Regime Shifts in Ecosystem Services

Reinette (Oonsie) Biggs, Garry Peterson, Christine Hammond, Rolands Sadauskis, Juan Carlos Rocha, Matteo Giusti
Stockholm Resilience Centre, Stockholm University, Sweden

Introduction

What is a regime shift?

A regime shift is a large, abrupt, persistent change in the structure and function of a system. We focus on regime shifts that lead to large, persistent changes in the bundle or suite of ecosystem services produced by a social-ecological system.

Why are regime shifts important?

- Often have large impacts on human wellbeing
- Often occur unexpectedly
- May be difficult, costly or impossible to reverse

What are examples of regime shifts?

Clear water lake

Turbid lake

Coloured corals

Bleached corals

How do regime shifts work?

Complex systems contain many components linked by feedback loops. As the system evolves, one or more feedbacks tends to become dominant, so that the system becomes structured and functions in a particular way – forming a particular regime. Dominant feedbacks tend to be self-reinforcing, creating conditions that enhance their persistence, and making regimes "sticky" once they form.

A regime shift occurs when a switch in the dominant feedbacks occurs, and is often associated with rapid non-linear change as the system reorganizes into a different structure and function. Such a switch can occur when a large shock (eg hurricane) overwhelms the dominant system feedbacks. More commonly, a gradual change (eg habitat loss) slowly erodes the strength of the dominant feedbacks until a threshold is reached at which a different set of feedbacks suddenly becomes dominant and the system rapidly becomes reorganized into a new regime. The slow erosion of feedbacks usually goes unnoticed until the actual regime shift occurs – hence it is often a surprise.

The Regime Shifts Database

Purpose

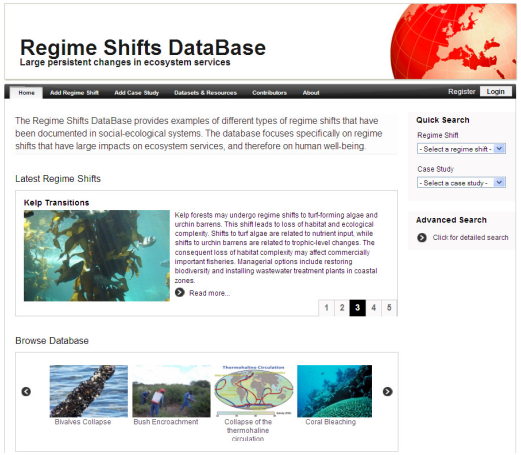
•To provide a high quality synthesis of different types of regime shifts documented in social-ecological systems, including their impacts on ecosystem services, drivers of the shift, and key feedbacks that maintain each regime.
•Develop consistent ways to identify regime shifts in social-ecological systems.

Uses

As input to: – Resilience and ecosystem assessments in particular areas – Research projects on regime shifts – Information for practitioners and ecosystem managers – Teaching resource – Information for students

Each entry describes

- The different regimes that can exist in the system
- Ecosystem services provided by each regime, and which societal groups benefit from these services
- Feedback mechanisms that maintain each regime
- Drivers that precipitate the regime shift, including shocks, slow internal system changes, external direct drivers, and external indirect drivers
- Management options to maintain a desirable regime or to transform to/restore a desirable regime
- Ecosystem type and land use under which the regime shift typically occurs
- Typical spatial and temporal scale at which the regime shift occurs
- Evidence in support of the shift, inlcuding observations, models, experiments, paleo-data
- Confidence about the existence of the regime shift and the underlying feedback mechanisms
- Links to other regime shifts
- Diagrams or photographs illustrating the different regimes



Regime 1	Regime 2	Ecosystem	Key feedbacks	Key drivers	Ecosystem service impacts	Evidence	Confidence
Clear lake	Turbid lake	Freshwater lakes & rivers	Dissolved oxygen – algae feedback	Fertilizer runoff	Freshwater, fisheries, water purification, pest & disease regulation, recreation, aesthetics	Models, observations, experiments	Well established
Coral-dominated reef	Algae-dominated reef	Marine & coastal	Herbivory feedback	Fishing, disease	Fisheries, natural hazard protection, tourism, aesthetics	Models, observations, experiments	Well established
Coral bleaching	Bleached corals	Marine & coastal	Zooxanthellae symbiosis	Sea surface temperature	Biodiversity, fisheries, natural hazard protection, tourism, aesthetics	Models, observations, experiments	Well established
Non-saline topsoil	Saline topsoil	Drylands	Water table & dissolved salts	Clearing of deep-rooted vegetation	Food crops, water purification, regulation of soil erosion	Models, observation, experiments	Well established
Open grassy savanna	Closed wooded savanna	Savannas, drylands, grasslands	Fire, herbivory	Overgrazing, fire suppression, exclusion of browsers	Livestock production, woodfuel, climate regulation	Models, observation, experiments	Contested
Forest	Savanna	Forests, savannas	Albedo-moisture feedback, fire	Deforestation, forest degradation	Biodiversity, freshwater, food crops, livestock, timber, woodfuel, climate & water regulation	Models, observations	Contested
Arctic with summer ice	Arctic without summer ice	Polar, Marine & coastal	Ice-albedo mechanism	Greenhouse gas emissions	Wild animal and plant foods, climate regulation, water regulation	Models, paleo-observation, contemporary observation	Contested
Strong thermohaline circulation	No thermohaline circulations	Marine & coastal	Salinity feedback	Freshwater influx due to climate warming	Fisheries, food crops, livestock, climate regulation	Models, paleo-observation	Contested

Research Projects

Global change drivers of regime shifts

Juan Carlos Rocha, PhD student

The aim of this project is to investigate the main global change drivers of regime shifts, and the impacts of regime shifts on global change drivers. I used a network analysis approach based on causal loop diagrams of 11 regime shifts. Preliminary results show that agricultural processes, global warming, biodiversity loss, demographic and economic drivers are the main causes of regime shifts. Based on the analysis of 400 pathways, we suggest five types of cascading effects between regime shifts.

Regime shifts in agro-ecosystems: Impacts on ecosystem services

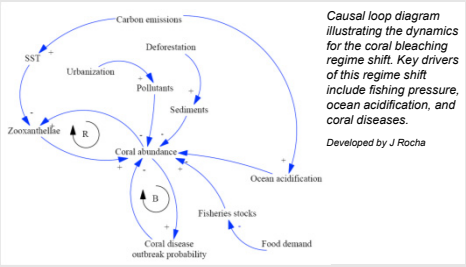
Christine Hammond, MSc student

This project characterizes the ecosystem service impacts of regime shifts in agro-ecosystems. Methods for qualitatively assessing the changes in ecosystem services associated with regime shifts, as well as the different stakeholders/users that benefit or lose under the different regimes, are being developed. Results will be illustrated and discussed in terms of management trade-offs.

Building resilience to climate-related regime shifts

Rolands Sadauskis, MSc student

This project investigates potential options for building resilience to climate change driven regime shifts. "Leverage points" for building resilience are identified from causal loop diagrams and an analysis of feedback mechanisms at different scales. The project will also analyze how IPCC adaptation and mitigation strategies are likely to influence the resilience of climate-driven regime shifts.



Causal loop diagram illustrating the dynamics for the coral bleaching regime shift. Key drivers of this regime shift include fishing pressure, ocean acidification, and coral diseases.

Developed by J Rocha

Key readings

Andersen T. et al. 2009. Ecological thresholds and regime shifts: approaches to identification. *Trends in Ecology and Evolution* 24:49-57.

Scheffer , M., 2009, *Critical Transitions in Nature and Society*. Princeton University Press, New Jersey, USA.

Scheffer, M. et al. 2001. Catastrophic shifts in ecosystems. *Nature* 413:591–596.

Please contribute or suggest additional examples!

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