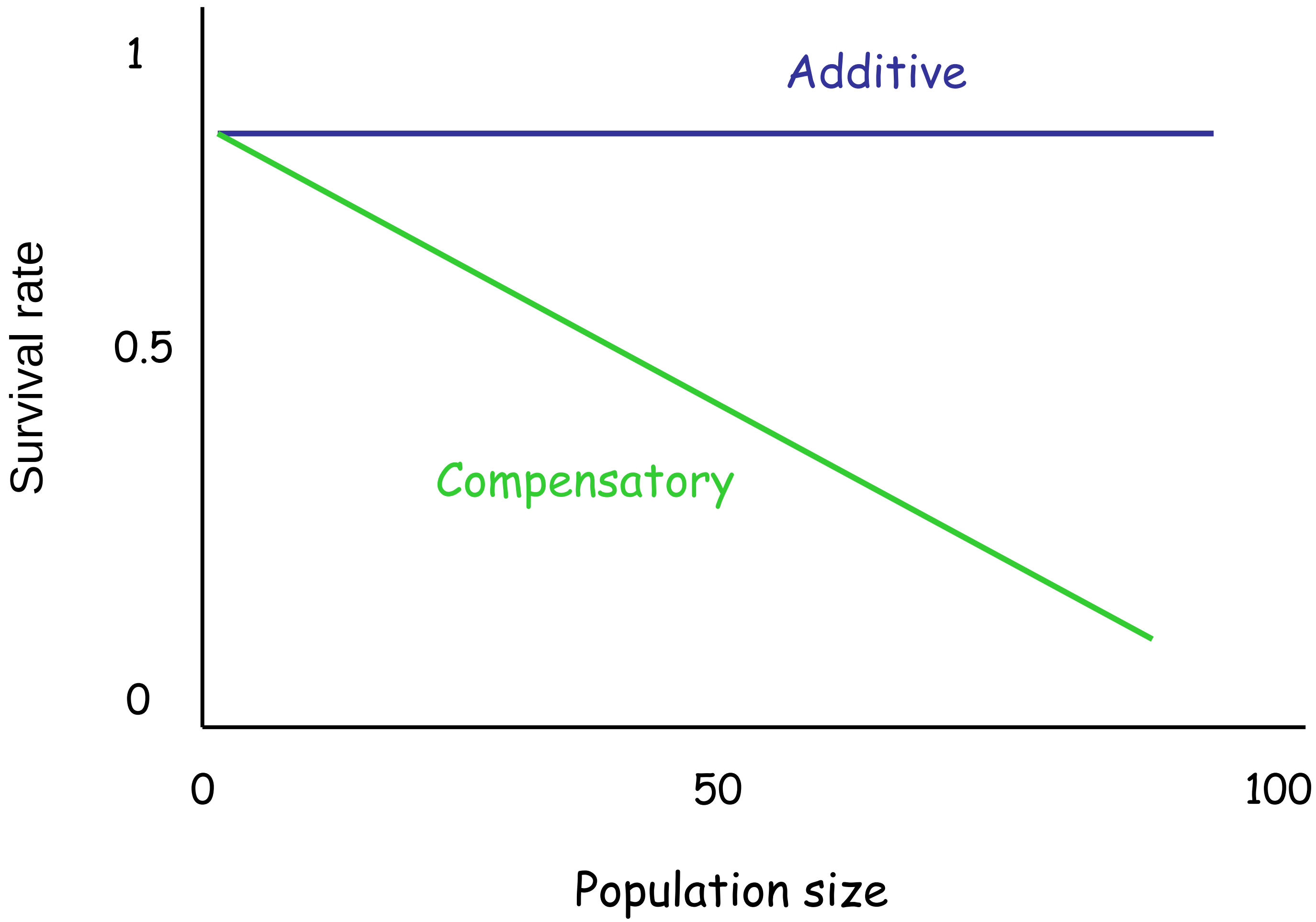
Compensatory and Additive Mortality

Definitions

- Additive mortality: all mortality factors work independently and their cumulative effects are additive
- Compensatory mortality: some mortality factors take the place of others either partially or completely, so the cumulative effect is less than the separate rates of mortality

Compensation requires density-dependent mortality



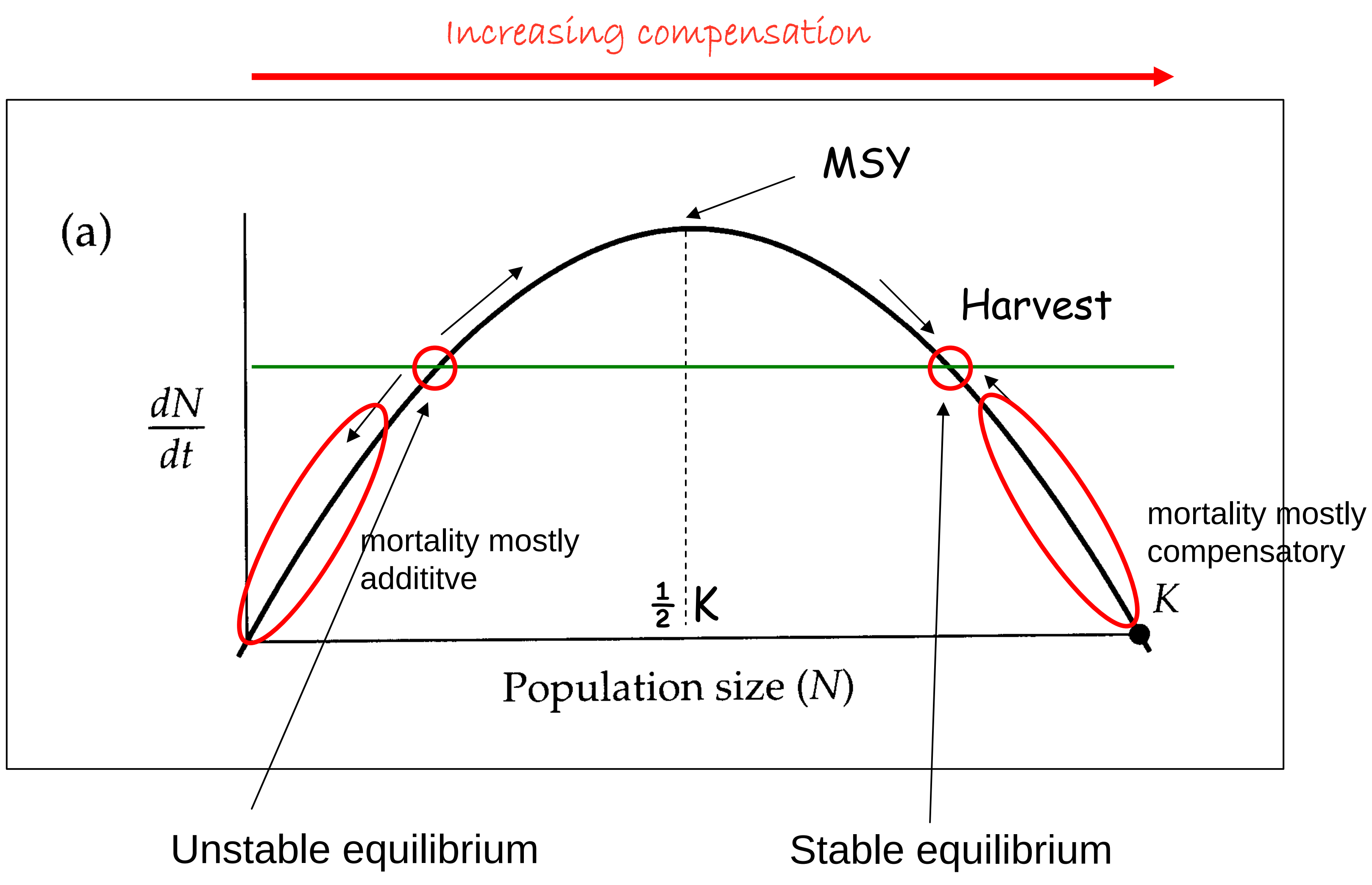
Types of compensation

- Total: complete compensation—mortality from one source is replaced by mortality from another
- Partial: replacement isn't total
  - $S_i = S_0 - bK_i$
    - S_i = annual survival rate
    - S_0 = non-hunting (non-predation) survival rate
    - K_i = annual kill (predation) survival
    - If b = 0, then compensation is total
    - If b = 1, then compensation is nill (total additivity)
    - Anything else is partial compensation

- Model
  - $S = S_0 - bK$
  - $S_0 = 0.833$, $b = 0.00556$
  - Population = 90
  - Hunting mortality (30, or K =60) takes place first
  - $S = 0.833 - 0.00556(60) = 0.5$ (30 individuals)

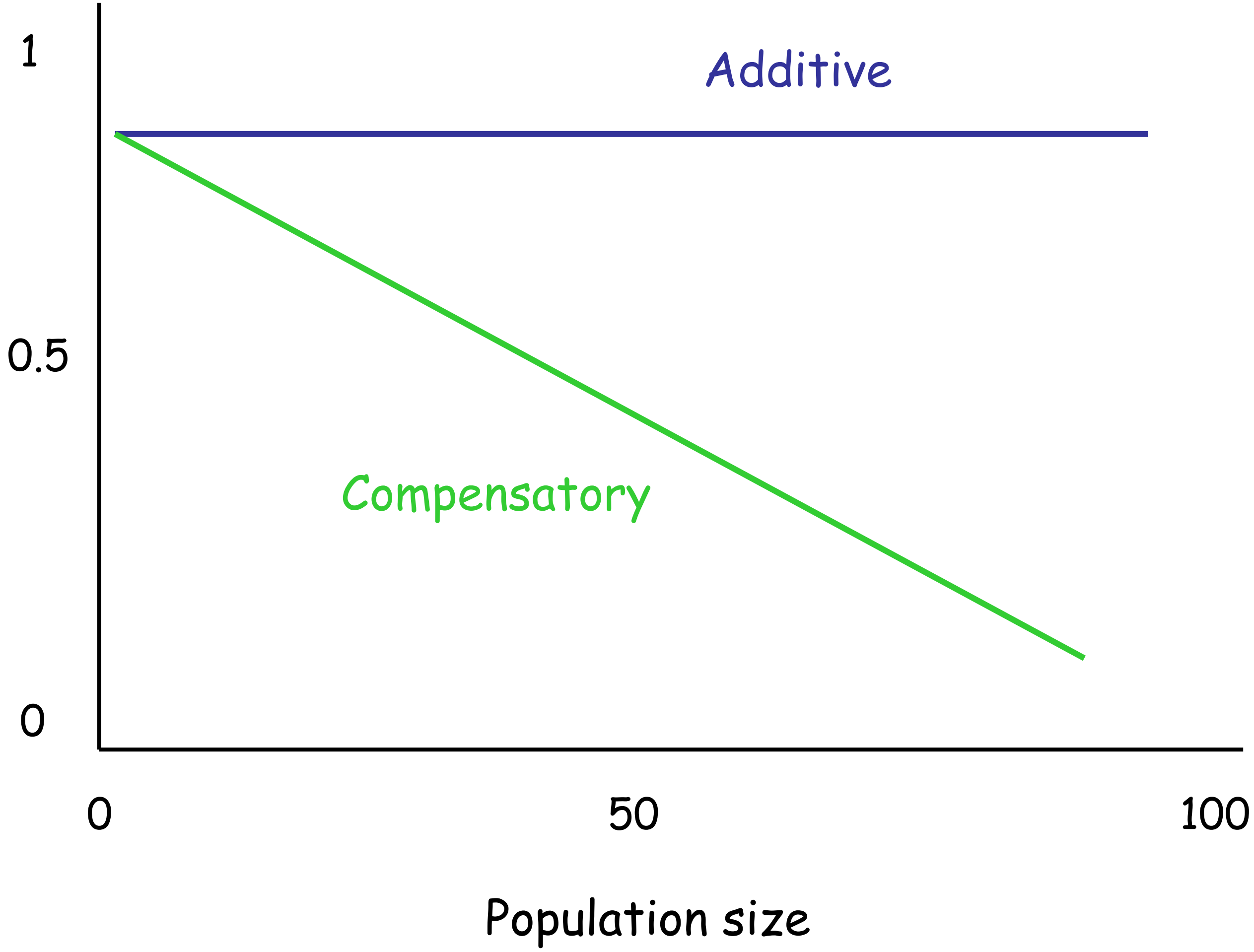
- Model
  - No hunting mortality (0 or *K* = 90)
  - *S* = 0.833 - 0.00556(90) = 0.333 (30 individuals)

- At low densities, mortality factors tend to be additive
- At high densities, mortality factors tend to be compensatory
- Why??
- Relation to recruitment is critical

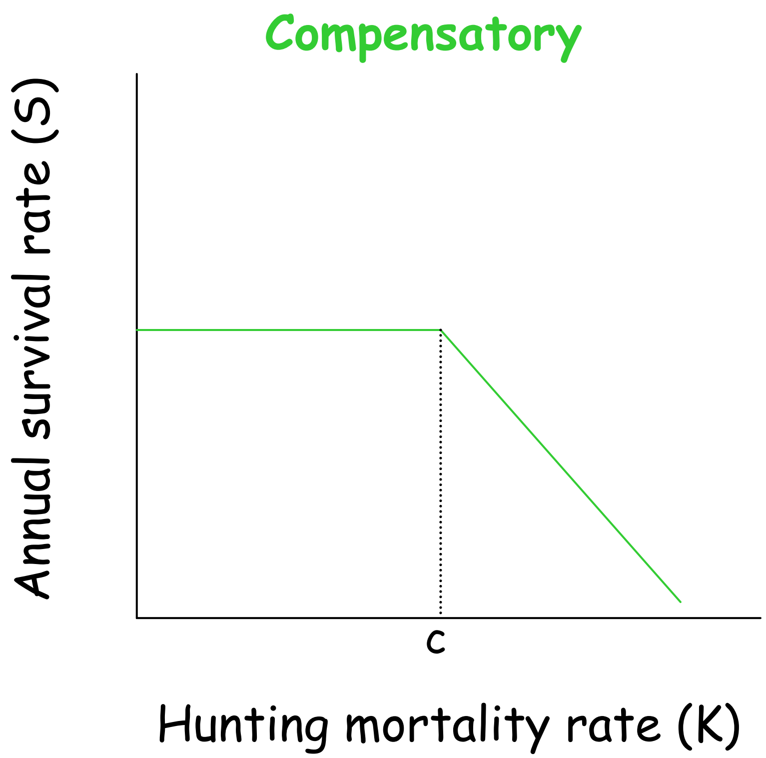


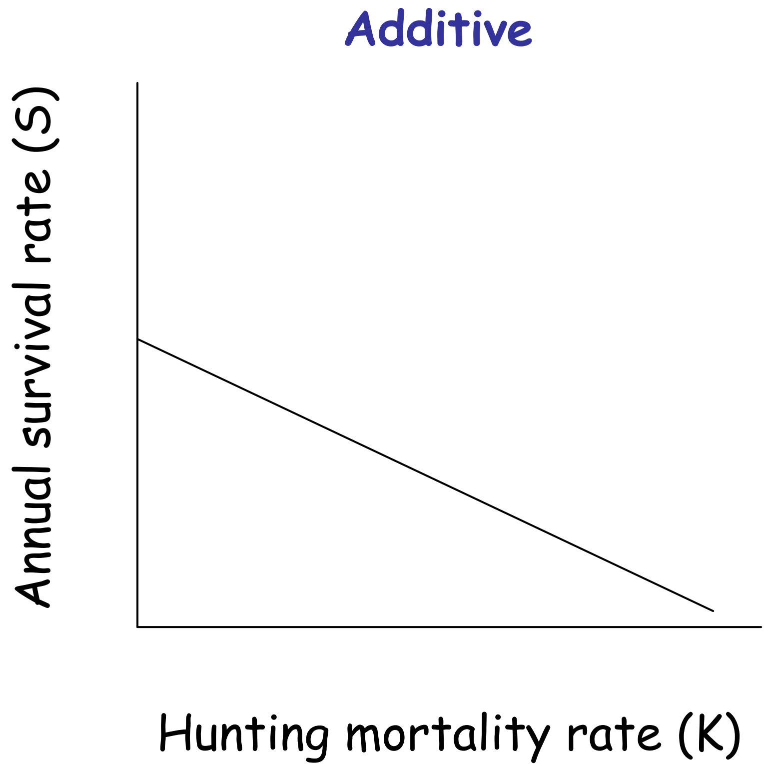
Increasing compensation
MSY
(a)
Harvest
$\frac{dN}{dt}$
mortality mostly addititve
mortality mostly compensatory
½ K
K
Population size (N)
Unstable equilibrium
Stable equilibrium

Compensation requires density-dependent mortality



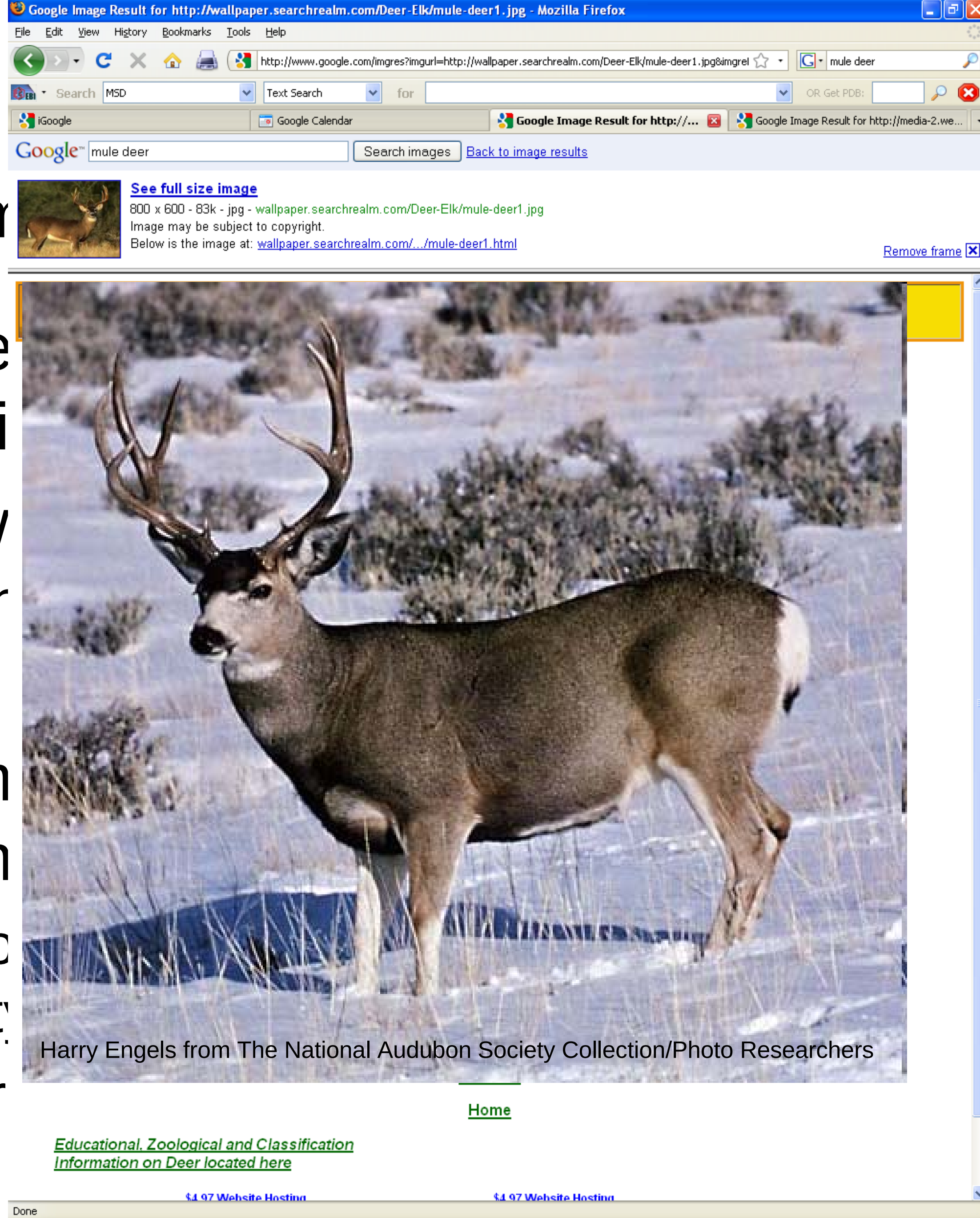
Threshold principle





(Bartm 992)

- Mule de populati
- In the w each winter ir n survival
- Fawn m tment and con
  - Did nc rigger a densit
  - Poor r



- Deer removed in previous study were stocked in 3 pastures at 44, 89, 133 deer/km^2, simulating removal of 67%, 33% and 0% of population

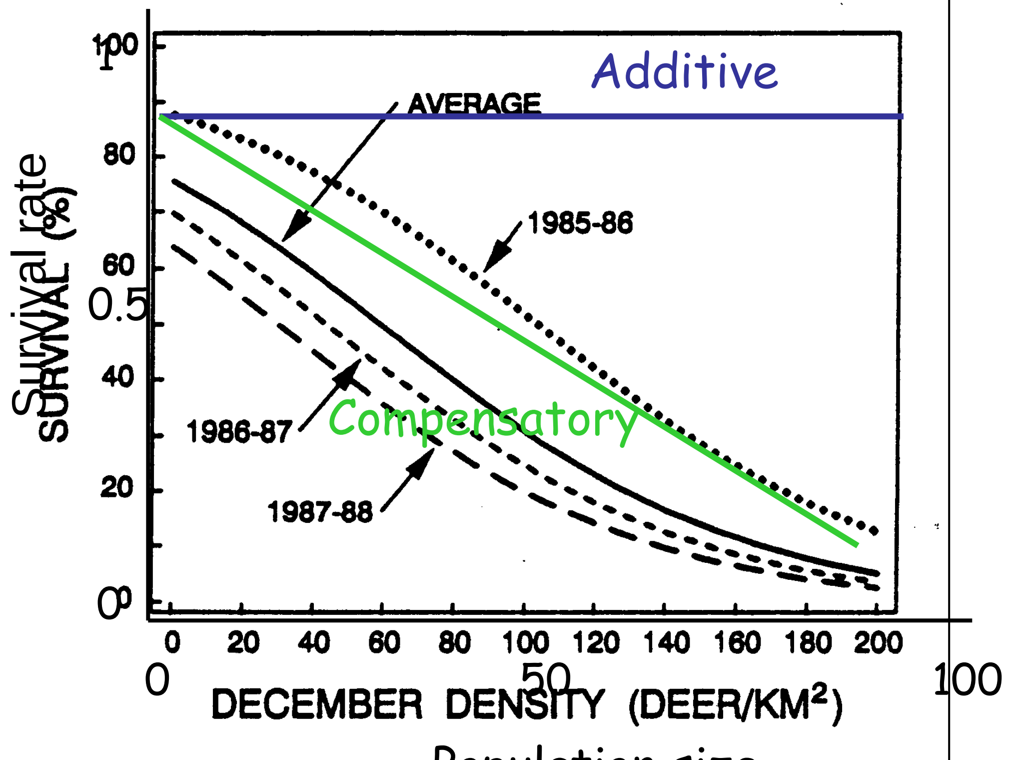


Fig. 9. Mule deer fawn survival predicted with a logistic regression fitted to observed survival of radio-collared fawns from the pasture experiment.

Fawn Survival Rates

Density	Low			Medium			High		
Simulated hunting removal	High			Medium			Low		
Year	1	2	3	1	2	3	1	2	3
Survival rate	0.814	0.455	0.102	0.480	0.353	0.108	0.424	0.104	0.000

Mortality was mostly due to starvation

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- Follow-up study reduced predators
- Remove coyotes for 3 years
- Predation rates decreased after removals
- Starvation rates of fawns increased after removals
- No change in overall fawn mortality
- Compensatory mortality!!!!

Roe deer fawns in Sweden

- 14-ye
- 51% … fawns
- 88% … foxes
- Whe … urvival incre
- Addi

Waterfowl populations

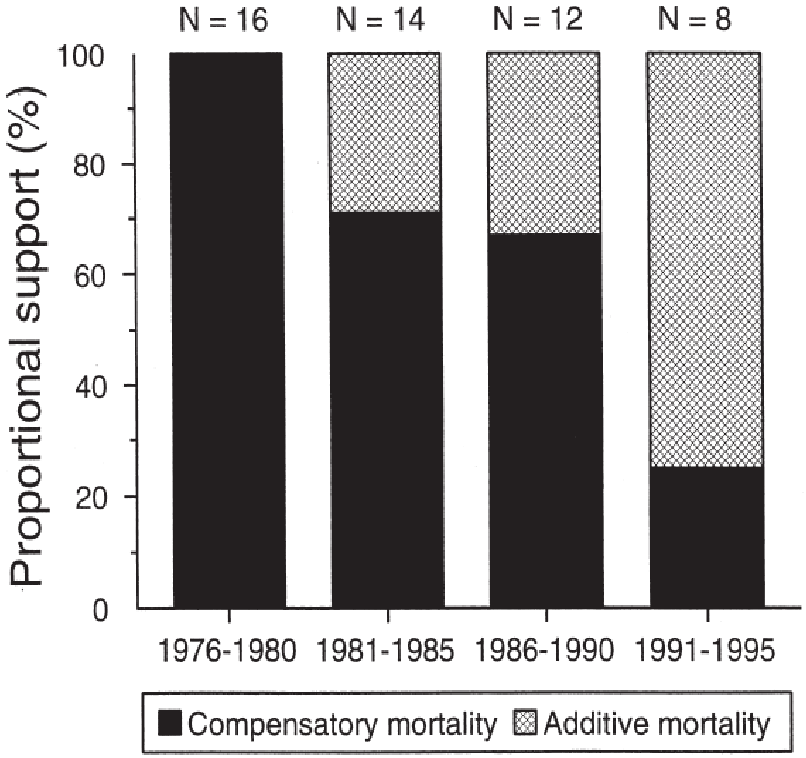

Fig. 1. Proportional support for the compensatory and the additive hunting mortality hypotheses in North American mallards from studies grouped into four time periods according to publication year. Total number of tests performed during each period is given above each column. See Table 1 for the original studies and the number of tests in each study.

Poysa et al. 2004, Oikos

Harvest Management

- Small game
  - no need; decreasing CPUE at lower densities ensures surviving base population
- Large game
  - need to restrict harvest due to high demand for meat and trophies
  - seasons and bags
  - access restrictions
  - antler/horn size restrictions
  - sex/age restrictions (e.g., female bears w/ cubs)
  - lottery allocation of permits in extreme cases

Harvest Management

- Waterfowl—Adaptive Harvest Management
  - Managers face uncertainty
    - environmental variation
    - can control harvest only partially
    - limited precision in population estimates
    - incomplete understanding of biological/population processes and mechanisms
  - Adaptive Harvest Management process
    - identify limited number of regulatory alternatives
    - realistic set of population models with reliability weights for each
    - mathematical description of management objectives

Harvest Management

- Waterfowl—Adaptive Harvest Management
  - Stochastic optimization procedure
    - each year an optimal regulatory alternative is identified based on resource and environmental conditions and model weights
    - model-specific predictions for subsequent breeding population sizes
    - monitoring data are used to adjust model weights
    - new weights are used in optimization process in iterative fashion
  - Iterative procedure should identify best model for predictive purposes