Chapter 14-Mills 2007

Population biology of harvested populations

Need

- Growing need to understand what population biology can tell use about harvest management
- Determine whether hunting is likely to affect either the demographic or evolutionary trajectory for a harvested population

Effects of hunting on population dynamics

- Numerical and functional responses of hunters
  - Number of hunters-numerical response
  - Number of animals harvested-functional response
  - Poaching losses
  - Crippling losses
  - Incidental take

Additive vs Compensatory

- Realized survival under additive mortality
  - $S_t = S_0(1-H_t) = S_0-S_0H_t$
- Realized survival under complete compensation
  - $S_t = S_0$

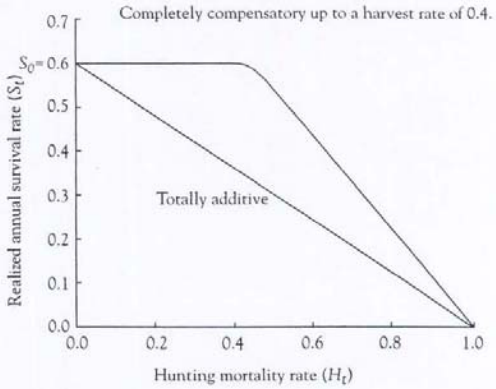

Fig. 14.1 How additive and compensatory mortality affect annual survival rate. With complete compensation, a harvest rate as large as 40% does not decrease the annual nonhunting survival rate of 0.6; however survival declines when harvest exceeds the compensation threshold of 40%. For totally additive mortality, annual survival declines linearly as hunting mortality rate increases.

Additive vs Compensation

- Maximum harvest rate threshold where hunting mortality can be completely compensated for via survival alone will be higher for species that have higher background mortality
- Species with short life times and high reproductive rates will tend to sustain relatively high hunting rates-longer life times and low reproductive rate –less resilient to hunting

Additive vs. Compensation

- Phenomenon of spatial compensation-spatial harvest control method—some area is closed to harvest

If nothing is known about compensation then most conservative approach is to assume complete additive mortality

Which ages and sexes get harvested?

- Animals of various ages and sexes get harvested differently and can impact population via growth
- Harvest males in polygynous species to maximize growth rate of population high
- Harvest males and females in polygynous species if growth rate of population is low
- Harvesting one sex can impact effective population size –but Randy DeYoung et al. JWM found no impact of heavy harvest on WTD genetics

Long-term effects of harvest

- Generally can impact population quality if population size is low—such as in bighorn sheep populations

Models to guide sustainable harvest

- MSY—too ridged for use in management because likelyhood of missing the point—result can be overharvest but you don't know it.

Fixed quota harvest

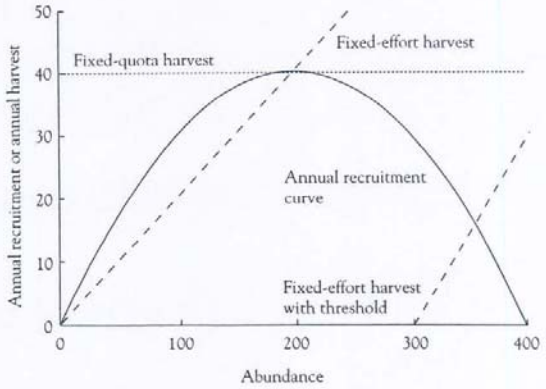

Fig. 14.3 Three different harvest approaches (dotted and dashed lines) to setting annual harvests. Each harvest type is plotted against the annual recruitment parabola (solid line; otherwise known as dN/dt; see Fig. 6.4) assuming logistic growth and $r=0.4$. Whenever the annual harvest is greater than annual recruitment, the harvested population will decline to the abundance where the harvest and recruitment lines intersect, or to extinction, whichever comes first. Thus, for the fixed-quota harvest (dotted line), the MSY (40 animals/year) is achieved when the abundance is held at 200, but if abundance were less than 200 this harvest level would lead to extinction. A fixed-effort harvest would give the same MSY but is more conservative against overharvest because if abundance were less than 200, recruitment exceeds harvest and abundance increases. The most cautious method uses fixed effort and also imposes a threshold (here arbitrarily set at 300 animals), below which no harvest occurs.

Fixed Effort Harvest

- Proportional harvest method--Must know population size and other variables

Adding Age Structure

- Using age structure to manage populations—used for long time but not in Leslie type matrix

Box 14.3 The base elk model (without harvest) used to explore effects of harvest on particular ages and stages

This is a pre-birth-pulse matrix model, where subscript numbers refer to stage (0, calf; 1, yearling; 2, young adult; 3, adult; 4, old adult) and letters refer to sex (f, male; m, female). Odd-numbered columns and rows refer to female vital rates and even numbered to males. So, the top two rows include both fecundity (m) and the survival of newborns to be counted as a female (row 1) or male (row 2) calf about to become a yearling 1 year later (P_0). The G terms represent survival and transition to the next stage. Harvest was added to the model either as a simple additive effect ($1-H$) or by a more complex function where bull harvest led to lower reproductive output of females (see text, and remember that a variety of other approaches are possible; that's the beauty of exploring what-if-type scenarios with structured models).

The stages ...	Calf female	Calf male	Yearling female	Yearling male	Young adult female	Young adult male	Adult female	Adult male	Old adult female	Old adult male
	0	0	$P_{0f}m_{1f}$	0	$P_{0f}m_{2f}$	0	$P_{0f}m_{3f}$	0	$P_{0f}m_{4f}$	0
	0	0	$P_{0m}m_{1m}$	0	$P_{0m}m_{2m}$	0	$P_{0m}m_{3m}$	0	$P_{0m}m_{4m}$	0
	G_{1f}	0	0	0	0	0	0	0	0	0
	0	G_{1m}	0	0	0	0	0	0	0	0
	0	0	G_{2f}	0	P_{2f}	0	0	0	0	0
	0	0	0	G_{2m}	0	P_{2m}	0	0	0	0
	0	0	0	0	G_{3f}	0	P_{3f}	0	0	0
	0	0	0	0	0	G_{3m}	0	P_{3m}	0	0
	0	0	0	0	0	0	G_{4f}	0	P_{4f}	0
	0	0	0	0	0	0	0	G_{4m}	0	P_{4m}

A pre-birth-pulse matrix model used to explore effects of harvest on particular ages and stages.

Adaptive Harvest Management

- Using data to test hypotheses and alter management on an annual basis

Adaptive Harvest Management

- HOLLING, C.S. (ED.) 1978. ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT. JOHN WILEY AND SONS NY. 377PP
-
- WATERS, C. 1986. ADAPTIVE MANAGEMENT OF RENEWABLE RESOURCES
-
- THEME: MANAGEMENT SHOULD BE VIEWED AS AN ADAPTIVE PROCESS.
-
- A. DEDUCE THE RESULTS OF MANAGEMENT ACTIVITIES
-
- B. CONDUCT MANAGEMENT IN AN EXPERIMENTAL CONTEXT TO LEARN WHETHER IT WORKS
-
- C. IF IT DOES NOT WORK, WE ADAPT OUR MANAGEMENT

Adaptive Harvest Management

- Embraces uncertainty
  - Structural uncertainty—underlying biological mechanisms
  - Patrial observability-sampling variance
  - Partial controllability-how proposed regulation feed back to population level effects

Adaptive Harvest Management

- List objectives
- Determine management options
- Build set of models
- Establish monitoring program
- Evaluate models to determine which are best for assessing population status

COMPONENTS OF ADAPTIVE MANAGEMENT

-
- SAME AS SCIENTIFIC METHOD EXCEPT THAT MANAGEMENT GOALS DEFINE THE HYPOTHESIS AND MANAGEMENT ACTIVITIES THEMSELVES ARE THE EXPERIMENT
-
- A. IDENTIFY THE PROBLEM (TOO MANY PRAIRIE DOGS)
-
- B. INITIAL OBSERVATIONS (DOGS PREFER COVER < 15")
-
- C. DEVELOP CONCEPTUAL MODEL
-
- D. MANAGEMENT GOAL= HYPOTHESIS (REDUCE PRAIRIE DOGS THROUGH GRAZING SYSTEM MANAGEMENT)
-
- E. IMPLEMENT MANAGEMENT (REDUCE GRAZING ALLOTMENT –USE EXPERIMENTAL CONTROLS)
-
- F. MONITOR RESULTS
-
- G. INTERPRET RESULTS (WHY OR WHY NOT?)
-

Overabundant and pest populations

- Difficult to deal with due to high intrinsic rate of increase—e.g., insect populations