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Dynamic system strategies for climate social tipping points

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1 DARETOTIP project

The DARETOTIP project aims to understand which courses of action should be established to reach a climate social tipping point (STP) as early as possible, to achieve system transformation by embedding the driving forces in new political and social norms.

STPs can be triggered by bottom-up (BU) approaches like socio-ecological contagion.

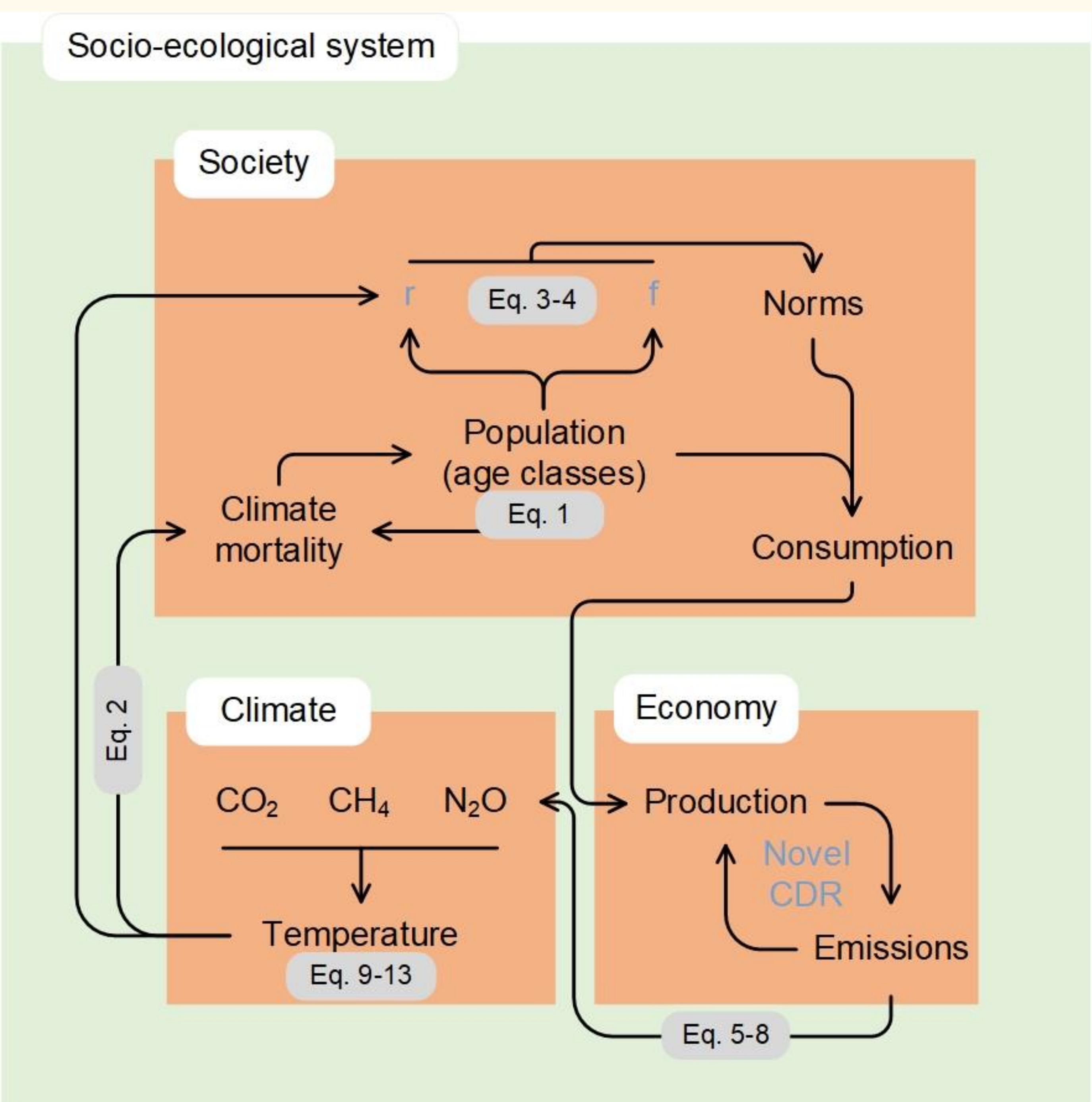
System dynamics is used to model how these bottom-up approaches can lead to STPs providing a deeper understanding of which types of change lead society towards a more sustainable status.

2 System dynamics framework

The system dynamics model consists of the three integrated modules.

These modules are:

- *Society* - population dynamics, norms including consumption patterns, and mortality change due to the climate;
- *Economy* - where demand for products drives supply and determines sectoral emissions; and
- *Climate* - stock and flow of greenhouse gases, their forcing and the global warming thus affected (Eq 9-13 from IPCC warming calculations, not shown on this poster).



$$P = \sum_{z=1}^{6} \eta_z P_z - (\iota_z + \ddot{\iota}_z) P_z \qquad \text{Eq. 1}$$

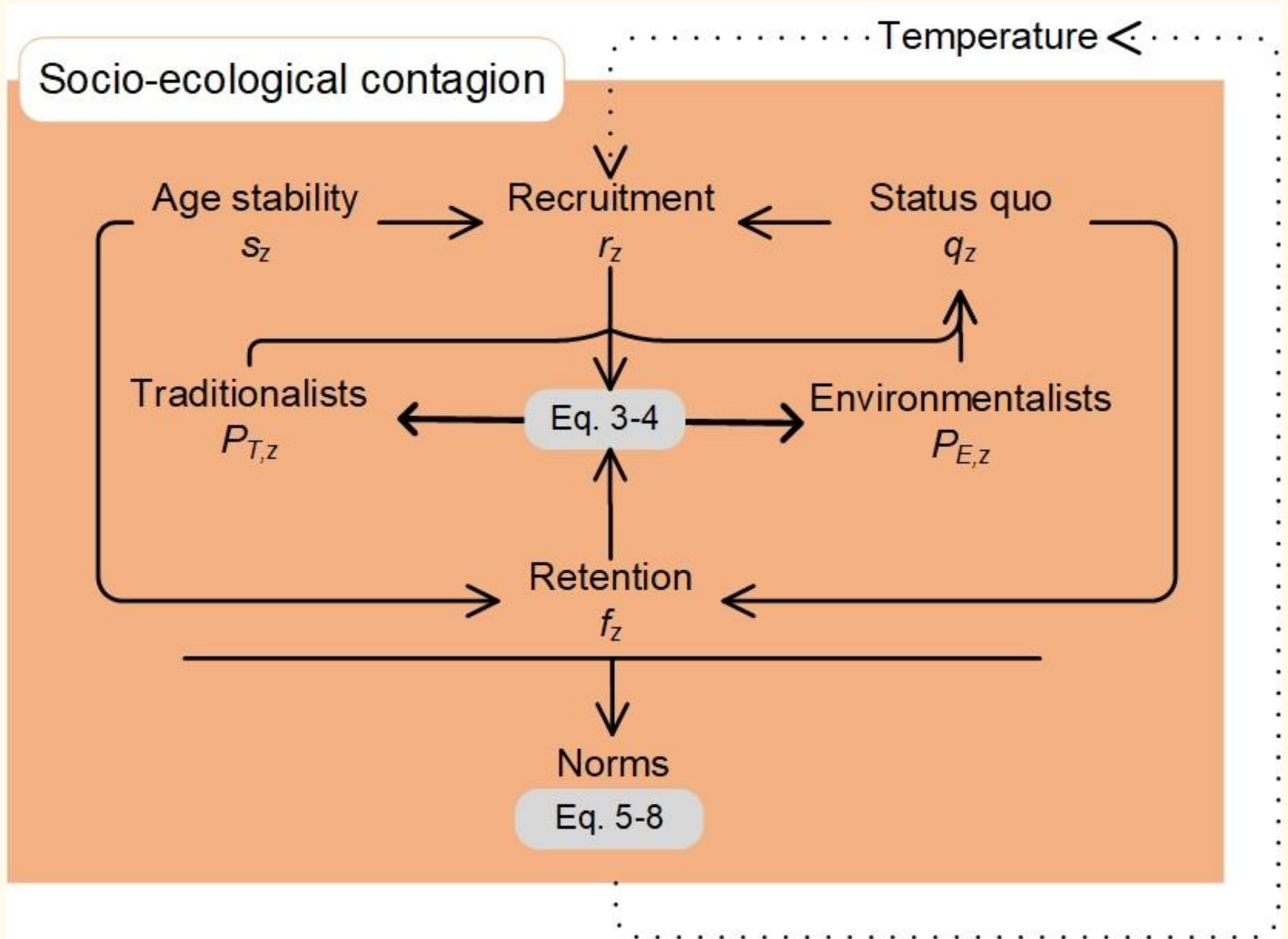
such that P_z is the population of age class z, with age-specific fertility (η_z) and mortality (ι_z) rates, and $\ddot{\iota}_z$ is the additional mortality due to climate change induced temperature increase

$$\ddot{\iota}_z = 0.253 \frac{T_{max} + \Delta T}{\theta_z} \qquad \text{Eq. 2}$$

as deaths per thousand people per year and temperature in degrees Celsius
such that T_{max} is the 1990 mean high temperature, and
θ_z is the heat stress threshold for age class z

3 Socio-ecological contagion

SEC divides the total population (P) into mutually exclusive cohorts corresponding to their distinct ecological norms; status quo "Traditionalists" and emergent "Environmentalists".



Traditionalists are characterized by having global average climate burdens, while Environmentalists are characterized by global average 1990 climate burdens. Members between the groups is modelled using Eq 3 and Eq 4 (below), while Eq 5-8 (not shown on this poster) are the greenhouse gas emission curves for the cohorts:

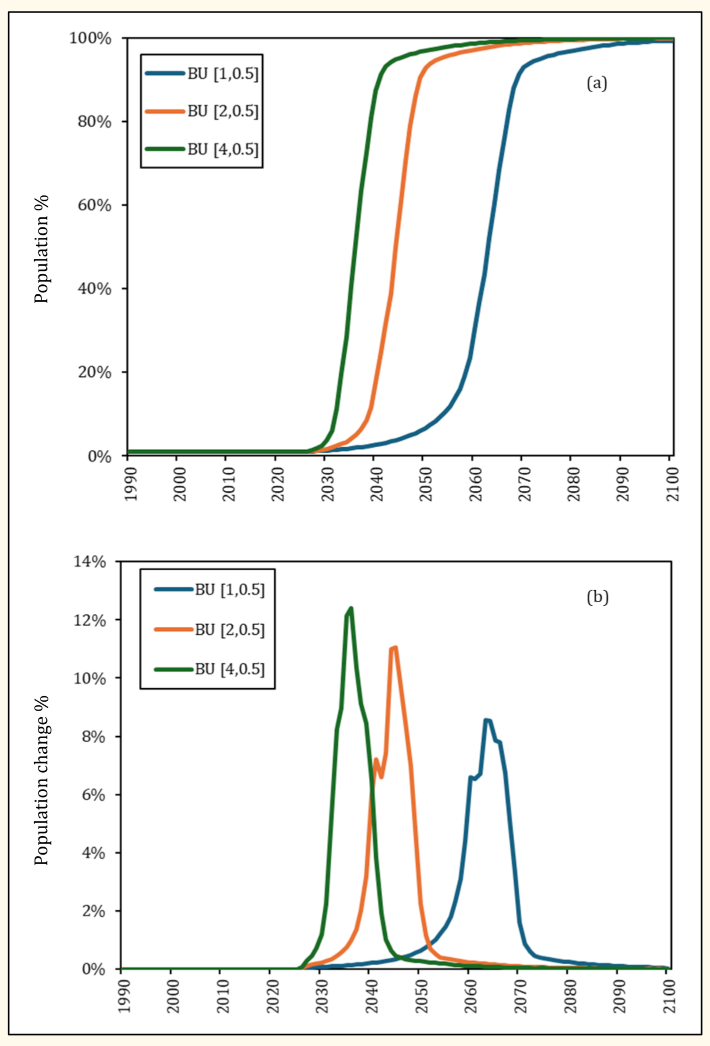
$$P = \sum_{z=1}^{6} P_{E,z} + \sum_{z=1}^{6} P_{T,z} \qquad \text{Eq. 3}$$

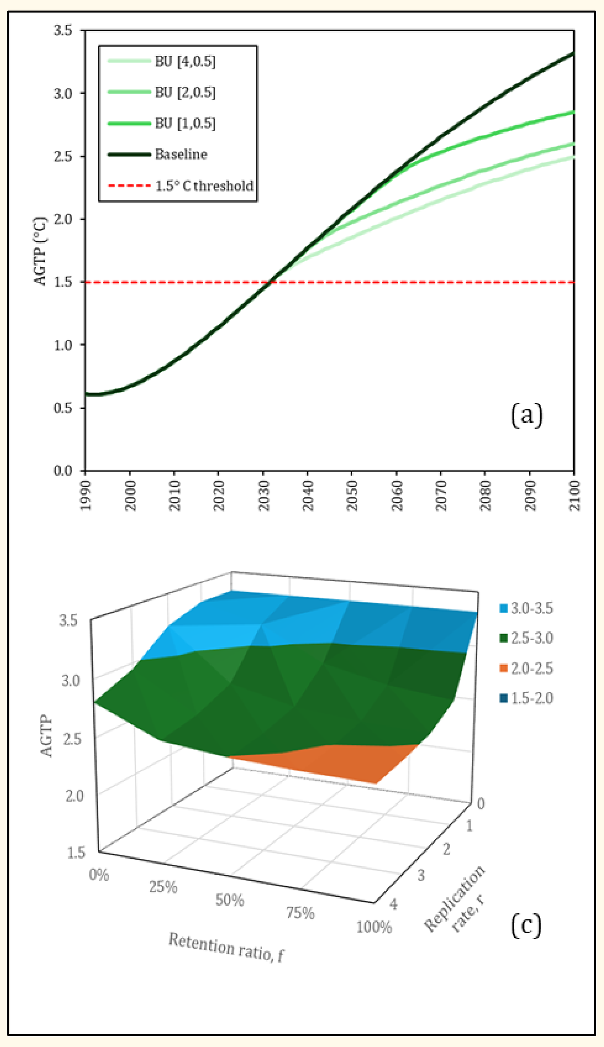
such that $P_{E,z}$ is the Environmentalist cohort and $P_{T,z}$ is the Traditionalist cohort

$$SEC = \begin{cases} max\{0, q_z P_{T,z}\} - max\{0, q_z P_{T,z}(1 - f_z)\} & for\ r_z P_{E,z} > P_{T,z} \\ max\{0, r_z P_{E,z}\} - max\{0, q_z r_z P_{E,z}(1 - f_z)\} & for\ r_z P_{E,z} \leqslant P_{T,z} \end{cases} \qquad \text{Eq. 4}$$

such that q_z is the quotient of Traditionalists in age class z, and
r_z is the recruitment rate of Environmental norms in age class z, and
f_z is the retention ratio of Environmental norms in age class z

4 Results & conclusions





Socio-ecological contagion can bring about a climate social tipping point by 2036, 11 years after activation, assuming a recruitment rate of 4 (higher recruitment rates would shorten this time but might be unrealistic). While this climate social tipping point leads valuable drops in global warming both by mid- and end-century, socio-ecological contagion does not achieve the 1.5 °C limit on its own, resulting in 2.5 °C (0.8 °C mitigation) warming in 2100 compared to no SEC (i.e. baseline).

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Related work

Elliot et al. (fc). "Merits of social tipping points for climate change mitigation"
Elliot & Levasseur (2022). "System dynamics life cycle-based carbon model for consumption changes in urban metabolism". *Ecological Modelling.*
Elliot (2022). "Socio-ecological contagion in Veganville". *Ecological Complexity.*

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