COMPETITION BETWEEN MULE AND WHITE-TAILED DEER METAPOPULATIONS IN NORTH-CENTRAL WASHINGTON

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Overview

- Introduction and review of competition concepts
- Measurement of competition
- Apply these ideas to competition between mule and white-tailed deer on Colville Indian Reservation
- Future directions

Do white-tailed and mule deer compete?

- A few authors have suggested that mule and white-tailed deer compete when their distributions overlap.
- What evidence is there?
- How severe is the competition?
- Can we measure the effects on the species populations?

Ecological Definitions (Birch 1957):

- Resource competition occurs when a number of organisms (of the same or different species) utilize common resources that are in short supply.
- Interference competition occurs when the organisms seeking a resource harm one another in the process, even if the resource is not in short supply.

Intraspecific vs. interspecific

- Intraspecific competition occurs between members of the same species.
- Interspecific competition occurs between two or more different species.

"Mule and white-tailed deer potentially compete."

- Diets and habitat used overlap substantially - Martinka, C. J. 1968
- Interspecific behavior and dispersion provides some evidence for interspecific competition - Kramer, A. 1973
- Adaptability and diversity of resource and habitat use by deer makes proof of resource limitation difficult.

Evidence for competition

- Of more than 30 papers published specifically on competition between ungulate species none provide convincing evidence for competition.
- None provide measures of strength or impact of competition

Competition Between Mule Deer and Elk

- Lindzey, et al. 1997 reviewed over 500 published papers or reports and surveyed biologists in the western states and provinces:
- "Unfortunately, we are not aware of studies that compare reproduction and survival in sympatric mule deer and elk populations. Such comparative information would be essential prior to drawing any inferences about competitive effects of one species on the other's population growth…"

How would you measure competition?

- "Interspecific competition occurs when two or more species experience depressed growth rate or equilibrium population level attributed to their mutual presence in an area." – Emlem 1973

Growth Rate

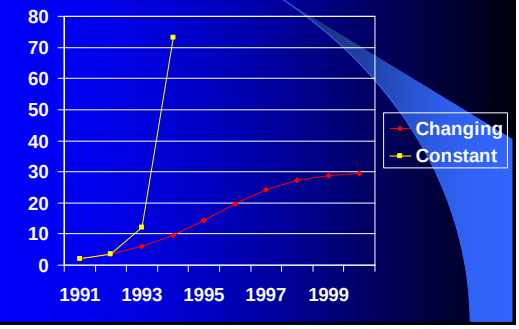
- Finite rate:

$$\lambda_t = \frac{N_{t+1}}{N_t}$$

- Instantaneous rate:

$$r_t = \ln \lambda_t$$

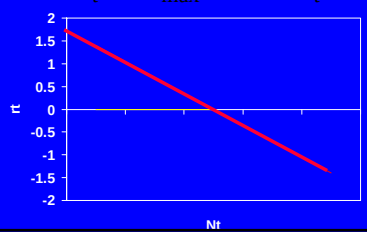
Constant or Changing Growth Rate?



Intraspecific Competition

- Ricker Model:

$$r_t = r_{\max} - a\ N_t$$



Intraspecific Competition

- Ricker Model: $r_t = r_{\max} - a\ N_t$
- Discrete time logistic growth
- Remarkably complex and rich behavior
- Robert May(1974) demonstrated 3 patterns:
- Low r_{max} = smooth logistic (s-shaped)
- Medium r_{max} = cycles
- High r_{max} = chaotic population changes

Interspecific Competition Added

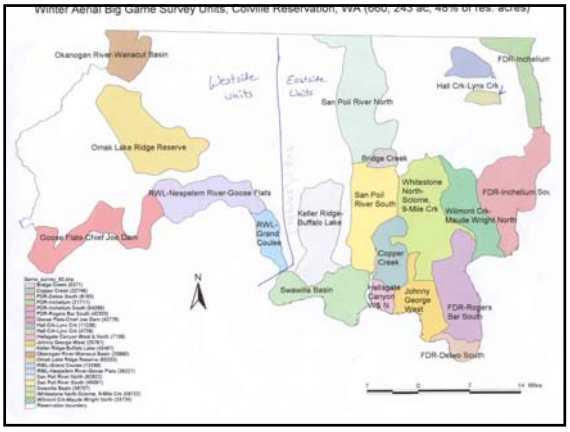
- Ricker Model:

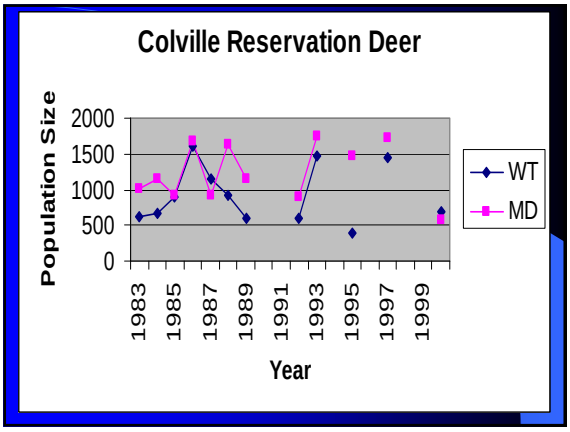
$$r_t = r_{\max} - a\ N_t$$

- Ricker Model with Interspecific Competition (May 1977):

$$r_t = r_{\max} - a\ N_t - bM_t$$

Can we apply these ideas to mule and white-tailed deer?





How could Eastside deer numbers change so quickly?

- Change in numbers due to more than birth and death
- Deer move around in response to hunting, environmental conditions and interactions
- Change = + births + immigrants
- - deaths – emigrants
- These are METAPOPULATIONS

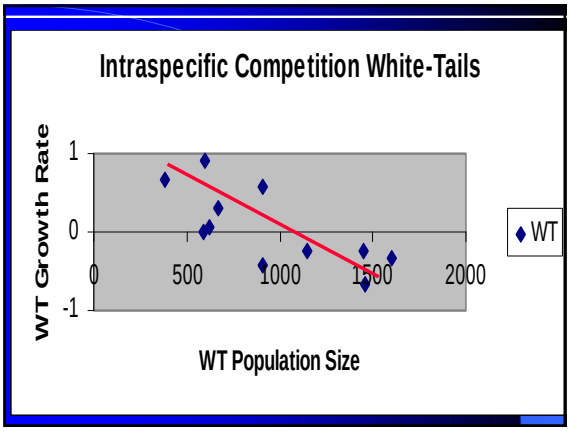
Interspecific Competition Added

- Ricker Model:

$$r_t = r_{\max} - a\ N_t$$

- May's Model with Interspecific Competition (May 1977):

$$r_t = r_{\max} - a\ N_t - bM_t$$



Intraspecific Competition

- Regression of r_t on N_t for white tails:
- $r_t = 0.99 - 0.956\ N_t$ for N_t in thousands
- n=12
- r = 0.73
- $F_{1,10} = 11.40$ P=0.007

Density-dependent Effects

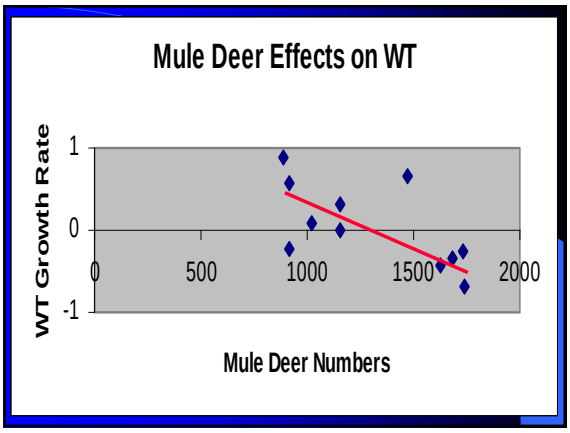
- Evaluating intraspecific competition like this has been treated as testing for density-dependent effects within populations
- Eberhardt (1970), in a famous paper in *Ecology*, demonstrated that you can easily get a high negative correlation coefficient from a random number sequence because N_t is in denominator of r_t as well as being the predictor.

Density-dependent Effects

- Dennis and Taper (1994) developed a Parametric Bootstrap Likelihood Ratio test of density dependence in census data:
- Applying this test to the t-test for significance of the slope of the regression for white-tails shows
- t = -3.338 P<0.05

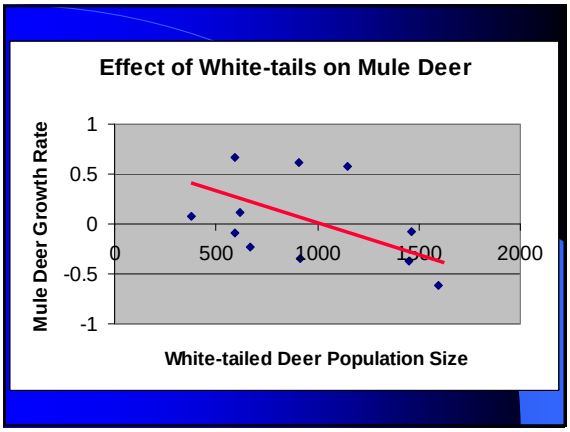
Intraspecific Competition in Mule Deer

- Regression of r_t on N_t for mule deer:
- $r_t = 1.314 - 0.989\ N_t$ for N_t in thousands
- n=12
- r = 0.86
- t = -5.28 P<0.01 by PBLR



Interspecific Competitive Effects on White Tails by Mule Deer

- Regression of r_t on M_t for mule deer:
- $r_t = 1.29 - 0.945\ M_t$ for M_t in thousands
- n=12
- r = 0.71
- $F_{1,10} = 10.30$ P=0.009



Interspecific Competitive Effects on Mule Deer by White Tails

- Regression of r_t on N_t for mule deer:
- $r_t = 0.552 - 0.504\ N_t$ for N_t in thousands
- n=12
- r = 0.44
- $F_{1,10} = 2.44$ P=0.149

Total Competitive Effects

- White-tail Model:

$$r_t = 1.417 - 0.48WT_t - 0.44M_t$$

- Mule Deer Model:

$$r_t = 1.30 - 0.06WT_t - 0.79M_t$$

White-tail Growth Model

- R=0.82
- R^2=0.66
- $F_{1,10}$ = 11.40
- P = 0.007

Mule Deer Growth Model

- R=0.86
- R^2=0.74
- $F_{2,9}$ = 11.37
- P = 0.002

Model Building Approach

- Since we have not (cannot) assign levels of predictors (mule and white-tail numbers) at random, many would question the application of inferential statistics and hypothesis testing to these data.
- An alternative approach is to treat this as a model building effort and apply information theoretic tools to selecting a parsimonious model.

Model Building Approach

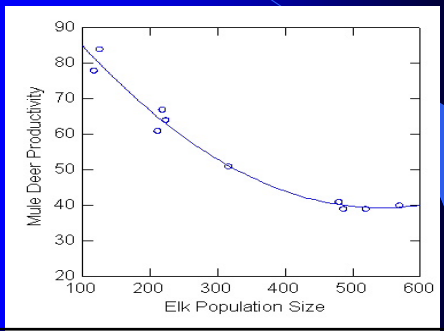
- Using Akaike's Information Criterion– AIC
- DeltaWhiteTails/Year = WT + MD 19.3
- DeltaWhiteTails/Year = WT 18.8

- DeltaMuleDeer/Year = WT + MD 34.1
- DeltaMuleDeer/Year = MD 19.3

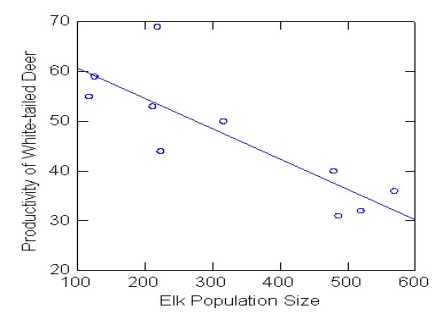
Elk Population Growth

- During the last 20 years elk populations have increased dramatically in many areas.
- Experimental studies at Starkey Experimental Forest have shown that mule deer avoid areas occupied by elk
- Elk on the Colville Reservation increased from about 100 animals in 1980 to almost 600 in 2000.

Mule Deer Productivity and Elk Population Size



White tailed Deer Productivity and Elk



What next?

- Stochastic model
- Simulation to explore behavior fully
- Apply methods of Subash Lele and Mark Taper that model im-/e-migration
- Apply to elk-deer competition and others