1 Some brief introductory thoughts on extinction, A way to get us thinking like environmental economists

erm: extinction.pdf revised August 28, 2017

- Can you imagine a set of circumstances under which it would be **optimal** for society to have a species become extinct? That is, what should society's "rule" be for purposefully driving a species to extinction?
- Given your rule, what properties of a species would make it or more, or less, likely that society would want to eliminate that species?
- What properties of a society would make it more or less likely society would want to eliminate a species?

A **sufficient**[1] rule would be: If the net benefits to society of killing an additional member of the species are greater than zero, and this is true at all population sizes, including those population sizes where an addtional death would lead the species to extinction.

Let's try to express this mathematically. Let

$$MB^s_{hx}(pop_x)$$

denote the benefit **to society** of harvesting an additional member of species x.[2] Note that I have made this marginal benefit a function of the population size for species x, pop_x. Of course we would expect this to be a function many things in addition to the population size. Much of these notes are a consideration of the other factors.

Let

$$MC^s_{hx}(pop_x)$$

denote the cost to society of harvesting an additional member of species x if the population size of species x is pop_x.

In which case, the net benefits to society of harvesting an additional individual is

$$MB^s_{hx}(pop_x) - MC^s_{hx}(pop_x)$$

And, if, starting at the current population size,

$$MB^s_{hx}(pop_x) - MC^s_{hx}(pop_x) > 0$$

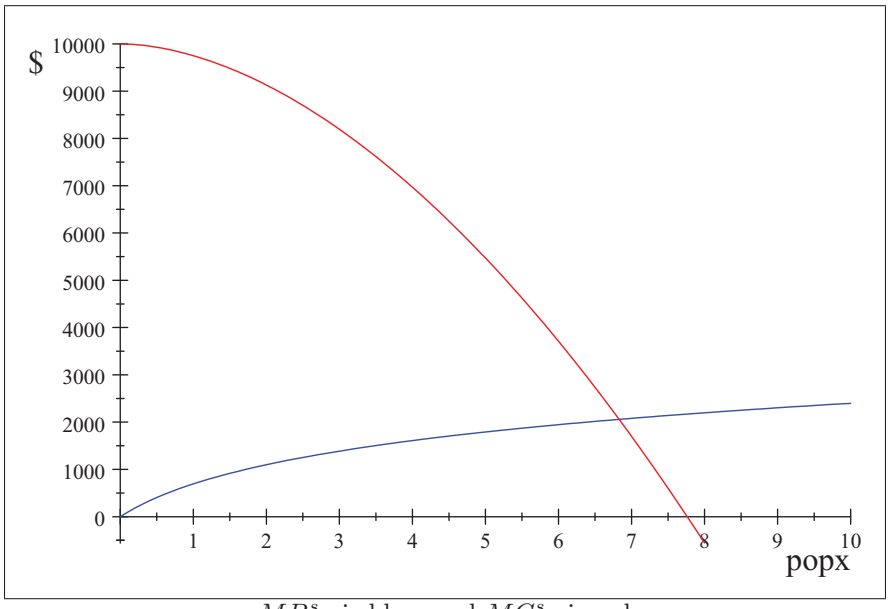
and this remains positive no matter how much the population declines, extinction of species x is socially optimal.

Important questions include how marginal benefits and costs vary by species and population size.

[1] Make sure you understand the difference between necessary and sufficient. I am not saying this condition is necessary.

[2] We would expect the explicit form of this function to vary a lot across species.

Graphically, consider a few possibilities. If



MB^s_{hx} is blue, and MC^s_{hx} is red

Assume population is being measured in thousands $(,000)$. So, $pop_x = 6$ is a population of 6 thousand $(6k)$.

Note that as more are killed, holding births constant, population declines.[3]

What do these graphs say? The red one is the cost to society of killing one more individual. The graph says that the cost to society of killing the last one thousand is approximately $\$10k$, but the cost to society of killing one thousand more when the the population is $8k$ is close to zero. (The red line, in part, reflects that harvesting costs are likely to increse as the population declines.)

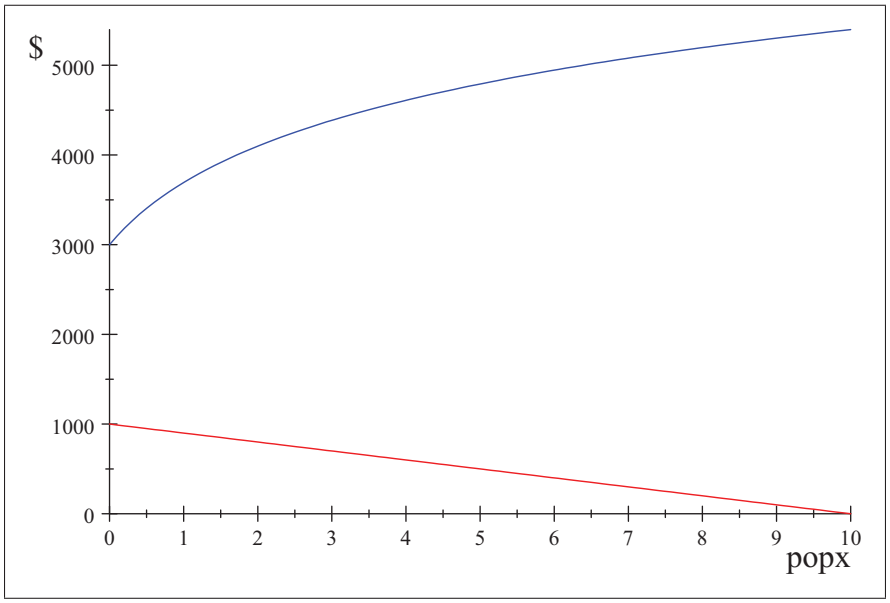
The blue one indicates the benefits to society of killing another one thousand, as a function of the the population size. Given the way I drew the curve, the benefits of killing the last one is basically zero.

In this graphical example, it looks like the socially optimal population size is around $7k$ individuals, and 7k is not zero. That is, extinction is not socially optimal: for population sizes below around $7k$ the marginal benefits of harvesting are less than the marginal costs of harvesting. What if the population was currently at 3 thousand? (we would not want to harvest more)

What is the population was currently at 10 thousand?

[3] When you factor in birth rates and natural mortality rates, which both depend on population size, things get more complicated.

However, if



MB^s_{hx} is blue, and MC^s_{hx} is red

extinction of species x will be socially optimal–the benefits of killing another one are always greater than the costs.

Expressed this way, the rule is simple to comprehend, but determining $MB^s_{hx}(pop_x)$ and $MC^s_{hx}(pop_x)$ in practice is difficult and raises many fundamental questions.

Note that I said my rule was **sufficient** for it to be socially optimal to drive a species to extinction. These conditions are **not necessary** for it to be socially optimal to drive the species to extinction, as we will see in a moment.

Think about a better criteria from an efficiency point of view.

Think about the difference between necessary and sufficient

A rule that is necessary and sufficient is that

At the current stock size the net social benefits of driving the species below it critical level for recovery are positive and larger in value than any lesser reduction in the stock size, or larger in value from any increase in the stock size achieved by stopping harvesting.

A couple things to note about this condition.

- Whether it is socially optimal to drive the species to extinction depends on the current stock size. For example, it might be optimal to extinct a species if its stock size is currently low, but not optimal if the stock size is currently high.[4]

- Our first rule, the sufficient rule, required that it was always socially optimal to reduce the stock by additional unit. The second rule does not require this. Imagine a situation where the benefits of killing one additional individual is not greater than the cost, but the benefits of killing all of them is greater than the costs of killing all of them.[5]

[4] For example, if the stock of cows is 1 and everyone is hungry, one might as well have a BBQ, the species is doomed either way.

[5] Imagine a huge swarm of killer flesh-eating flies who reproduce at an incredible rate. Killling one has a cost, but no real benefit, whereas getting rid of all of them might be a social improvement.

1.1 How to define society (who counts)? This is a fundamental question because we decide on the benefits and costs to society. Throughout the course, the question "who counts?" will be the fundamental question.

People? Which ones? French people?

Future generations?

Dead people?

Individual animals who are not human (Bob the bear? your dog?, a killer fly?)

Are individual plants (George the Fern) members of society?

Are the members of the species being considered for extinction members of society?

There might be great difficulty agreeing on a definition of society. Then, correctly measuring benefits and cost to that society could be very difficult. (A big difference between students of economics and, for example, environmental studies majors, is who they include in society.)

1.2 Identify factors that make it more likely, less likely, that a species should be driven to extinction.

Factors that are important include:

- The discount rate: how much the future counts relative to the present
- Whether members of the species are members of society
- Whether dead members of the species are important inputs into the production of things society wants (cheesburgers)
- Whether alive members of the species create utility or whether alive members of the species causes significant injuries to society
- Whether the cost of harvesting (killing) members of the species is high or low
- The current size of the species (number of members or biomass)
- Whether members of society get pleasure from, or are repulsed by, killing members of the species.[6]
- If relevant, the cost of keeping the species from going extinct in terms of breeding programs, etc.

[6] When I first wrote this factor down, I was thinking of one species hunting or harvesting another species (white human males shooting ducks, or elephants, for fun, or coyotes eating rodents), but what if members of a species enjoy killing members of their own species)

If hungry should we eat the last two cows, and drive the species to extinction?[7]

1.3 The effect of different factors on whether we would want to drive a species to extinction

I used to think that how these factors influenced the optimality of extinction was clear cut, but I was wrong. The different influence of the different factors interact in complex and interesting ways.

1.3.1 the effect of the discount rate

what is the discount rate?

Assume we like the taste of dead cow and are hungry. If there are only two cows left should we eat them and drive cows to extinction. It depends, in part on the discount rate and how hungry we are. Being very hungry and having a high discount rate, increases the probability that we shoudl eat them. If the discount rate is very low (we care about the future almost as much as we care about the future), the probability that we should eat them is lower? Why? Because if we eat them all now there will be no burgers in the future. If we care little about the future (have a high discount rate), chomping away makes more sense, but if we have a low discount rate it might be better to wait.

Partially explaining: why invest in breeding and raising a cow that cannot be eaten until next year, if you do not give a shit about what is going to happen next year to either you or the cow?

On the other hand, assume that there exists a nasty bacteria that has a one-hundred year incubation period, but will then kill everyone – think the Black Plague with a hundred-years notice. We can kill off the bacteria now (drive it to extinction) but it will be costly? Should we do it? Not if we have high discount rates.[8]

[7] Note that if there is only one cow, cows are already doomed to extinction. If there is only one left should we have texas-style BBQ or should we let it live out its life in pastoral bliss?

An aside: Certain species of whales might be doomed to extinction because even though they are not extinct, their number is below the critical mass. For some species, one male and one female is not enough.

[8] Note that bacteria might be an example where the benefits of killing one more individual is not greater than the cost, but the benefit of killing all of them is greater than the cost. In explanation, given how bacteria reproduces, killing one individual will not have much affect on the future stock size.

(On another note, think how the the discount rate influences what we might want to do about global warming.)

So, **we can't say** that higher discount rates (less concern about the future) always makes it more likely we will want to drive a species to extinction (or that a low rate of discount means we will necessarily want to save it).

1.3.2 another factor: are members of the species members of society?

It is probably safe to conclude that if members of the species are members of society, it is less likely that it will be optimal for society to drive the species to extinction.

Note my term "less likely," Explaining my qualifer, even if humans are the only members of society, it still might be socially optimal for us humans to go extinct.

For example, we might decide that the cost of keeping humans from extinction is simply too high in terms of lost short-term fun. Consider the article by **??** .

Also note that even if members of a species are members of society, it still might be socially optimal to kill some of them. Consider, for example, deranged ax murderers.

1.3.3 another factor: do they taste good dead? or make cool shoes?

If they taste good dead, is it more or less likely that extincting the species is best for society? It depends

1.3.4 another factor: do we like knowing that they are around?

Some people get pleasure from seeing animals, and some people get pleasure simply from knowing animals exist in living form.

How much pleasure depends on the animal, consider polar bears and chimps vs. snakes and cockroaches. If we get pleasure from an animal being alive, in most circumstances we will be less likely to want to drive it to extinction. I hope my conclusion is correct.

1.3.5 another factor: harvesting costs

C.P., the more it costs to harvest (kill and collect), the less likely we will want to do it.

1.3.6

1.3.7 another factor: a bad species, one whose living presence injures members of society

benefits to harvesting could include the benefits from having less of the species around.

Examples?

The AIDS virus?

1.3.8 another factor: the joy, or repulsion, of the kill

if we enjoy killing them... if we are repulsed by killing them

1.3.9 another factor: the stock size (how many there currently are)

This will influence the cost of killing them off, and the cost of keeping them from going extinct.

If there are just a few left, the cost of killing the last few might be quite low? or quite high?

Imagine a species that is endangered and the stock is low, a stock that could be saved from extinction but only at a high cost to society (polar bears? the rhinoceros Iguana? (an endangered lizard, most live on one Caribbean island)).

If to save the polar bear we have to greatly reduce our rate of global warming by drastically and immediately reducing our rate of CO_2 emissions, it might not be worth it?[9]

Make sure you understand the distinction between whether a species should be eliminated and whether a species will be eliminated under current conditions. Here we are discussing "should" not "whether".[10]

[9] Polar bears are probably already doomed to extinction. An interesting is whether polar bears are a unique species.

[10] A lot of species have or are going extinct, and, in many cases, this is socially bad.

1.4 Note that this whole meaning of extinction is in question if it is possible to re-create a species from the DNA of a dead specimen.

If that is possible, it would be possible to have no living members of a species now but have living members in the future. This possibility would greatly complicate the analysis. The whole meaning of "extinct" is called into question.

The question on the other sign of the coin from extinction is the creation of new species. Under what conditions is it efficient to create a new species. And if we did create a new species should it members be members of society?

Note that global warming will likely create new species. Consider the Grolar Bear aka Prizzly Bear. Global warming is causing grizzly bears to move northward. Polar bears are in decline and its getting more difficult to find another one to mate with, so .....[11]

You might want to read "**??**

(Consider the senior female at Yale who needed a great topic for her senior essay- this is an urban legend)

Lots of people are afraid of genetic engineering because they are worried about new species.

[11] Often the progeny from mixed-species hookups are sterile (e.g. horses and donkeys) but this is not always the case.

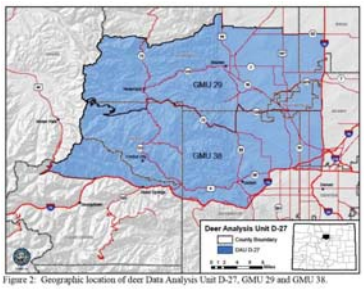


Figure 2: Geographic location of deer Data Analysis Unit D-27, GMU 29 and GMU 38.

1.5 socially optimal population size

To say extinction is optimal is equivalent to saying that, given the current stock size, the longrun optimal stock size is zero.

We might all agree that deer should not be driven to extinction. That is, the optimal stock size is not zero. This raises the question, what is the optimal stock size for a species?

How might one determine the optimal stock size, and then how to achieve the optimal stock size? (note that my first graph drawn so that the optimal stock size is around $7k$.

What is the optimal number of deer in Boulder County, assuming deer are not members of society? Licensed hunters take 50,000 to 80,000 deer annually in CO from a population estimated at **??**

If If I remember correctly, Boulder averages more than one deer/car accident a day. Sadly, I know of someone whose wife was decapitated when a deer came through her windshield—there are good and bad things about having deer around. Deer carry diseases, attract mountain lions (good or bad?), and cause a lot of damage to gardens.

As far as I know there is no population estimate for Boulder county. There is an estimate of appoximately $8k$ for the Boulder Creek **??** , much bigger area than Boulder. See map.

One could even ask if there is an optimal stock size for humans, and, if so, how to achieve it.

1.6 Based on the criteria mentioned, choose a species and argue it is likely that we should drive this species to extinction.

divide up into groups of three and prepare to present you species and argue that it should be drivent to extinction.