

Tragedy of the Commons

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Why do rational people make choices that lead to collective ruin?

Traffic: We all want the fastest route home, so we all take the same road, so no one moves.

Climate Change: One extra flight won't melt the ice caps, right? But 8 billion will.

Overfishing: If I don't catch the fish, someone else will.

Tragedy of the Commons

- Where individuals act independently and rationally according to their own self-interest -> worse outcome for the whole group.
- In real life, it can be used to predict human behaviour and save the planet.

Farmers sharing a pasture

- 10 farmers share a pasture that support 10 cows.
- If one farmer adds an 11th cow, they get 100% of the profit from that cow, but the cost is spread across all other farmers.
- Do you add another cow? Do you stick to your one cow?



Cooperate = stick to one cow

Defect = add an extra cow

The Maths behind: Payoff Matrix

	Farmer B: Cooperate	Farmer B: Defect
Farmer A: Cooperate	(10, 10)	(0, 15)
Farmer A: Defect	(15, 0)	(5, 5)

Several options of choice:

1. Dominant strategy: Farmer A "Defect" always yields a higher number (15 vs 10, or 5 vs 0) regardless of what Farmer B does. The individual benefit does outweigh the individual cost. However, overtime the field is destroyed.
 2. Nash Equilibrium: Is the stable point because neither farmer can improve their outcome by changing their own strategy alone, even though (10, 10) is better for everyone = mutual choice, no regrets, most logical choice based on self interest
- Individually rational, but collectively this can be disastrous

The Maths behind pt2: The resource model

Population of a resource from one year to the next.

Population of the resource
next year →

$$P_{n+1} = P_n + rP_n - H$$

← Harvest: how much we take
(the defecation)

The total units of resource
removed by all players

↗
Current population

↖
Regeneration rate

Assumptions

$$P_{n+1} = P_n + rP_n - H$$

Population of the resource next year →

← Harvest: how much we take (the deflection)

↗ Current population ↖

↗ Regeneration rate ↖

A: Sustainability $H < rP_n$

The harvest is less than the natural growth, so the resource is safe, and it grows.

B: Steady State $H = rP_n$

This is the "Golden Rule." The population stays exactly the same year after year.

C: The Tragedy $H > rP_n$

This is where the Tragedy of the Commons happens. Because the "Prisoner's Dilemma" forces every player to maximize their own harvest for short term gain, the total harvest eventually exceeds the regeneration rate.

$$P_{n+1} = P_n + rP_n - H$$

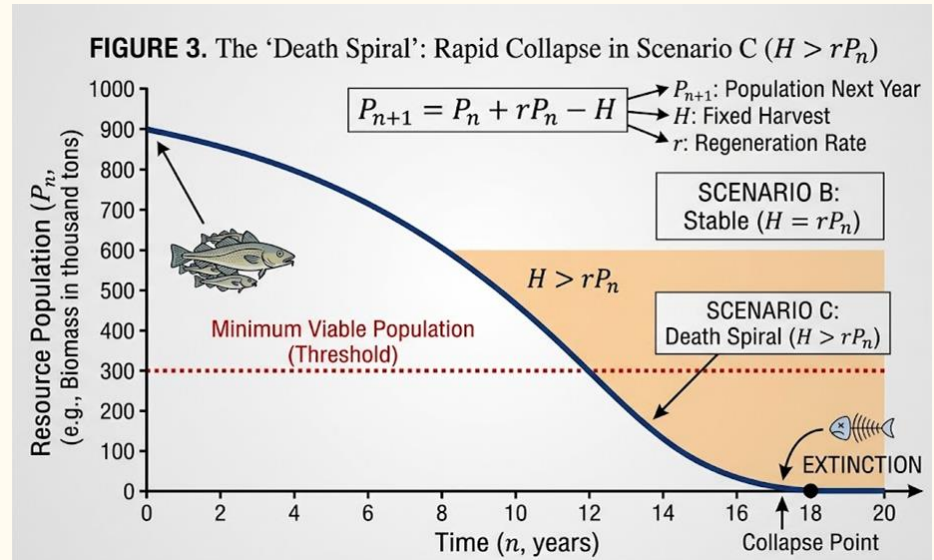
Population of the resource next year \rightarrow \leftarrow Harvest: how much we take (the deflection)

\nwarrow \nearrow

Current population Regeneration rate

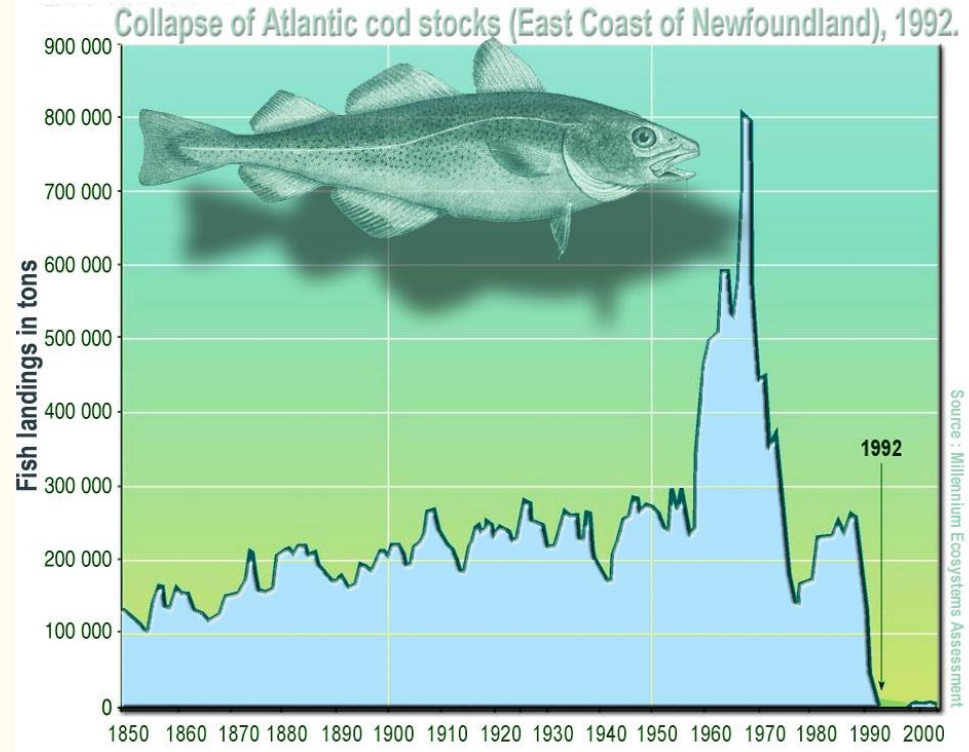
If H is a fixed number and the current population starts to drop, what will happen to the population?

If H is a fixed number (e.g. we always take 100 tons) but the current population is shrinking, you are taking a larger and larger percentage of the population every year. This is what causes the "Death Spiral" where the resource doesn't just decline - it accelerates toward zero. This is exactly what happened in the Atlantic Cod collapse.



The Atlantic Cod Collapse

- 1992 Grand Banks collapse in Canada.
- For decades, different countries followed the dominant strategy to fish as much as possible.
- The population fell below the sustainability threshold -> 40,000 people lost their jobs, and cod fell to 1% of historic levels.



What can we do to prevent it?

$$P_{n+1} = P_n + rP_n - H$$

Population of the resource next year →

← Harvest: how much we take (the deflection)

↗ Current population ↖ Regeneration rate

- To save the resource, we must change the payoff Matrix.
 - Quotas: limiting H so that $H < \text{or equal to } rP_n$.
By capping H , you ensure that you are only ever harvesting the the growth and never the population.
 - Fine: If we add a fine of -11 for "Defecting," the payoff of 15 becomes 4.
The Result: Now, the Nash Equilibrium shifts to the "Cooperate" box because 10 is a higher payoff than 4.

Conclusion

Resource collapse isn't just a "bad event" - it is a mathematical certainty if the harvest rate exceeds the regeneration rate for too long.

The Tragedy of the Commons isn't a concept of inevitability, it's a math problem. By changing the incentives behind it, we can change the outcome.

Thank you

Any questions?