Tipping points in sustainable agriculture? A coupled natural human systems approach to understanding diversified practices

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Abstract

Keywords: diversified practices, ecosystem services

Note: this is just me attempting a fresh outline to get a sense of what a greater CNHS-style pitch would look like. Intending the outline to be just figures and topic-sentences of each paragraph / section for startes.

Introduction

- Agricultural systems are both important for their fundamental influence over human and ecosystem wellbeing, and a prime example of a global change issue in which societal and ecological issues are tightly enmeshed.
- Our understanding of these systems rarely reflects the dynamic and tightly integrated nature of societal and ecological processes in agricultural systems. We advance a basic conceptual model

Model setup

Results

Subsidies

Discussion

Methods

Acknowledgements

References

Appendix

{>> Where this bit winds up (and how concise it needs to be) will probably depend on the venue <<} Mathematically, the farmer's decision model can be expressed as

$$\max_{\{a_t\}} \mathbb{E}\left[\sum_t^T U(x_t, a_t)\delta^t\right]$$

where $\{a_t\}$ is the set of available actions to be taken at each point in time t, δ is the discount rate, $\mathbb{E}$ the expectation operator, and $U(x_t, a_t)$ the utility which the farmer associates with being in state x_t and taking action a_t at time t. T is the land tenure of the farm ($T = \infty$ if the farmer owns the land or otherwise

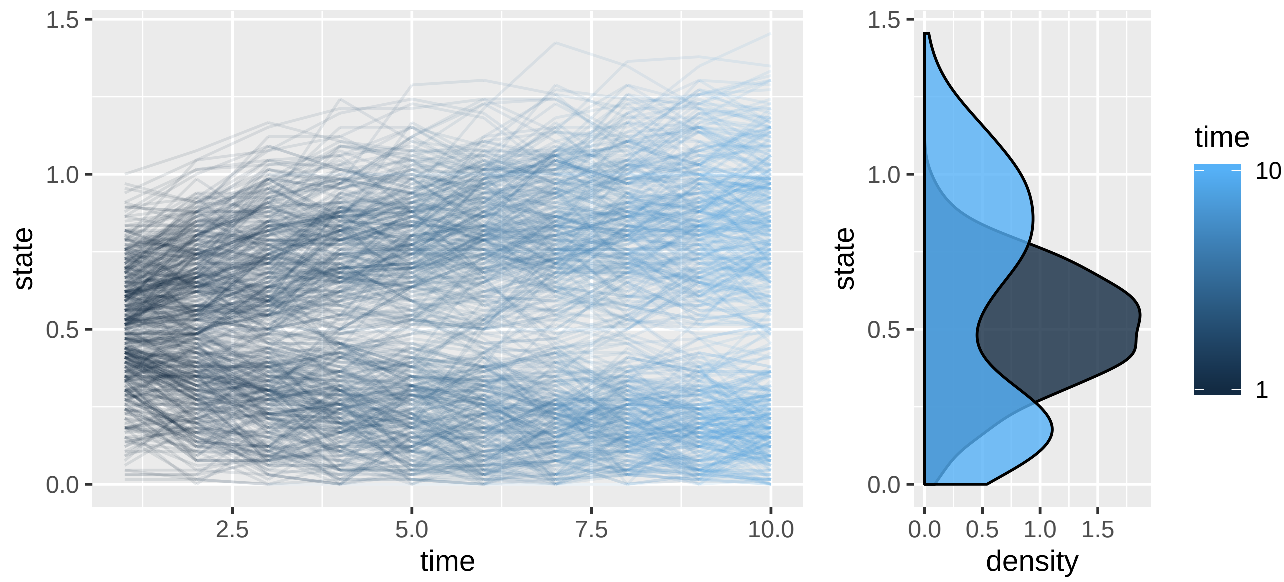

Figure 1: Simulations of the ecosystem state of 500 farming plots over time. Plots are initialized with a truncated normal distributed ecosystem state (mean state 0.5, standard deviation 0.2, truncated at 0,1). Plots are then managed according to the decision rule as discussed in the main text.

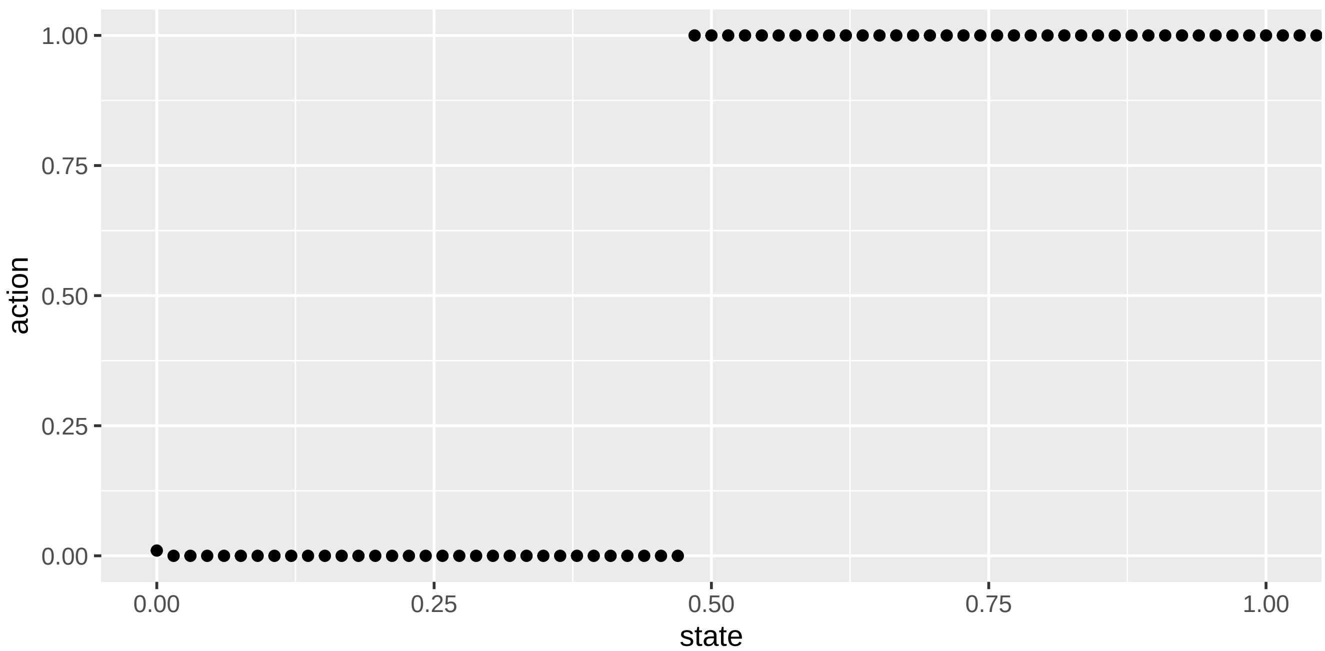

Figure 2: The emergent decision rule

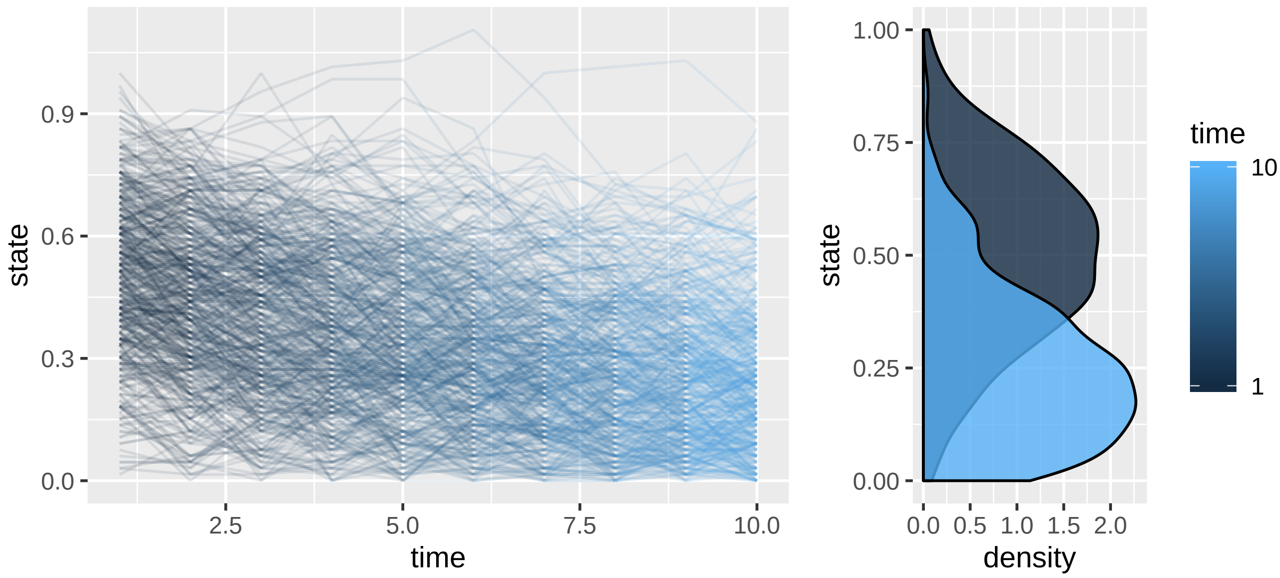

Figure 3: Under short land tenure (shown at 2 years), farmers on most farm plots opt to discontinue or not to adopt diversified practices. This results in a degredation of ecosystem state even among those plots with an initially high value. All parameters are as in previous figure, but decision problem is solved under the finite, 2-year horizon during which farmer will have access to the current plot and thus be able to reap the benefits of the ecosystem state.

expects to be able to farm the same land and thus benefit from the ecosystem services established there indefinitely)

We assume a simple model for the farmer's utility $U(x_t, a_t)$ as combination of the costs associated with adopting the diversified practice and the benefits derived from the ecosystem state (which is in turn influenced by the diversified practices or non-diversified practices adopted),

$$U(x_t, a_t) = bx_t - ca_t$$

Where x_t is the ecosystem state, b the benefit associated, and ca_t the cost of taking action a_t. In general, more complicated nonlinear functions of both the ecosystem state and action are possible in this framework.

The ecosystem state is also dynamic, evolving according to the transition function $f(x_t, a_t)$

$$x_{t+1} = f(x_t, a_t) := x_t + r\,(a_t - x_t)$$

This provides a minimal, one-parameter model in which the parameter r sets the natural timescale at which the ecosystem can respond to a change in mangement practice.

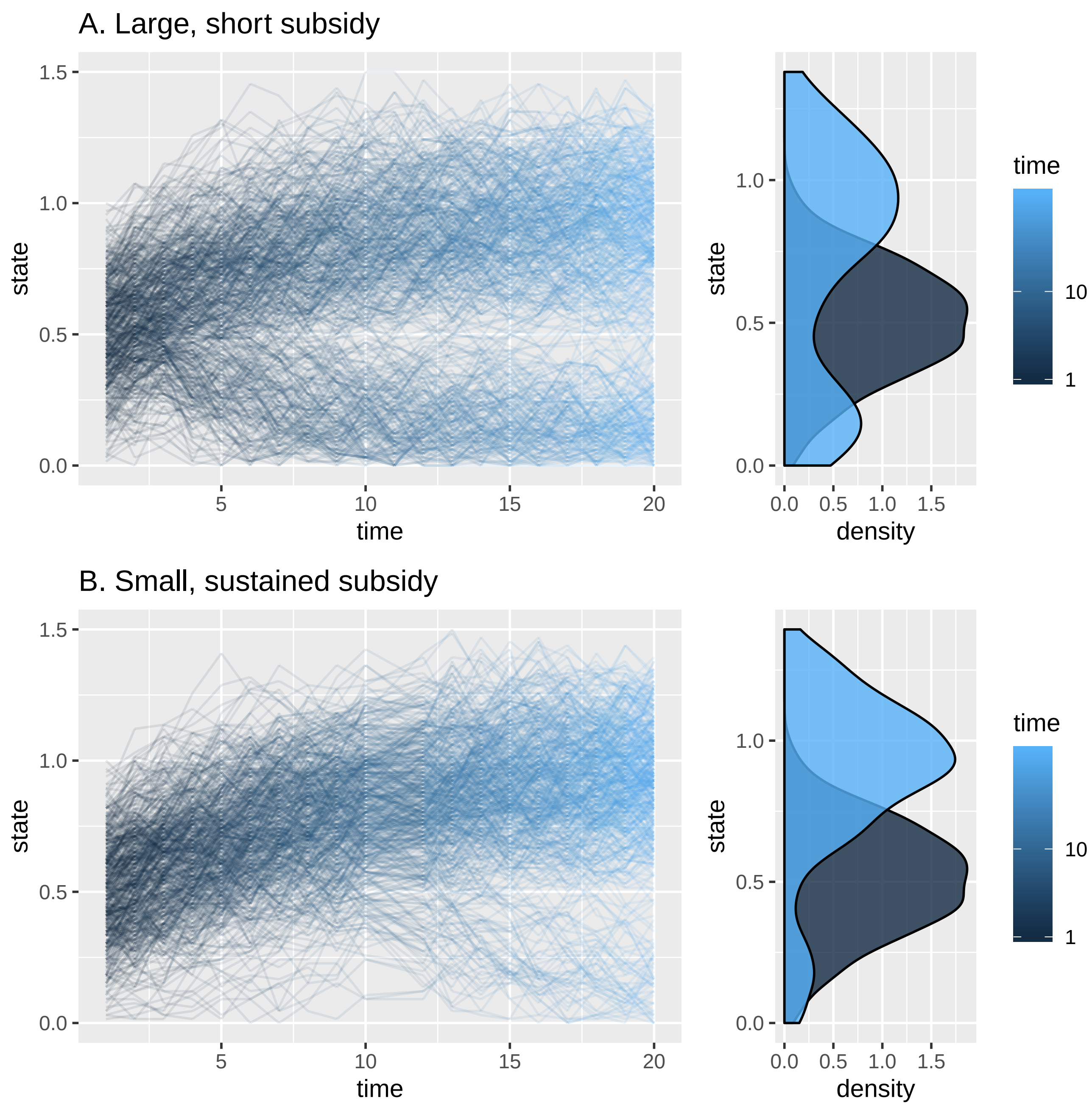

Figure 4: Panel A: replicate simulations from 500 normally distributed starting states under a large subsidy (no direct cost to adoption) over two years. Panel B: the same starting conditions for 500 simulations under a smaller subsidy (cost = 0.9) for 10 years. Ingoring discounting, subsidies have the same total cost After subsidy is removed, farmer adjusts their decision rule to that of no subsidy.