Economic aspects of Harvesting

I. Discounting

Clark CW 1973. Profit maximization and the extinction of animal species. Journal of Political Economics 81:950-961.

Net return from harvest = Population size - stock left for next year:

$$R_t = N_t - s_t$$

Population size ***next*** year is some function of stock left after harvest ***this*** year (function G, for 'growth'):

$$N_{t+1} = G(s_t)$$

This growth model is likely to be some variation of density dependent growth.

The present economic value of the population is:

$$V_P = R_0 + \alpha R_1 + \alpha^2 R_2 + \alpha^3 R_3 + ...$$

Here, α is the discounting factor: *the proportion by which future economic profits are devalued, relative to current economic profits.* This is the value presently assigned (V_p) to a benefit received in the future (V_f). In this case, we are dealing with an annualized discount factor (assuming that the time step between t and t+1 is a year).

$$\alpha = \frac{V_p}{V_f}$$

($0 \leq \alpha \leq 1$)

Substituting the first two equations into the third equation yields:

$$V_P = N_0 - s_0 + \alpha(G(s_0) - s_1) + \alpha^2(G(s_1) - s_2) + ...$$

Using this equation, Clark's theory proves that maximum economic profit comes from harvesting at a level that holds the population size after harvest, S, constant.

At first this seems counterintuitive, but the solution basically *finds the post-harvest population size at which the current profit from taking one more fish is exactly offset by future losses due to taking that fish.*

The economically optimal stock size, S, depends both on:

(A) Population biology - the population growth function $N_{t+1} = G(s_t)$: as the growth rate of the population increases, it increases the payoff to leaving individuals unharvested, and thus increases the optimal stock size. (Consider a non-renewing resource, meaning one with no population growth. Leaving a stock behind does not increase the size of the subsequent 'harvests' at all.)

(B) Economics - the discount factor, α. Recall that α is *the proportion by which future economic profits are devalued, relative to current economic profits.* As the discount factor declines, the economically optimal stock size declines.

If the discounting rate becomes too low, then the harvest strategy that maximizes economic profit is ***hit-and-run***: take the entire population now, even thought this causes an extinction.

(Overhead: Ludwig Fig 2.3, p. 24)

Clark's summary of this states: "often it is economically rational to harvest to extinction". In economic language, sometimes the rational decision (if the sole goal is to maximize economic profit) is to ***liquidate*** the resource – that is, to convert it into another commodity (or cash). This is why regulation of industries that extract from live populations **CANNOT BE LEFT IN THE HANDS OF THE INDUSTRIES.** Economics does not favor being a 'good steward' when the discount factor is low.

When the interest rate (growth rate of money) is high, the discounting rate will be low. This is logical - high interest rates favor the immediate conversion of natural resources to cash, if cash will grow faster than the resource itself. Recall that ***money in the bank grows exponentially and deterministically***, unlike natural populations.

Example with commercial vs non-commercial tree species:
(Overhead: Figure 15.5 Meffe & Carroll)

Discounting rates – how are future profits weighed against current profits?

The discounting rate essentially summarizes the time horizon over which profits are being maximized. Several factors will affect this:
(a) ***Uncertainty*** in the future harvests… the resource may not be there (fire burns a forest), you may not be there to realize the profit (sadly, death even affects rich folks), or the market may change unpredictably. Increasing uncertainty leads to a higher discount, so ***highly variable populations*** are more prone to large discounts.

(b) ***Economic hardship*** forces a short time horizon on decision making. A subsistence hunter may have little option to reduce or delay harvests, even if they are not sustainable.

Economic theory suggests that the discounting should work like this:

$$V_P = \frac{V_f}{(1+d_e)^t}$$

that is, ***exponential*** decline in current value of future harvests. Each period, t, that a profit is delayed, leads to an increase in the ***exponent*** applied to the discount.

Empirical data show that discounting works like this:

$$V_P = \frac{V_f}{1+d_h t}$$

that is, hyperbolic decline in current value of future resources. Each period, t, that a profit is delayed, leads to an increase in the ***multiplier*** applied to the discount. Hyperbolic discounting is observed in people and most other animals.

This is good news for sustainability, because the *actual decline rate for* V_P / V_f *is less than the theoretical (exponential) decline rate, and this favors long-run sustainability, via larger stocks.*

(Overhead fig 12.2, Sutherland et al.)

II. Problems of Open Access

Overhead: Fig 15.4 Meffe & Carroll
Overhead Fig 1.4 Mace & Reynolds

Curves are economic cost and revenue of harvesting, NOT recruitment and offtake curves. These curves relate COST and YIELD to EFFORT

Harvest by one individual: maximum efficiency is economically optimal
Harvest by many individuals: pushes the economic optimum to the "open-access break even"

These points define three ranges:
preservation - below the point of maximum efficiency
sustainable exploitation - between max efficiency and OA break even
hit-and-run - above the OA break even

Given the many collapses observed for marine fisheries and systematic declines due to overharvest in bushmeat animals, it is apparent that harvests often exceed the open-access break-even point, and lead to hit-and-run liquidation of natural populations. Why?

1. Marine case:

Over-capitalization. Once an individual has invested in a boat and gear, the costs must be paid back. Favors harvesting no matter what.

Subsidies. Almost invariably, governments subsidize extractive industries when they being to collapse and create economic hardship. Favors continued harvest by creating an artificial (external) profit to harvesting a resource that has been driven down below the size at which it is actually profitable to harvest.

In 2005, $50 billion globally was put into subsidy of marine fisheries alone.

Diversified and international harvestors. Can liquidate one resource and put the profits into another economic operation. Can push a harvest in one nation and then go to another when conditions become unfavorable.

2. Bushmeat case. Strong constraints in alternatives to continuing harvest.

A final word on preservation:

This basically takes into account the value of resources to future generations, which is not included in standard economic analysis.

Overhead: Fig 15.7 Meffe & Carroll

And lastly, what are the ethics of considering life a ‘resource’… using the term ‘resource management’ to refer to the harvesting of animals. It is important to understand the forces created by consideration of harvested animals as ‘commodities’, but that does not mean that it is logical or ethical to think of them only as resources or commodities. Is it desirable to define success as ‘maximizing profit while not causing a collapse’?