Resilience Changes in a River Basin using long-term streamflow data

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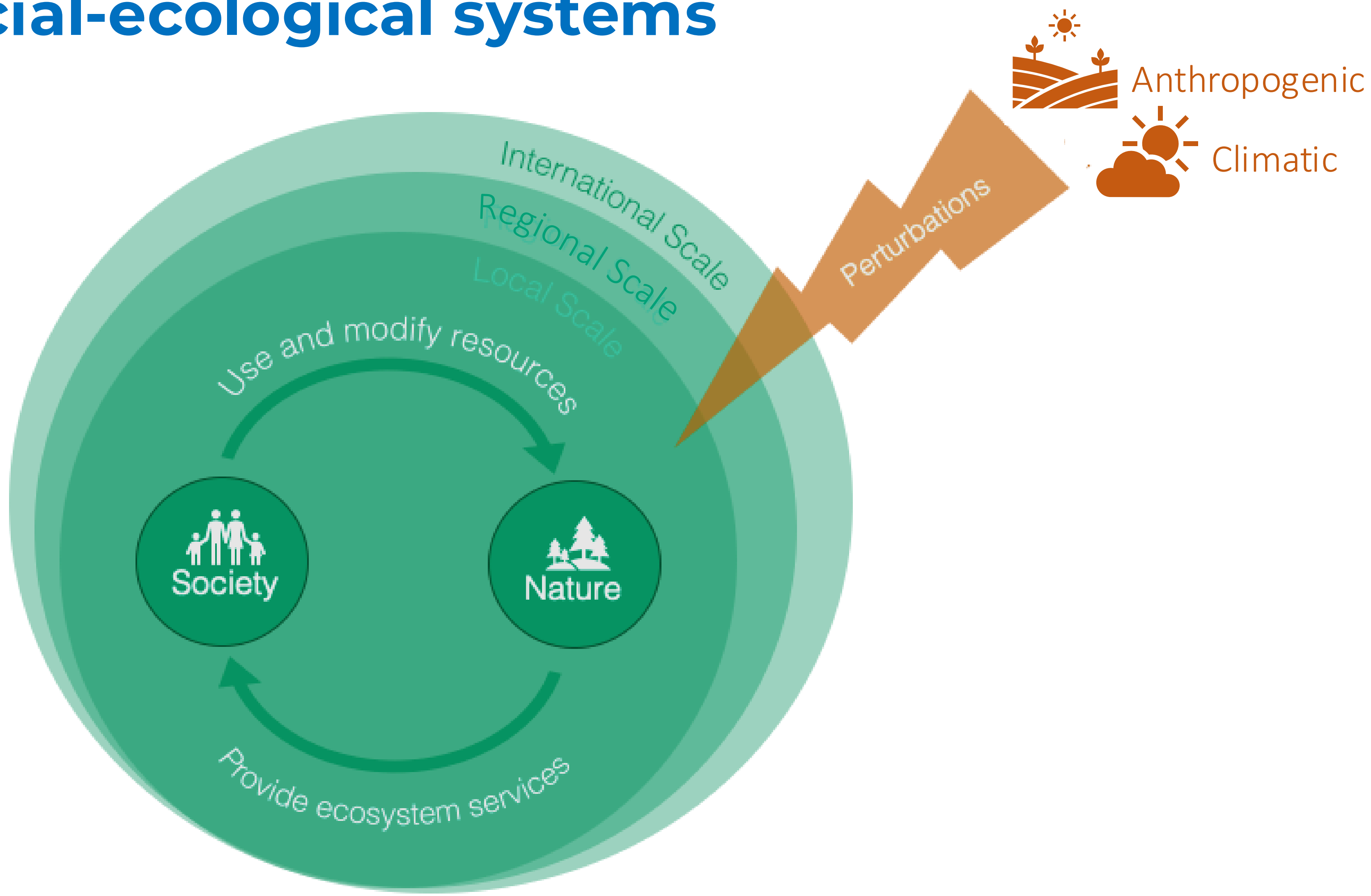
River Basins

As resilient social-ecological systems



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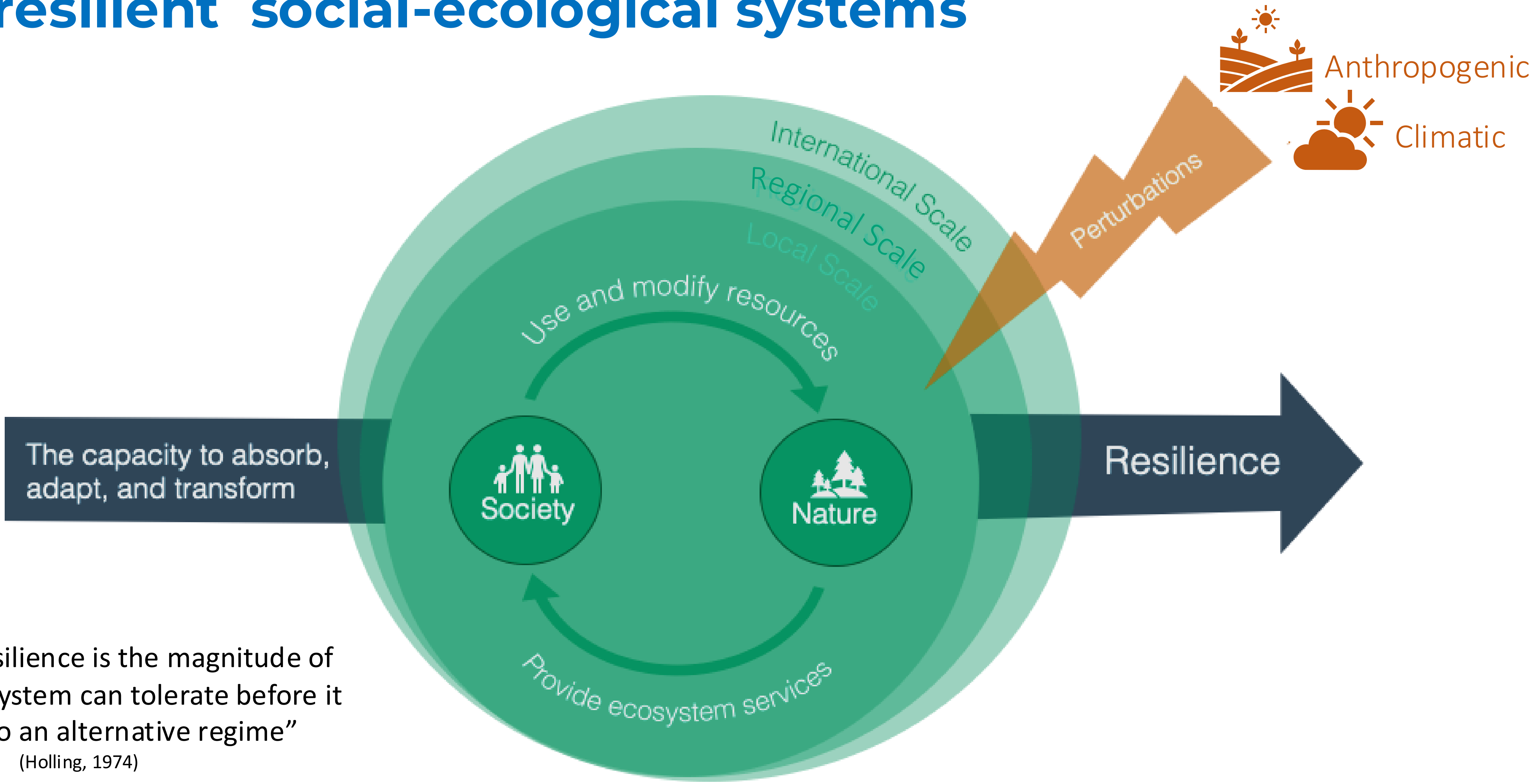

"Ecological Resilience is the magnitude of disturbance a system can tolerate before it changes into an alternative regime"
(Holling, 1974)

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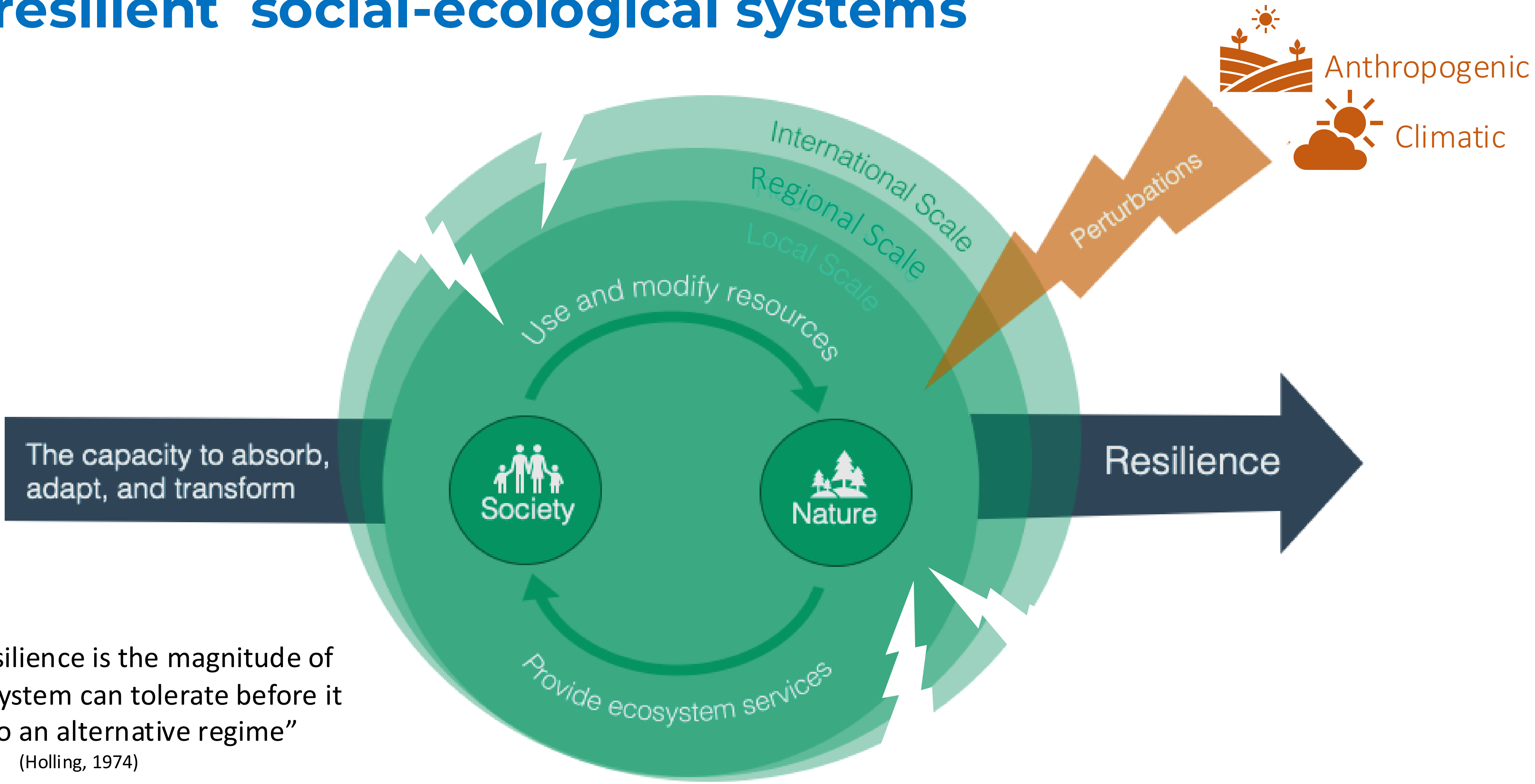

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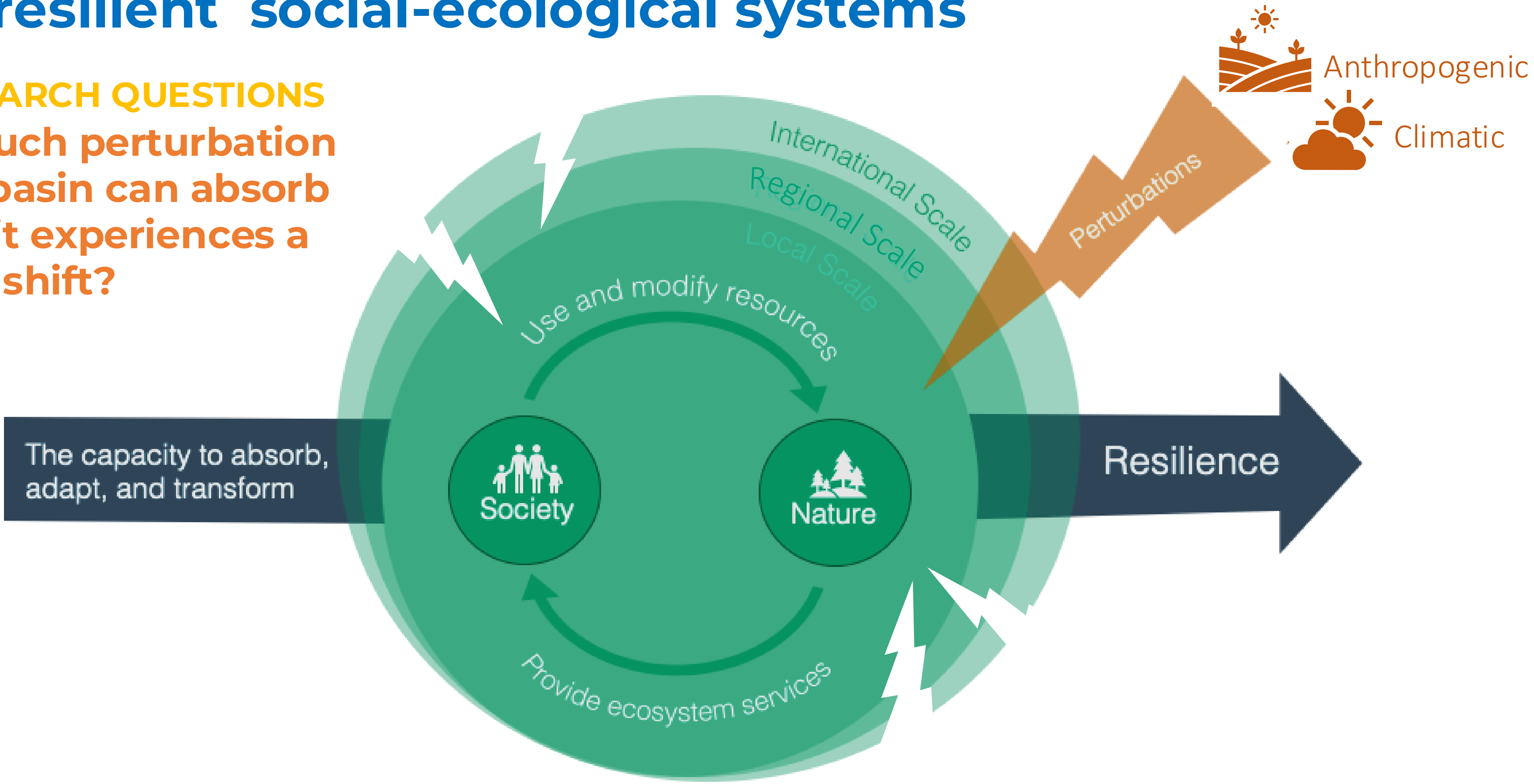
RESEARCH QUESTIONS

How much perturbation a river basin can absorb before it experiences a regime shift?



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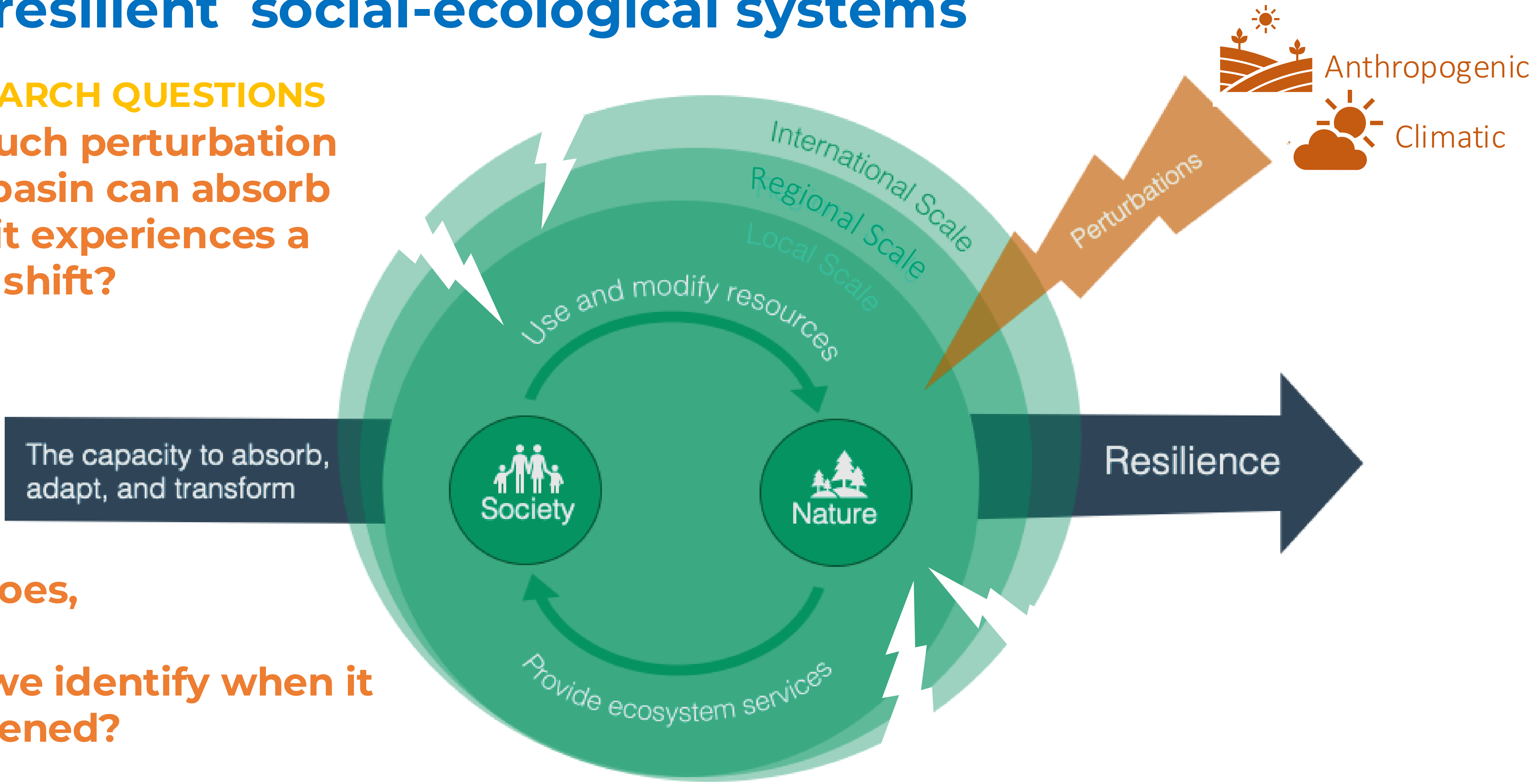
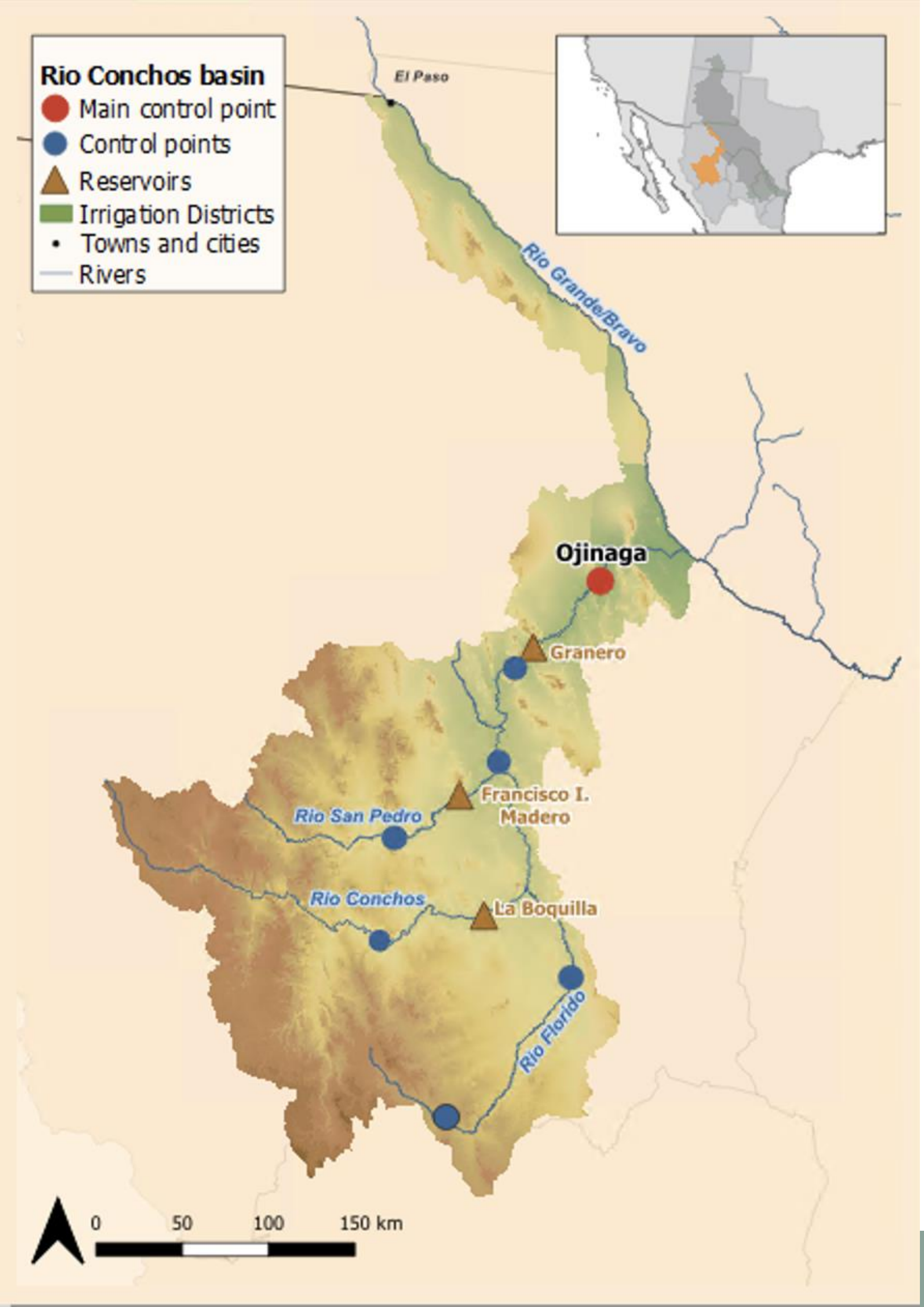


If it does,

Can we identify when it happened?

OBJECTIVE

Identify regime shifts, and changes in the stability landscape of a river basin using long-term streamflow data through an ecological resilience assessment



Case Study
The Rio Conchos

The Rio Conchos Basin is one of the most important areas of northern Mexico and it is a vital tributary of the transboundary Rio Grande-Bravo basin shared between the U.S. and Mexico

Data: 7 Control Points
Period of 110 years (1900-2010)
Timestep: Monthly
Results: at Ojinaga control point

Ecological Resilience Assessment

Output

Input Data: Regulated streamflow time series from 1900-2010

1. Streamflow Naturalization

- Water Balance

$$Q_t^{nat} = O_t - I_t + \Delta S_t$$

Naturalized Streamflow timeseries

2. Hydrologic Assessment

- Streamflow Drought Index (SDI)

Time-window: 120 months

Naturalized and Regulated SDI values

3. Regime Shift Assessment

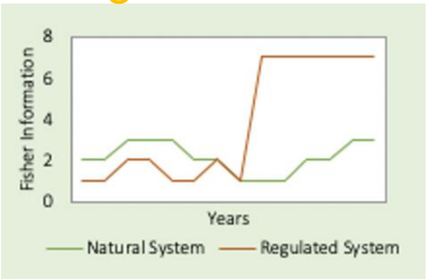
- Fisher Information (FI) (Ahmad *et al.*, 2016)
- Regime Shift Analysis

Sustainable Regime Hypothesis

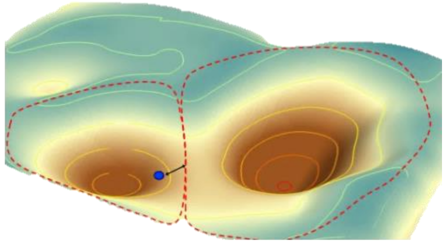
Mann-Kendall non-parametric test (CI 95%)

Probability Density Functions

Regime Shifts

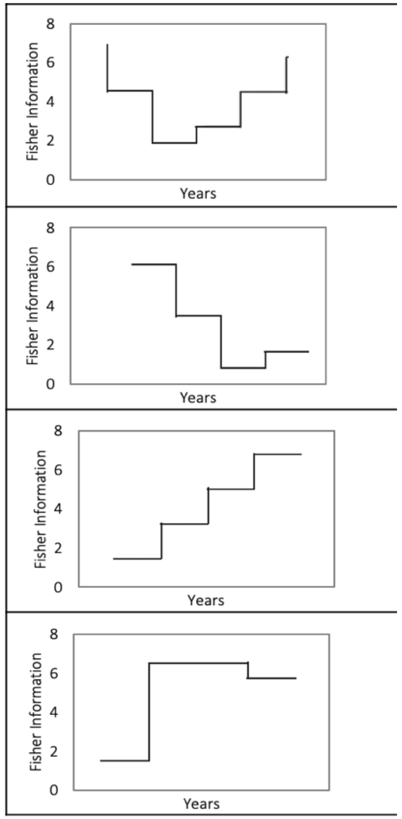


Stability Landscapes



How do we determine regime shifts?

Sustainable Regime Hypothesis (Cabezas and Fath, 2002)



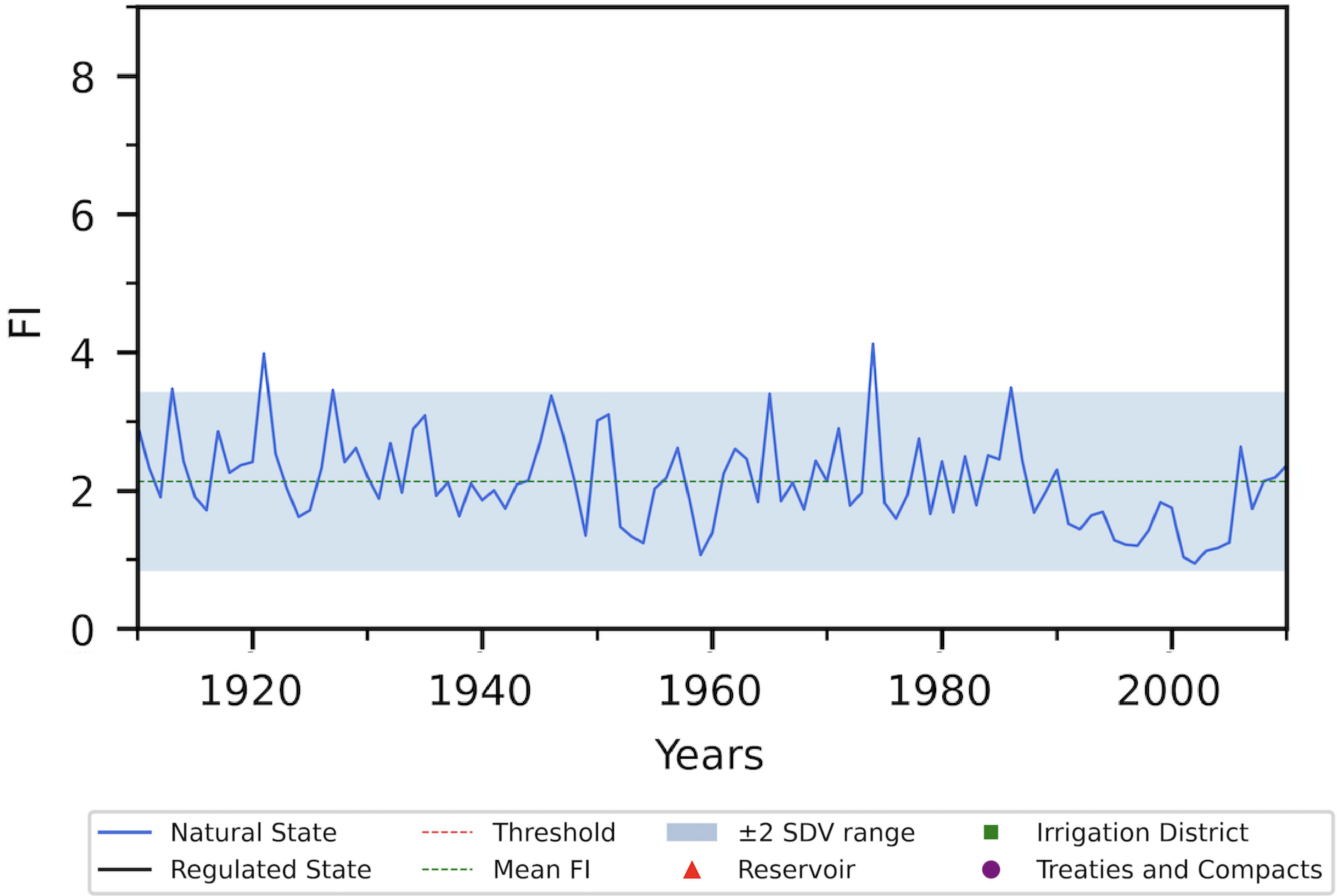
(1) A system is dynamic when a non zero Fisher Index (FI) is constant

(2) A steady decrease in FI indicates warning of regime shift

(3) A steady increase in FI indicates the system is becoming organized and stable

(4) A sharp change in FI denotes a regime shift*
*FI values are greater than +-2 SDV from the mean of FI
(Gonzalez-Mejía *et al.*, 2012).

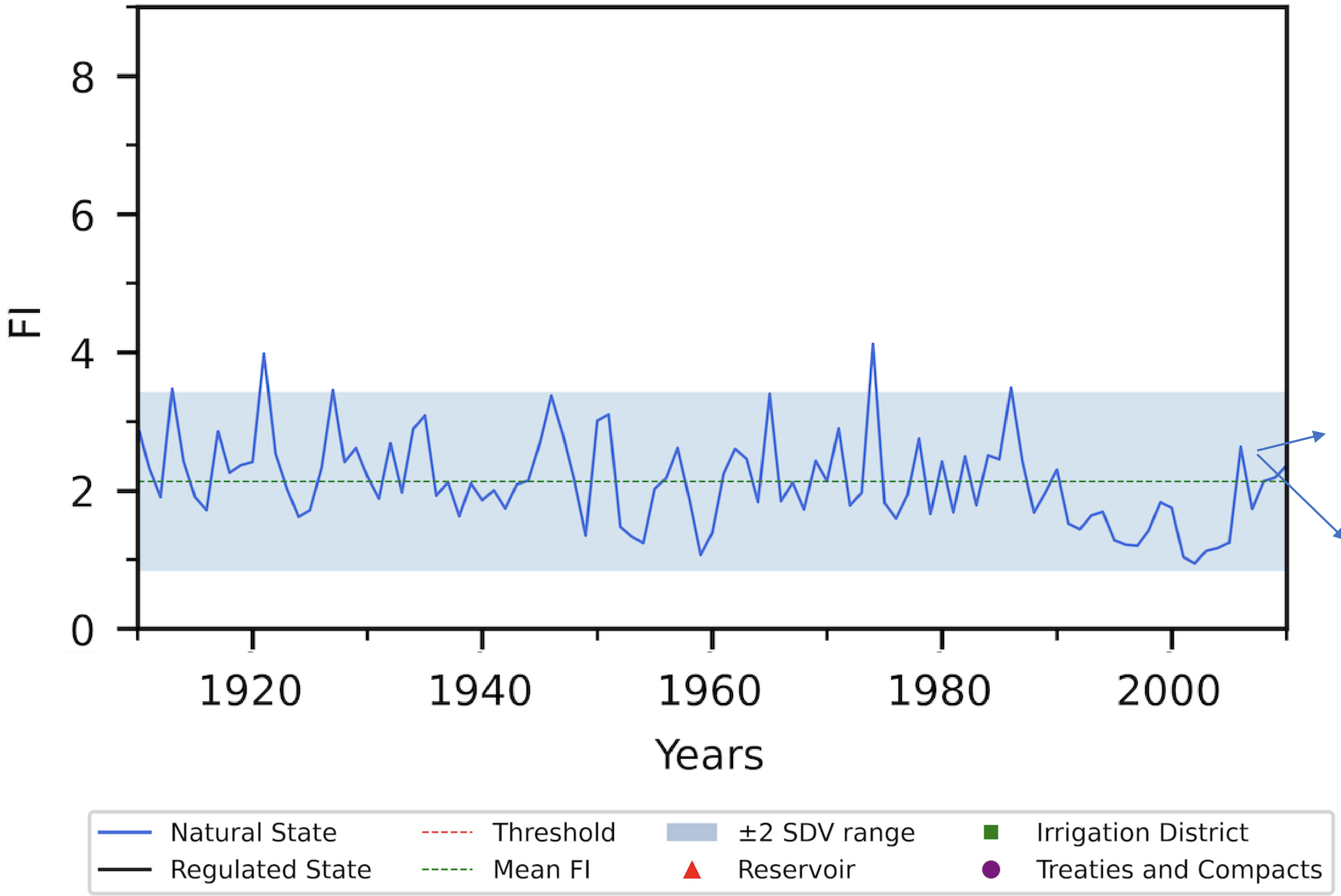
Regime Shift Analysis



Regime Shift Analysis

Sustainable Regime Hypothesis

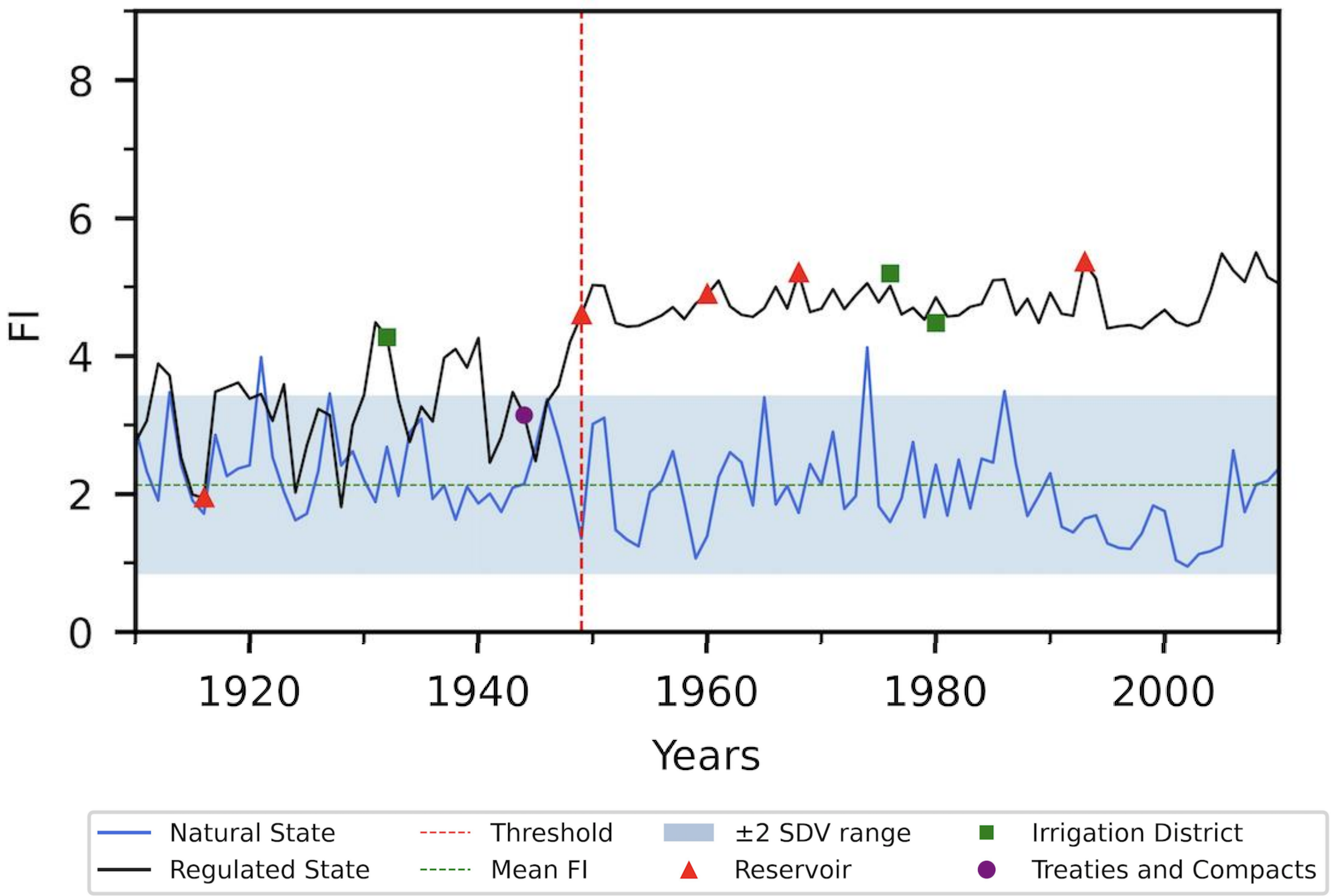
(2) A steady decrease in FI indicates warning of regime shift



Natural System remains within the +-2SDV range

Mann-Kendall showed a decreasing trend indicates warning of regime shift. (2)

Regime Shift Analysis



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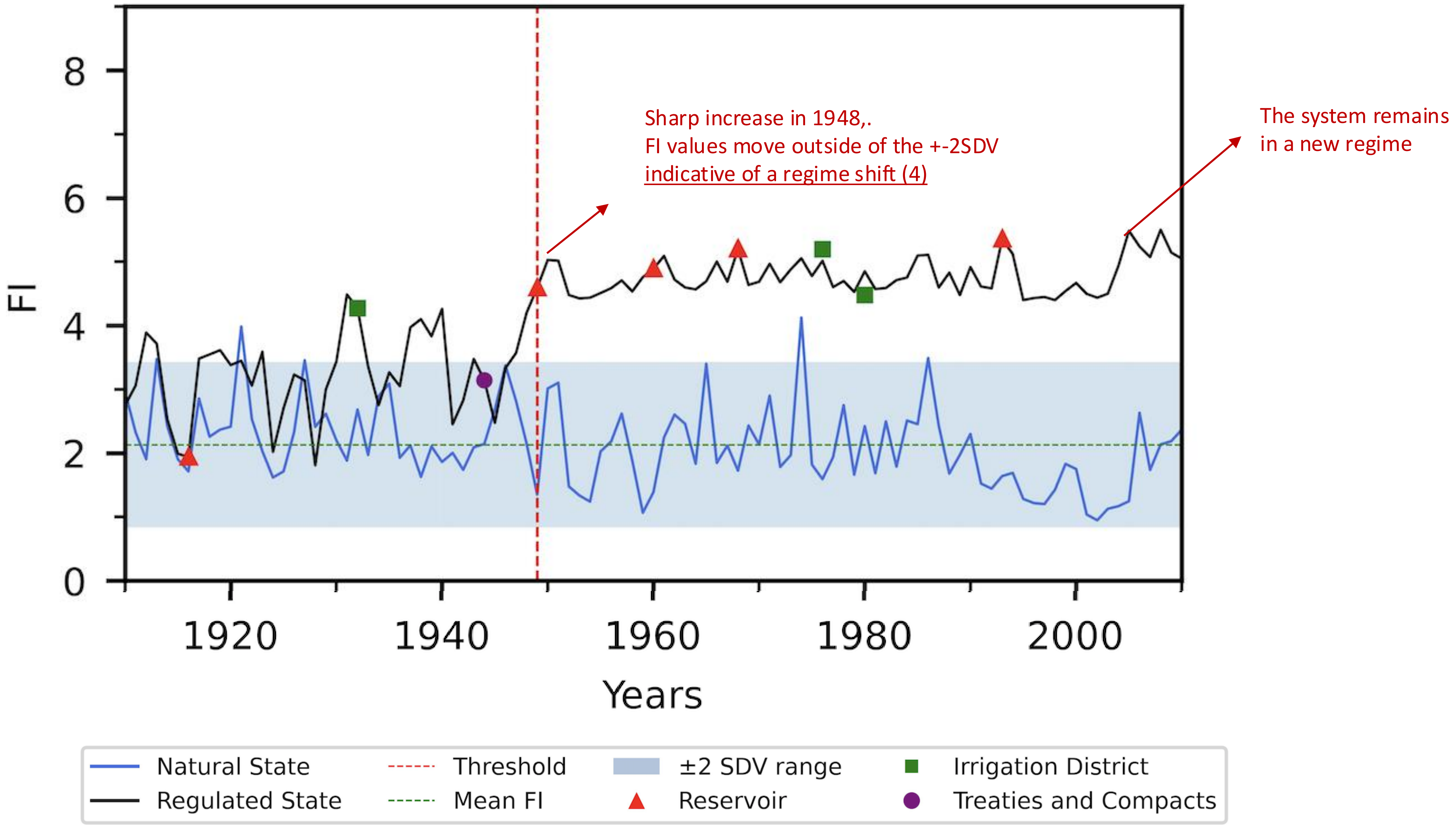

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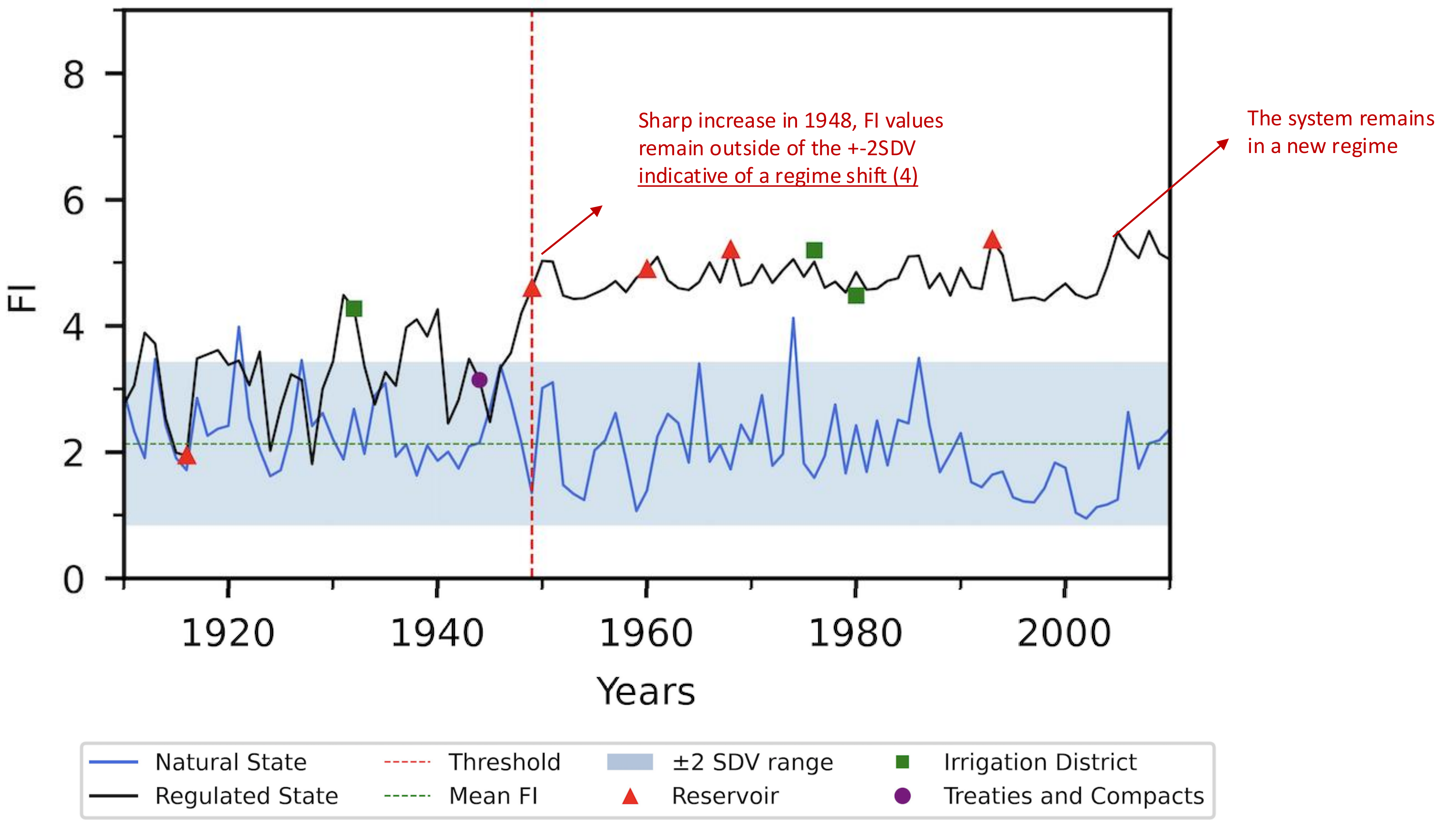
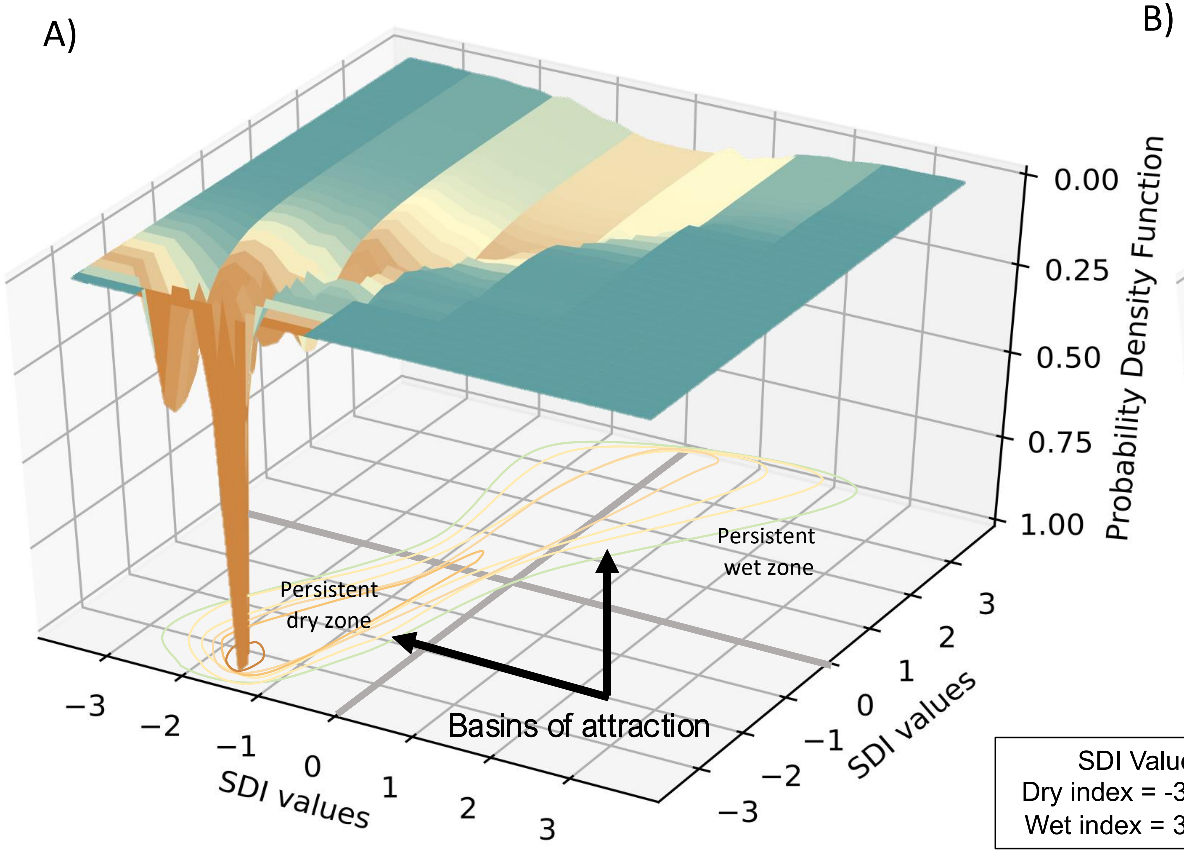
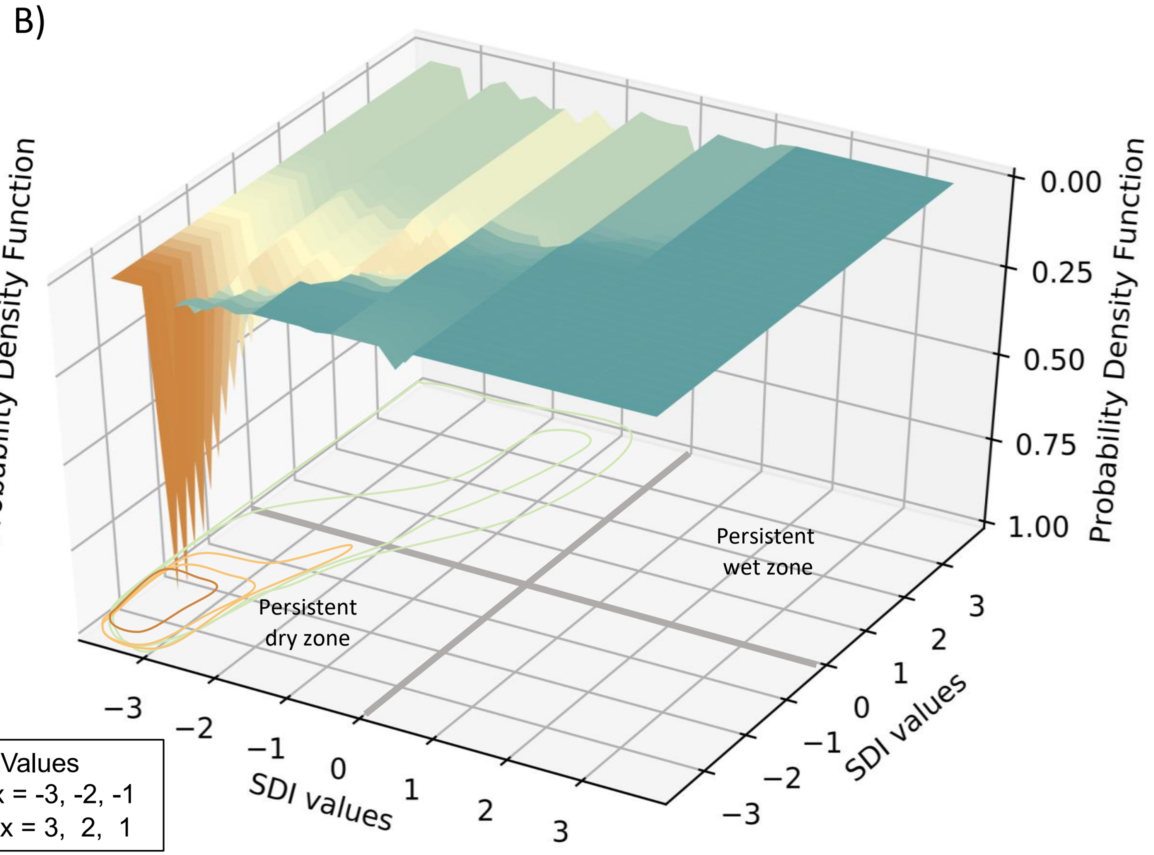


Changes in Stability Landscape



Naturalized System

SDI Values
Dry index = -3, -2, -1
Wet index = 3, 2, 1



Regulated System

Conclusion

A resilient river basin system can cope with shocks and perturbations until its sustainable carrying capacity allows it.

1) A regime shift occurred in the Rio Conchos Basin by 1948.
2) Four perturbations are identified as the causes of a regime shift:
3) Changes in resilience and are visible using stability landscapes

Closing knowledge gaps

Ecological resilience assessments have long remained mostly conceptual in hydrology; thus, there is a need to use quantitative methods for estimating resilience and understand the effects of rapid global change river basins

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UC DAVIS WATER MANAGEMENT LAB

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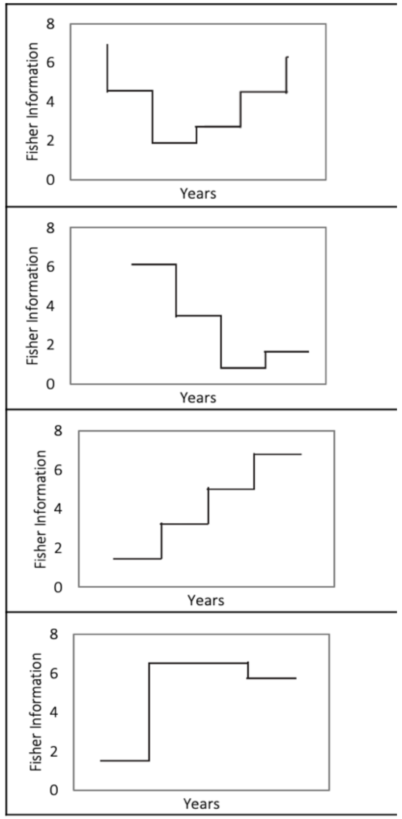
USGS science for a changing world

How do we determine a regime shifts?

Sustainable Regime Hypothesis (Cabezas and Fath, 2002)



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