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The i-CONN project has received funding from the European Union's Horizon 2020 research and innovation programme under the Maria Skłodowska-Curie grant agreement No 859937.

The Role of Connectivity in Driving Grassland-Shrubland Regime Shifts

Impacts of Aridity, Grazing and Wind Dynamics

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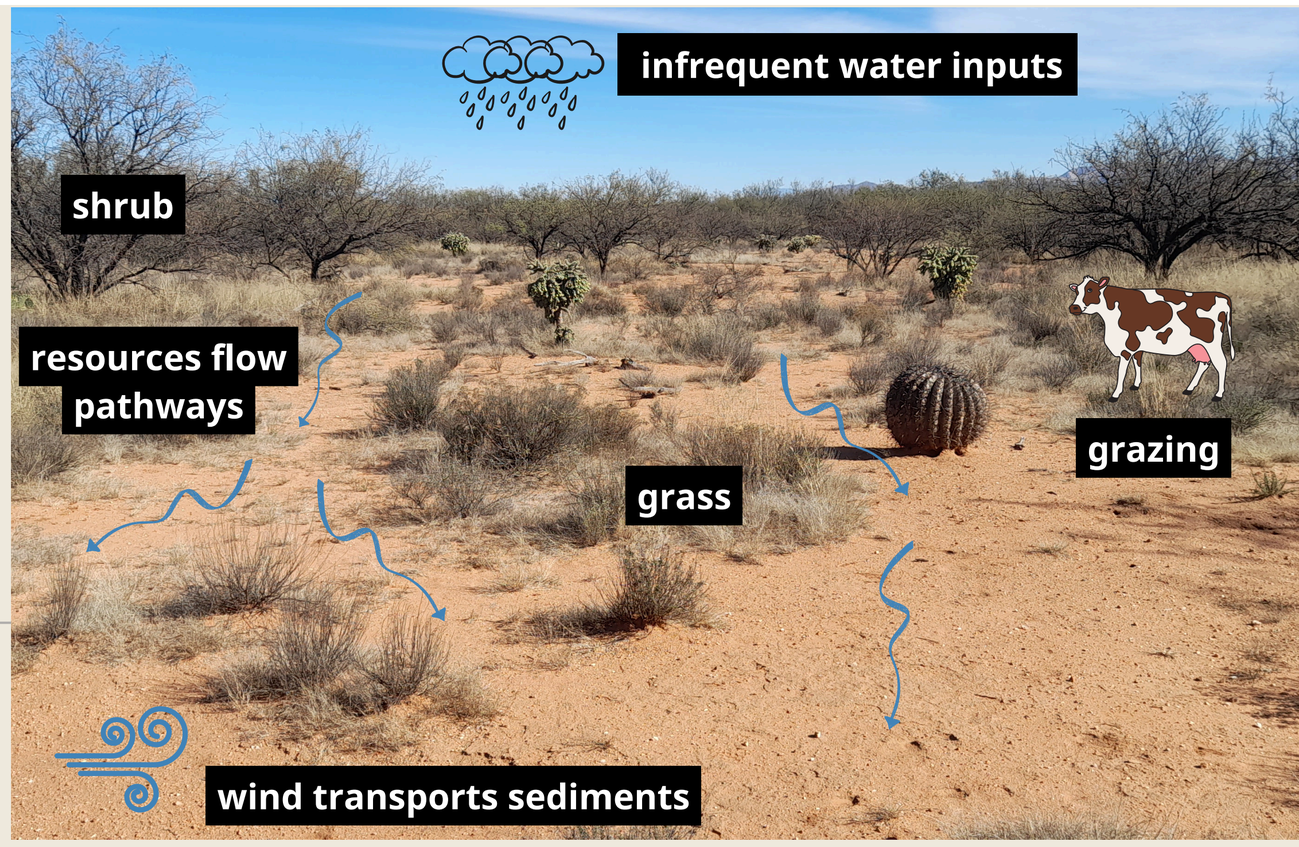
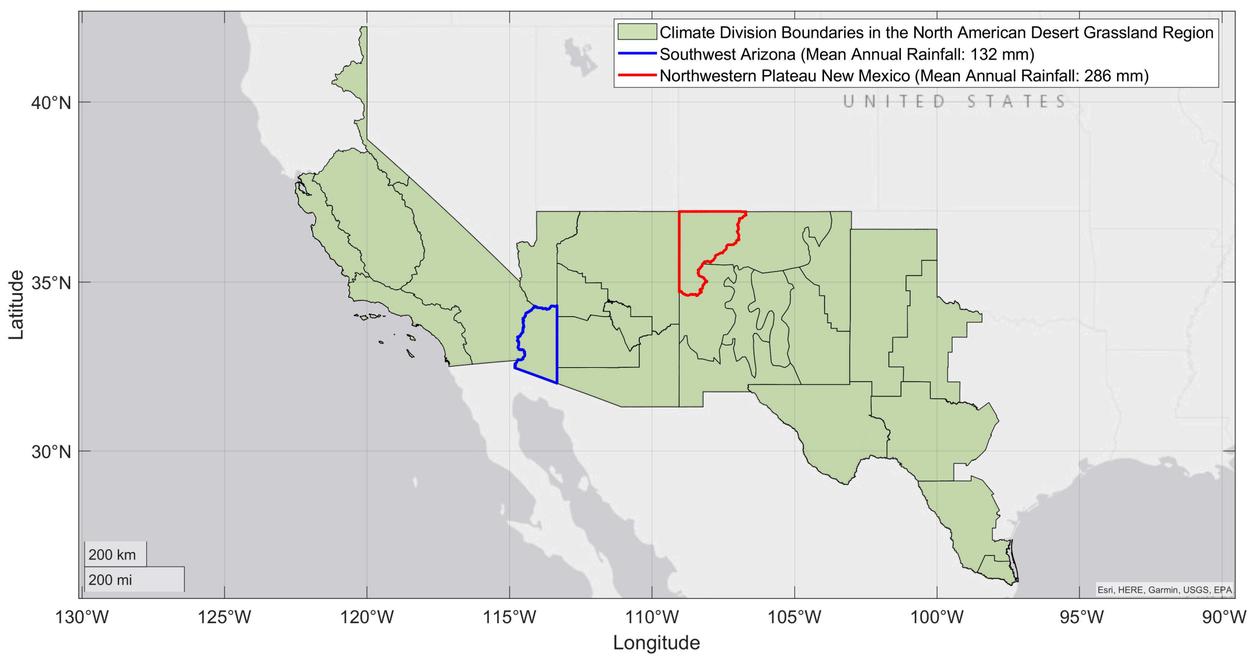
1. Background & Research Questions

Grasslands are increasingly **transitioning to shrublands** due to factors like drought and overgrazing, impacting ecosystem health. This study examines how **connectivity—physical and functional links** between landscape components—drives these shifts in drylands.

1. How do different levels of aridity and grazing intensity affect vegetation and resource distribution in drylands?
2. How do different wind patterns influence soil erosion and resource movement?
3. What early indicators can signal potential regime shifts from grasslands to shrublands?





2.Study Area and Methodology

The research focuses on the **southwestern United States,** particularly the Chihuahuan Desert region. Historically, this area has seen transitions between grassland and shrubland states due to climate variability, intense grazing, and drought. We present two representative climatic zones:

- Dry (Southwest Arizona, 132 mm mean annual precipitation)
- Wet (Northwester Plateau New Mexico, 287 mm)

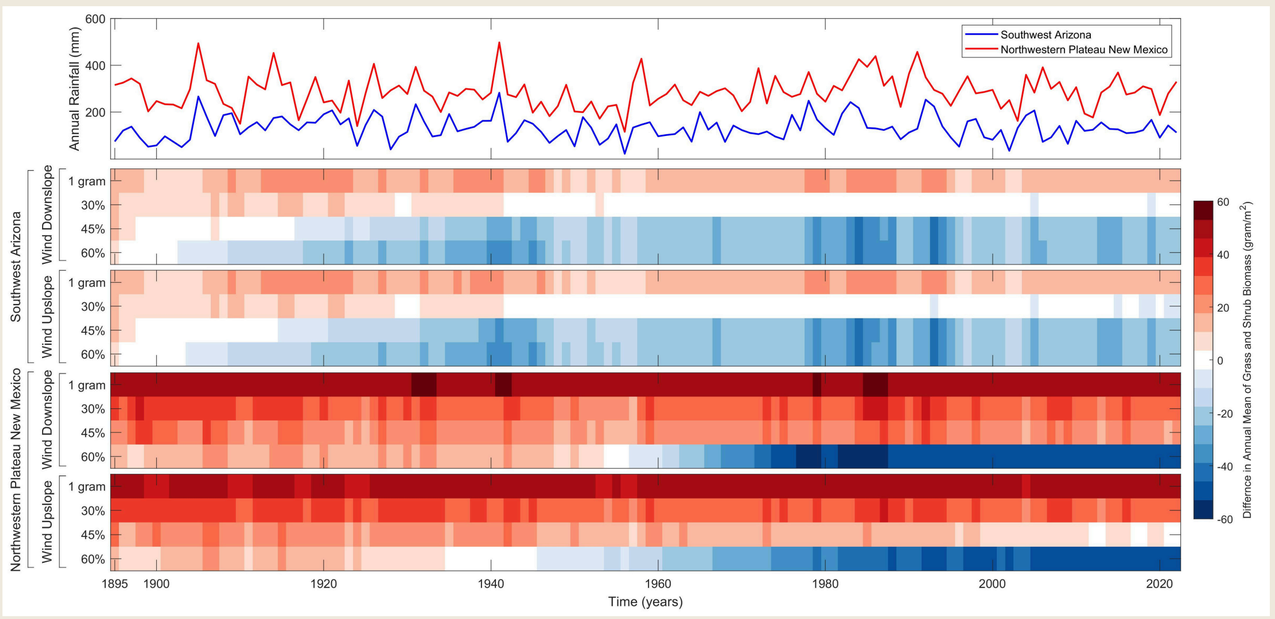
Numerical Modelling

A validated ecogeomorphic model simulates vegetation dynamics under varying aridity, grazing, and wind conditions. The model uses annual time steps to analyze changes in vegetation and resource distribution across 100 m × 100 m grid plots.

Network Analysis

We use Global Efficiency as the primary network metric to quantify how changes in connectivity of water affect ecosystem resilience. This metric measures the efficiency of resource movement across the landscape.

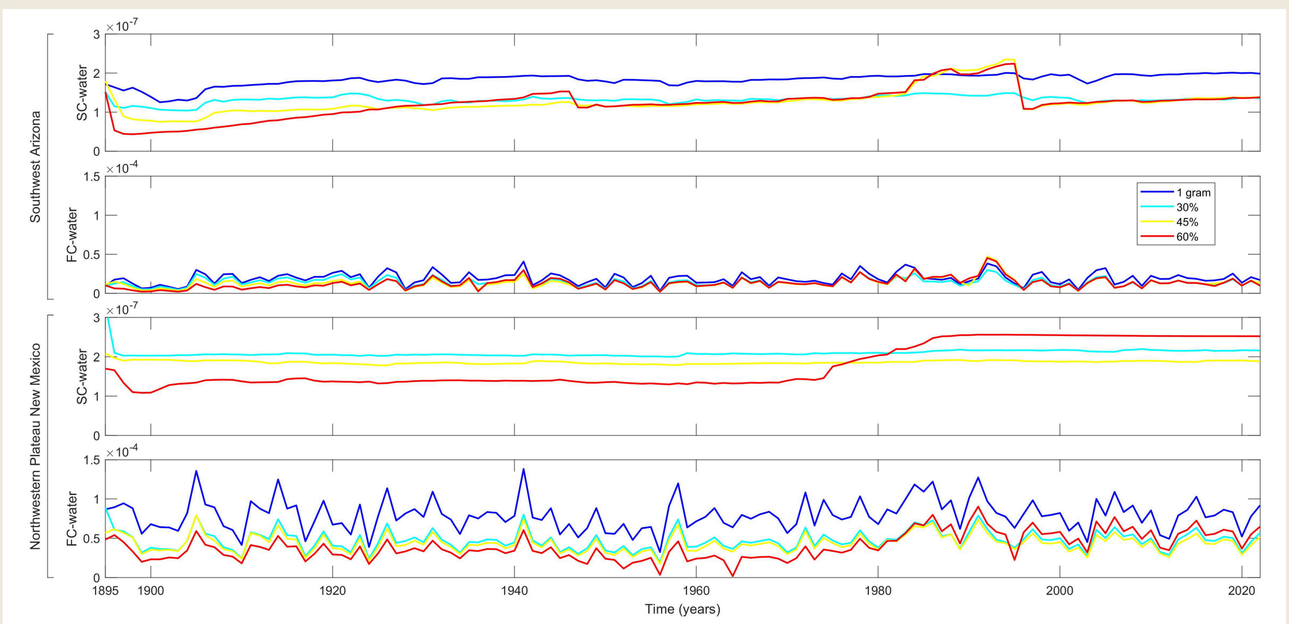
3. Results

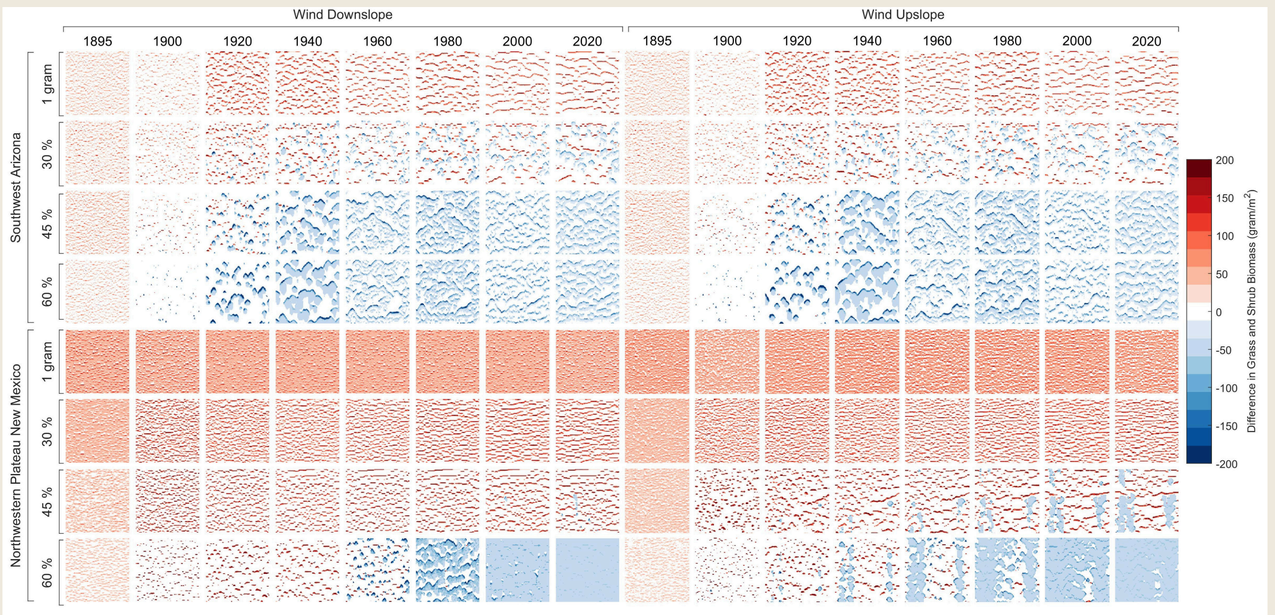


Grass and Shrub Biomass

- **Southwest Arizona (Dry Conditions):** Grass and shrub biomass coexist with a grazing rate of 30%. Shrub dominance occurs at 45% grazing, with minimal influence from wind direction.
- **Northwestern Plateau New Mexico (Wetter Conditions):** Grasses remain dominant up to a 45% grazing rate, with shrub dominance emerging at 60%. Additionally, upslope winds accelerate shrub dominance under wetter conditions.

Global Efficiency for Structural and Function Connectivity of Water





- **SC-Water:** Global Efficiency (GE) values are less affected by annual rainfall, increasing with shrub invasion but decreasing when shrubs stabilize.
- **FC-Water:** GE values are highly sensitive to annual water input, showing a sharp increase just before grass-shrub regime shifts occur.

4. Conclusion

- Connectivity dynamics significantly influence the transition from grasslands to shrublands, with both aridity and grazing intensity playing critical roles.
- Monitoring global efficiency in water connectivity can provide early warning signals for impending regime shifts, aiding in proactive land management strategies.