Evolving sustainability

Can group selection create sustainable socio-ecological systems?

Sandra Hughes Goff, Timothy Waring, School of Economics & Sustainability Solutions Initiative, University of Maine

Hypothesis Group selection processes encourage the evolution of sustainable socio-ecological systems (SESs)

Background Group selection matters to sustainability science

Differences between groups create conditions in which some groups are better matched to the demands of their environment than others.

Over time, differential survival and reproduction, as well as imitation and migration, cause less successful groups to give way to more successful groups.

This evolutionary process, known as group selection, affects the types of behaviors which proliferate within a population due to conflict between group-level and individual-level beneficial behaviors.

All else equal, groups whose members cooperate will outperform groups whose members maximize their own self-interest at the expense of fellow group members.[1]

Cooperation is vital to the sustainable management of SESs.

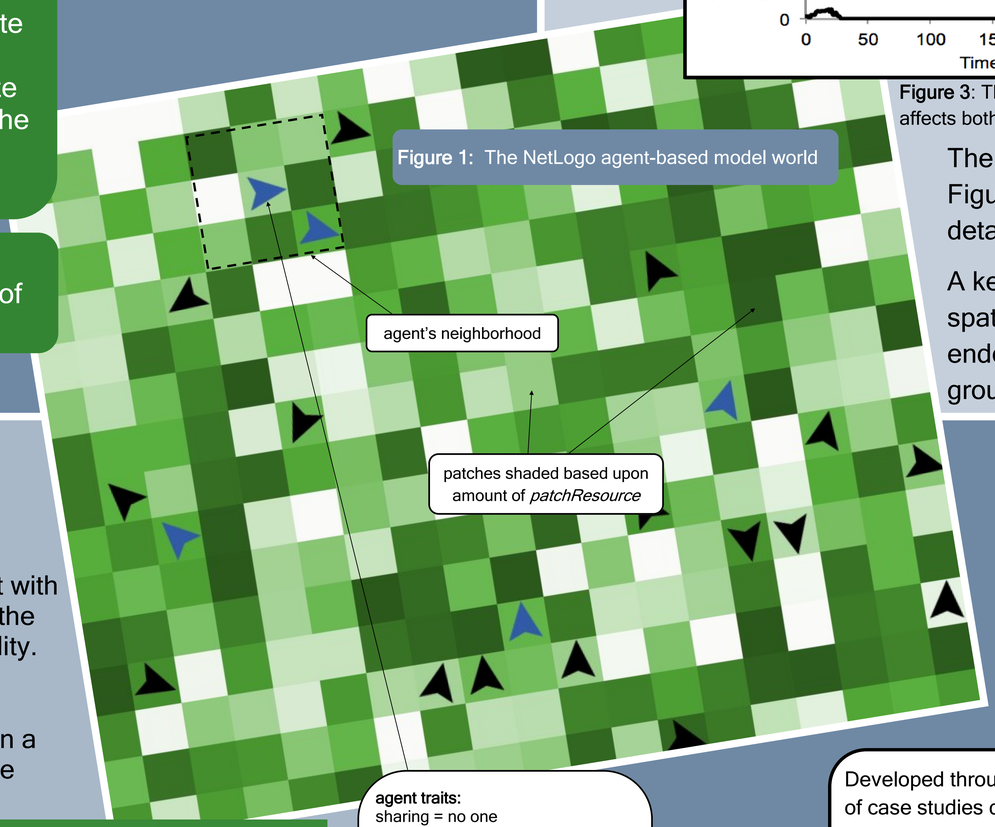

Figure 1: The NetLogo agent-based model world

Methods Using an agent-based model (ABM) to test our hypothesis

Why use an ABM?

ABMs allow heterogeneous, autonomous agents to interact with each other and their environment, making it easy to model the evolutionary mechanisms; variation, selection, and heritability.

Socio-ecological ABM created in NetLogo[2]

Figure 1 represents the ABM world in which patches contain a random amount of resource *(patchResource)*, which may be harvested and can regrow.

The world is populated by agents, who make "choices" about how much resource to harvest, with whom to share, whom to imitate, and whether or not to move.

These "choices" are based upon randomly assigned traits such as the ternary traits (see Figure 2), *imitate* and *share*, as well as *color*, and *harvestPref.*

agent traits:
sharing = no one
imitate = group
color = blue
harvestPref = low

agent choices:
harvests a small amount
keeps it all for itself
reproduces if has enough resources
moves if patch resources getting low
probabilistically imitates harvesting behavior of a blue agent within its neighborhood

	share with no one	share with group	share with anyone
imitate no one	imitates no one, shares with no one **(anti-social)**	imitates no one, shares only with group members	imitates no one, shares with anyone
imitate group members	imitates only group members, shares with no one	imitates only group members, shares only with group members **(group-centric)**	imitates only group members, shares with anyone
imitate anyone	imitates anyone, shares with no one	imitates anyone, shares only with group members	imitates anyone, shares with anyone **(extensive)**

Figure 2: The interaction of the two ternary traits, *imitate* and *share* create nine possible other-regarding agent behaviors, with the downward diagonal creating combinations of particular interest (anti-social, group-centric, and extensive)

We expect group selection to select for lower harvesting preferences, higher sharing, and more group-centrism

Results Preliminary evidence supports group selection as a potential driver of sustainable resource use

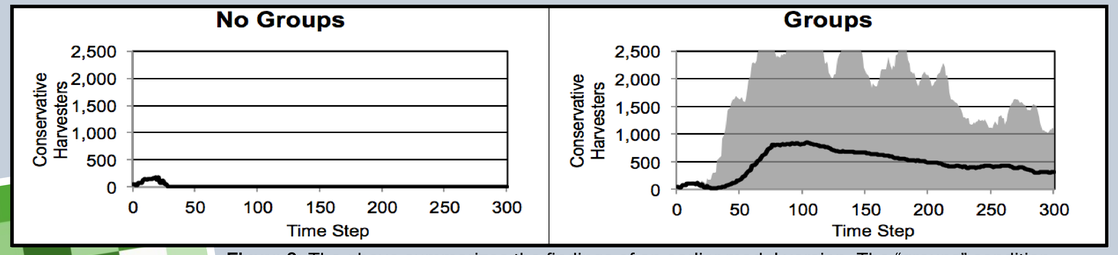

Figure 3: The above summarizes the findings of an earlier model version. The "groups" condition affects both system longevity and the prevalence of individual pro-environmental behavioral traits.

The compelling results of an earlier model implementation, detailed in Figure 3, emphasized the need for the more sophisticated ABM detailed herein.

A key difference in this updated model is the implementation of spatially-defined social groups which are allowed to form endogenously as a result of agent traits and parameters, enabling groups, traits and resource conditions to co-evolve.

Directions Using ABMs to explore how group selection on SESs can reveal the evolution of Ostrom's core design principles[3]

Developed through rigorous review of case studies detailing the successful management of common pool resources, Ostrom's eight core design principles are an emerging framework for the analysis of sustainability within SESs.

In the near future we hope to use this model to treat each of the design principles as a testable hypothesis.

For more information contact:
Sandra Hughes Goff
5710 Norman Smith Hall
Orono, ME 04469
sandra.goff@maine.edu

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