NetLogo model Conditional Defection in the Commons (Pay to escape).
Model Overview, Design concepts, Details (ODD)

WHAT IS IT?

This model simulates the evolution of sustainable and unsustainable (greedy) harvesting strategies in a shared commons under conditions of monitoring and punishment. It is an updated NetLogo implementation of the second model presented in the article:

Ibrahim, A.M. The conditional defector strategies can violate the most crucial supporting mechanisms of cooperation. Sci Rep 12, 15157 (2022). https://doi.org/10.1038/s41598-022-18797-2

The model explores how different agent types (sustainable harvesters, greedy harvesters, punishers, and escapers) interact in the commons, and how punishment, escape attempts, and monitoring accuracy affect sustainability outcomes.

Key finding: The model highlights how escaping cheaters (Conditional defector agents who cooperate to reduce the perception accuracy of the punishers.) can undermine punishment mechanisms and kin selection that would otherwise enhance cooperation, thereby threatening the evolutionary stability of sustainable strategies.

HOW IT WORKS

- The world is a grid of patches with renewable resources.
- Agents (turtles) harvest resources with either sustainable (low) or greedy (high) strategies.
- Some sustainable agents are punishers:

  They monitor their neighborhood within a radius of 2 patches.

  punishers pay a perception cost for detecting greedy agents.

  Upon detection, punishers can sanction cheaters depending on the punishment rule:

  Kill → remove the cheater.

  Fine → subtract a fine from the cheater's harvest, which is redistributed among neighboring agents.

  Suspend harvest once → prevent cheater from harvesting in the current round.

  Punishers also pay an additional punishment cost when applying sanctions.
- Greedy agents are escapers.

  They monitor their neighborhood within a radius of 2 patches.

  If punishers are nearby, escapers can attempt to avoid detection by paying an escape cost.

  These escape costs are summed up, every round, into a global interference level.

The interference reduces the effective detection accuracy of punishers in proportion to the total escape energy wasted.

- Agents update their energy after harvest and costs, reproduce with mutation, or die if their energy is depleted.
- Resources regrow logistically each round.

THINGS TO NOTICE

- The effectiveness of punishment in suppressing greed when no escapers are present.
- How the introduction of escapers undermines punishment:

  Escapers invest energy in escape attempts when punishers are nearby.

  The accumulated escape energy generates interference, reducing detection accuracy.

  As interference grows, greedy agents escape more frequently, avoiding sanctions.
- Key insight: even though punishment and kin selection usually promote cooperation, the presence of escaping cheaters, "conditional defectors," can erode both mechanisms, allowing greed to persist or dominate.

HOW TO USE IT

- Number-Agents: number of agents initialized.
- Percent-Sustainables: proportion of sustainable harvesters.

- Percent-Punishers: proportion of sustainables that are punishers.
- Harvest-sustainable: harvest amount for sustainable agents.
- Harvest-greedy: harvest amount for greedy agents.
- Living-costs: baseline energy cost per round.
- Costs-perception: the costs in units of energy that punishing agents have to pay for perceiving other agents.
- Costs-punishment: the costs in units of energy that punishing agents have to pay to punish other agents. All punishing agents of an agent divide the costs of punishment.
- Costs-escape: the costs in units of energy that escaping cheater agents have to pay for avoiding detection.
- Fine: fine imposed on cheaters when punishment is "pay fine".
- Punishment: mode of punishment ("kill", "pay fine", or "suspend harvest once").
- Growth-rate: intrinsic growth rate of resources.
- Carrying-capacity: maximum resource capacity per patch.
- Mutation-rate: probability of trait mutation during reproduction.
- Death-rate: baseline mortality rate.
- Perception-accuracy: base probability of detecting greedy harvesters.

- interference-scale: strength of interference caused by escape energy waste.
- Buttons:
- setup: initializes agents and resources.
- go: runs the simulation continuously.

THINGS TO TRY

- Change Costs-escape and Harvest-greedy to see whether escape becomes an effective strategy.
- Increase Fine or switch Punishment type to test different enforcement regimes.
- Explore how Perception-accuracy interacts with interference-scale.

EXTENDING THE MODEL

- Add spatial mobility beyond local moves (migration dynamics).
- Allow heterogeneous perception and escape ranges for punishers and cheaters, respectively.
- Explore the coevolution of resource regeneration parameters with harvesting behavior.

NETLOGO FEATURES

- Uses turtles-own and patches-own to manage agent and resource states.
- Implements logistic resource growth with carrying capacity.

- Employs detection accuracy modified by interference, combining agent-level and global variables.
- Mutation is implemented directly in reproduce.

RELATED MODELS

- Models in the NetLogo library: Commons, Altruism, Evolutionary Strategies.
- Other commons dilemma and cooperation models that explore punishment, monitoring, or resource harvesting.

CREDITS AND REFERENCES

This model is an update of the second model from: * Ibrahim, A.M. The conditional defector strategies can violate the most crucial supporting mechanisms of cooperation. Sci Rep 12, 15157 (2022). https://doi.org/10.1038/s41598-022-18797-2

NetLogo: Wilensky, U. (1999). NetLogo. Center for Connected Learning and Computer-Based Modeling, Northwestern University.

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