The Economics of a stage-structured wildlife population model

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1. Introduction

- Bio-economic models:
  Interaction economy and biology (fish, forest, wildlife, biodiversity..).
  Typically: Maximization under ecological constraints

- Usually: Biomass models: ‘a fish is a fish’, ‘an animal is an animal’
  In many instances this works quite well; stylized facts models/results.

- Here: wildlife population model. Application; Moose harvesting in Scandinavia.
  Very important: Harvest: Sweden 100,000, Norway 40,000
• Stage structured wildlife population models; long tradition in biology

• Few economic analysis stage structured wildlife models; Skonhoft et al. (EA 2002), Clark and Tait (EM 1982).
  Fishery models more…
This paper:

- More explicit on the economic forces in a stage structured harvesting model.
  - Effect of changing demand conditions for wildlife hunting
  - Two regimes; meat hunting and trophy hunting
  - Moose population in a general PV maximising setting.
2. The population model

- Four-stage model of a moose population in a given area (no dispersal etc.)
  - Calves
  - Yearlings
  - Adult females
  - Adult males

- Fecundity affected by female density and male density (however, male effect small and negligible when large male population)

- Mortality/survival fixed and density independent
• Recruitment: 

\[ X_{c,t} = r(X_{f,t}, X_{m,t})X_{f,t} \]

\[
\frac{dX_{c,t}}{dX_{f,t}} < 0, \quad \frac{dX_{c,t}}{dX_{m,t}} > 0
\]

• Yearlings

\[ X_{y,t+1} = s_c (1 - h_{c,t}) X_{c,t} \]
• The abundance of (adult) females

\[ X_{f,t+1} = 0.5s_y (1 - h_{y,t}) X_{y,t} + s (1 - h_{f,t}) X_{f,t} \]

• The abundance of (adult) males

\[ X_{m,t+1} = 0.5s_y (1 - h_{y,t}) X_{y,t} + s (1 - h_{m,t}) X_{m,t} \]
• Functional forms and data
  – Ricker recruitment function
  – Linear demand function trophy hunting
  – Uniform shift quality effect
  – Constant marginal cost trophy hunting

  – Biological data: Nilsen et al. (2005)
  – Economic data: Surveys, and calibration
3. Exploitation. The traditional regime; hunting for meat.

- Meat income:

\[ \pi_t = p \left[ w_c h_c r(X_{f,t}, X_{m,t}) X_{f,t} + w_y h_y r(X_{y,t}) X_{y,t} + w_f h_f r(X_{f,t}) + w_m h_m r(X_{m,t}) \right] \]

- Maximization of meat income subject to the biological constraints
- Basic result: Only adult harvesting.
  Why?? The weights.....
4. Exploitation. Modern times; trophy hunting

- From meat value maximisation ('local people’) to a market for hunting

- Trophy hunting males
  Still meat value hunting of the other three stages
Inverse market demand for male hunting:

\[ q_t = q(h_{m,t} X_{m,t}, X_{m,t}), \quad h_{m,t} X_{m,t} = H_{m,t} \]

\[ \frac{\partial q}{\partial H_m} < 0, \quad \frac{\partial q}{\partial X_m} > 0 \]
Quality effect
(Higher male density)
• Results:
  – Pulse harvesting females
  – Oscillations males
  – No yearlings and calves harvest

Why: Low weight and low value…
6. Concluding remarks

- Meat value maximization:
  - Only biological parameters influence the outcome
  - No price effect (…body weights)
  - No calf and yearling harvest
  - Harvest a substantial part of the ‘biological end product’ (0.5 baseline calculation)
  - Modest female harvest (0.25 baseline)

- Trophy hunting adult males:
  - Economic conditions spill over to the meat value maximization stages, and the vice versa
  - Pulse harvest females
  - Oscillations males
  - Quality effect important