Hunting and exploitation of terrestrial animal species

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- 1. Difference fish and terrestrial animal species
- 2. Harvesing and competing use of habitat land
- 3. Conflicting uses; conservation vs. exploitation
- 4.From biomass models to stage structured models
- 5. Final remarks

- **1. Difference fish and terrestrial animal species**
  - Fish: Four important factors that may cause overexploitation
    - Price-cost ratio of the yield
    - The natural growth of the fish stock
    - Opportunity cost of capital (’either in the bank or in the ocean’)
    - Intsitutional setting … ’open-access’ harvesting

- Same factors may also cause overexploitation, and possible depletion, of terrestrial animal species, but some important differences
  - Harvesting terrestrial species more likely to be controllled (property rights)
  - More value components included
    - Harvesting value, but biodiversity and existence value, tourist value, damage, etc…
  - Number of competing uses habitat land.
    - Land use has almost always an opportunity cost

- These differences more stylized than absolute
  - Ex. whales existence value, eco-tourist value. Wild salmon existence value, etc.
  - Marina habitats may have alternative uses (fish-farming, marinas, oil drilling, etc.)
  - Also ‘open-access’ exploitation terrestrial animal species. Lack of enforcement capacity, fugitive nature of animal species, etc. In short: also here endogenous property rights.
  - Etc.

2. Harvesting and competing use of habitat land

- Stylized model. How the opportunity cost of habitat land may work.
- And how the species value may work. Remember Clark model: Valuable fish; high exploitation pressure

- Model:
  - Development country setting
  - Social (unified) planner model. No conflicts
  - Two types of land-use; habitat land and agricultural land

    $$H + A \leq L$$

    -Wildlife represented by one stock of animals ('large mammals'). Growth depending also on size habitat land

$$X \,/\, dt = F(X, H) - y$$

– Various, but restricted number of value components

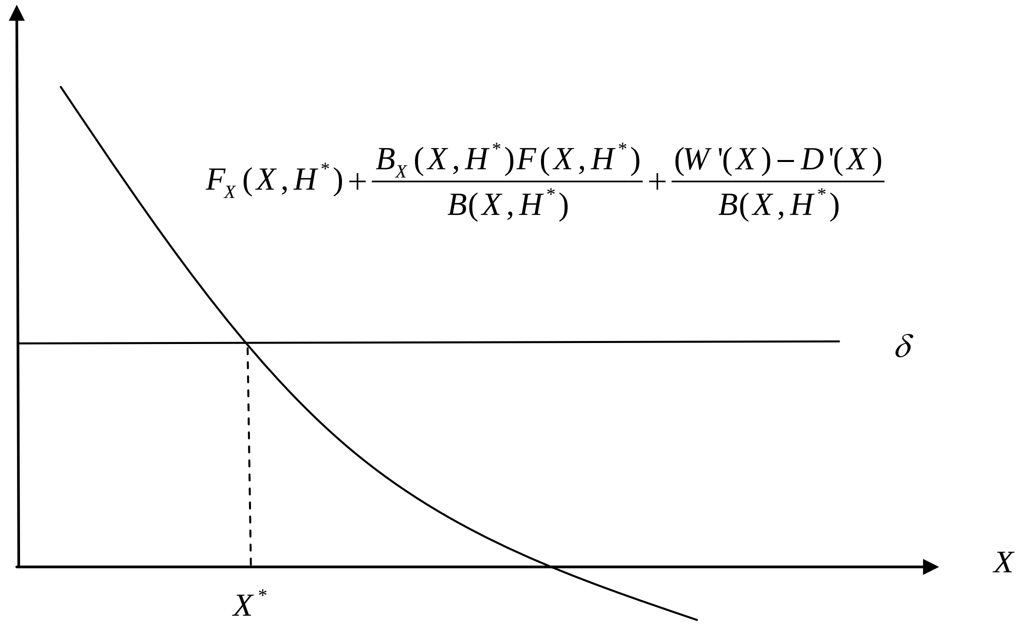
$$SB = B(X,H)y + W(X) + G(A) - D(X)$$

- Problem:

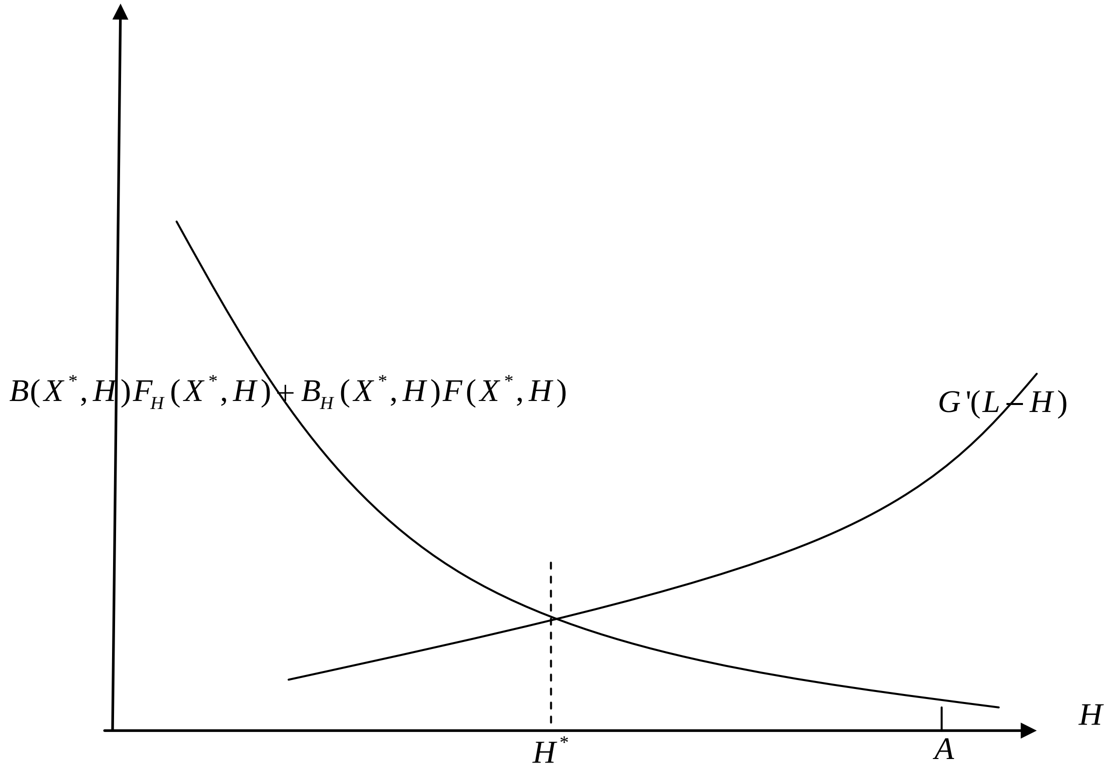
$$\max_{y,H} = \int_{t=0}^{T=\infty} [B(X,H)y + W(X) + G(A) - D(X)]e^{-\delta t}dt$$

s.t. land-use constraint (all the time binding) and population growth

Figure 1. The equilibrium (steady state) conditions for the wildlife stock and land use social planner model



Panel a): The equilibrium wildlife stock (Eq. 4).



Panel b) the land-use equilibrium (Eq. 5)

- The working of the economic forces:
  - Higher opportunity cost of habitat land will shrink both wildlife and the habitat
  - Harvest price/cost ratio unclear. This in contrast to fisheries and Clark-model
    - Two contrasting forces:
      - Increased value of hunt motivates for stock disinvestment according to the Clark model
      - In creased value makes habitat investments more attractive as the marginal wildlife/agricultural value increases

- Sum: The disinvestment process, i.e., competition for natural habitats, identified as the basic driving force behind terrestrial species decline.
- According to this mechanism; rather than being overexploited, species are undercut
- In line with ecologists, habitat degrading the most serious threat.

- But this simple analysis says possible something more; habitat land converts because wild species does not pay its way

- CITES Policy

3. Conflicting uses: Conservation vs. Exploitation

- The above model social, or unified, planner framework. No explicitly stated conflicts on land-use and wildlife exploitation.
- Now highlights on such conflicts. Still large mammals in a developing country context (e.g., elephants Sub-saharian Africa). Lan-use fixed.
- Two agents; a conservation agency and a group of local people.

- To make it simple: Biological equilibrium; natural growth equalizes total harvest.
- Nash equilibrium concept

- Biological equilibrium: Iso-conservation contours

$$F(X) = y_1(e_1, X) + y_2(e_2, X)$$

$$X = X(e_1, e_2)$$

- Conservation agency *de jure* property rights wildlife. But because of small funds for policing, large areas etc., poaching can not be effectively prevented. *De facto* property rights, or endogenous property rights structure
- Cost and benefits conservation agency:

$$\pi = B_1(e_1, X) + W(X)$$

- Local people:

$$U = B_2(e_2, X) - D(X)$$

- Economic problem of the conservation (park) agency: Find the profit-maximizing hunting effort s.t. the biological equilibrium constraint and given the effort of the local people

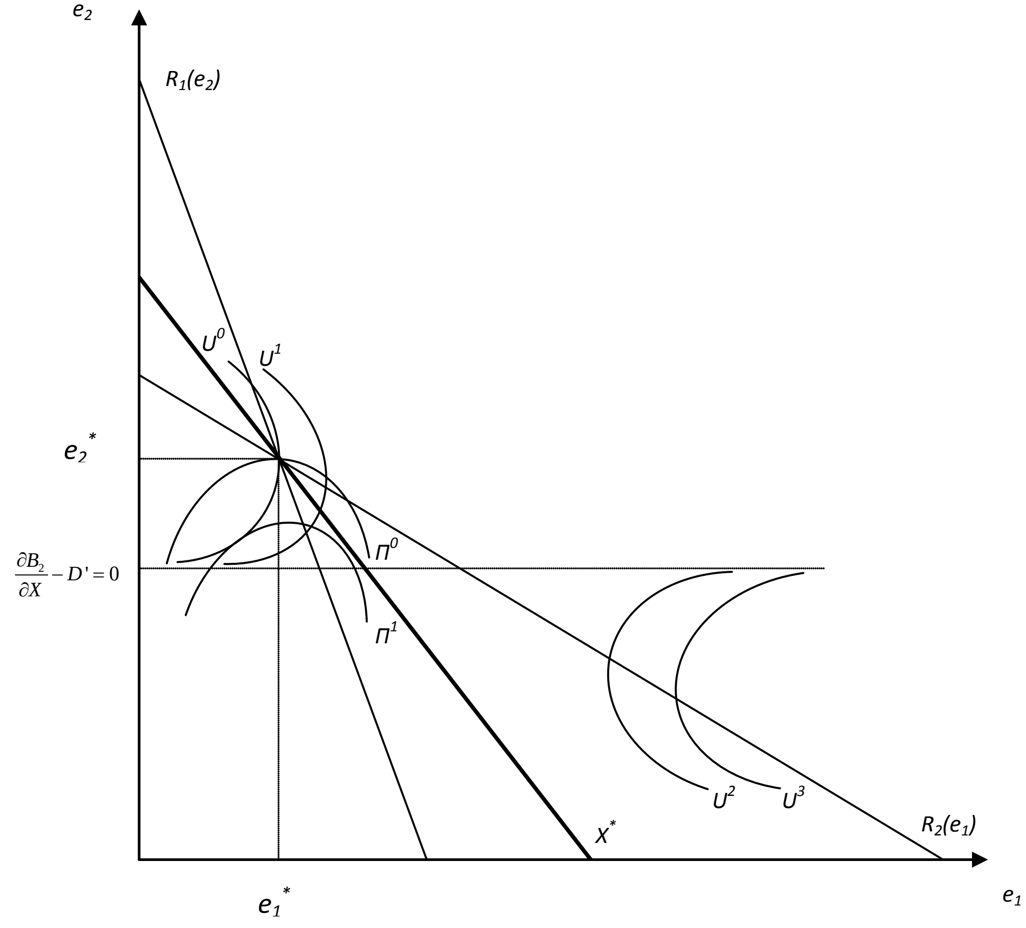
- Best-response function:

$$\partial B_1(e_1, X) / \partial e_1 + [\partial B_1(e_1, X) / \partial X](\partial X / \partial e_1) + W'(X)(\partial X / \partial e_1) = 0$$

- Economic problem of the local people: Find the utility maximizing effort s.t. biological constraint and the effort of the conservation agency

- Best response function:

$$\partial B_2(e_2, X) / \partial e_2 + [\partial B_2(e_2, X) / \partial X](\partial X / \partial e_2) - D'(X)(\partial X / \partial e_2) = 0$$



e_2
$R_1(e_2)$
U^0
U^1
e_2^*
$\frac{\partial B_2}{\partial X} - D' = 0$
Π^0
Π^1
U^2
U^3
X^*
$R_2(e_1)$
e_1^*
e_1

- Simple model, but the conflict between exploitation and conservation determined by several forces that work in a relatively complex way
- Welfare and conservation may go hand in hand, or in the opposite direction, as indicated by comparative static results

- Assuming linear stock value functions, and Schaefer harvest functions

Table 1: The two agent conflict model. Comparative-static results

	e_1^*	e_2^*	X^*	π^*	U^*
p_1	+	–	–	+	?
w	–	+	+	+	?
d	–	+	–	–	–
p_2	–	+/–	–/+	–/+	?
c_1	–	+	+	–	?
c_2	+	–	+	+	?
r	?	?	?	?	?
K	?	?	?	?	?

Note: +/– implies different sign effects e_2^* and X^* (and π^*). ? implies ambiguous sign effect.

- General price and cost effects ('the general theory of the second best'; Lancaster and Lipsey 1965)
- Reduced nuisance works beneficial for conservation as well as welfare improving of the local people
- Benefit-sharing strategies may also be analyzed within this model. More conservation, but unclear welfare effects
- The working of ICDP (integrated conservation and development projects) may be questioned...

4.From biomass models to age/stage (demographic) harvesting models

- Above models carried out in a biomass context; ‘an animal is an animal’.
- This is the traditional modelling concept within natural resource economics.
- Works often well when one aims to examine the basic driving trade-off forces behind conservation and exploitation of wildlife/fish (Clark model).

- But sometimes a more ‘fine tuned’ analysis needed.
- More practical oriented fishery management/plans
- Detailed wildlife management plans; deer hunting, moose hunting, etc.
- Such models long tradition in biology, but always as numerical simulation models
- In economics; few models within an optimizing framework. Chapter in Clark (1990), but…. Tahvonen (2009)

- Steps involved when constructing an age/stage structured model:
  - Number of age classes
  - The time step. Usually one year when reproduction once a year (but pest rodents like rats...)
  - The sequence of events taking place over the year cycle (natural mortality, hunting/fishing mortality, damage costs, benefits, etc.)
  - etc.

- Here a model for harvesting moose (*Alces alces*) in a Scandinavian institutional context: The landowners have the hunting rights and bear the timber browsing damage costs. Traffic damage costs external to them
  - Four age classes (calves, yearlings, adult males and females)
  - Time step one year
  - Sequences over the year; spring reproduction, fall hunting, winter natural mortality, winter timber browsing damage

- The biological model:

$$X_{c,t} = r(X_{f,t}, X_{m,t})X_{f,t}$$

$$X_{y,t+1} = s_c(1-h_{c,t})X_{c,t}$$

$$X_{m,t+1} = 0.5s_y(1-h_{y,t})X_{y,t} + s(1-h_{m,t})X_{m,t}$$

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

- Cost and benefits (assuming linear functions):

$$Q_t = p(w_c h_{c,t} X_{c,t} + w_y h_{y,t} X_{y,t} + w_f h_{f,t} X_{f,t} + w_m h_{m,t} X_{m,t})$$

$$D_t = d_c (1 - h_{c,t}) X_{c,t} + d_y (1 - h_{y,t}) X_{y,t} + d_f (1 - h_{f,t}) X_{f,t} + d_m (1 - h_{m,t}) X_{m,t}$$

- Management goal: Maximizing net present value profit s.t. the law of mother nature (i.e., the biological constraints)
- Because of linear cost and benefit functions, the control conditions easy to interpret.
- The ‘biological discounted’ meat and omitted damage value (due to harvesting) steers the optimal harvesting composition (Olaussen and Skonhoft 2011).

Table 2. Steady state selective hunting and uniform hunting.

	h_c^*	h_y^*	h_f^*	h_m^*	X_m^* / X_f^*	π^*
Selective hunting	0	0	0.25	0.90	0.29	100
Uniform hunting	0.18	0.18	0.18	0.18	1.00	67

5. Final remarks

- A small taste of models analyzing exploitation/conservation of terrestrial animal species.
- Compared to fish: More cost and benefits components.
- Compared to fish: Land habitat has generally more competing uses.
- Both these points: Richer analysis.
- But don't forget the large commercial harvesting value of fish!