Human fire use stabilises forest-savannah boundaries, but only where climate allows

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Detecting the anthropogenic hand: A modelling approach to test fire management legacies in forest-savannah systems

Forest-savannah boundaries exist across vast regions of Africa, South America and Australia where climate alone cannot explain what we see. Alternative stable states theory tells us internal dynamics matter, but one of the most pervasive internal forcings, millennia of human fire use, has been consistently overlooked. We built a spatial simulation model to quantify its role across climatic contexts.

A landscape shaped by more than climate

Sharp forest-savannah boundaries persist across a broad climatic zone where both states are theoretically possible. Existing models driven by climate and stochastic fire dynamics reproduce this variability but leave a systematic human signal unaccounted for, with consequences for conservation and land management. Across Africa, South America and Australia, people have been burning these landscapes for tens to hundreds of thousands of years.

Adding people to the model

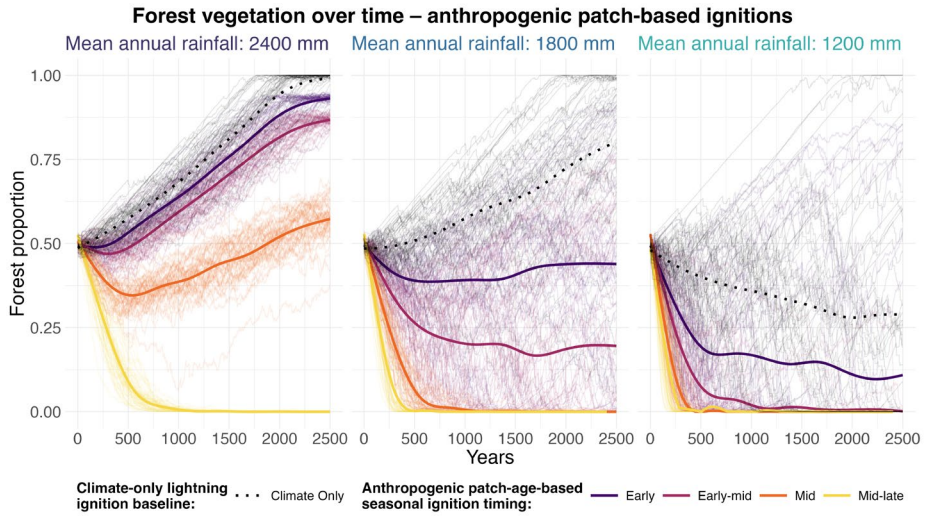
We introduced patch-age-based burning into a spatially explicit fire-vegetation model that captures landscape-scale patch dynamics. In this, people observe the landscape and burn patches that have grown old enough, constrained by realistic energy limitations. We modelled outcomes in three climatic contexts and for four anthropogenic seasonal burning timings across 50 stochastic realisations each. Comparisons were made against climate-only (no people, otherwise equivalent) baseline model runs.

A stabilising effect, climate dependent

Human burning can shift the system toward partly stable mixed states, but the effect varies with climate, and in turn with the timing of seasonal burning. In wetter scenarios, the potential for co-occurrence emerges amidst an otherwise forest-dominant context. In moderate climates, some stability is possible with certain ignition timings, but too severe, and/or too much fire serves only to hasten forest loss.

History is written in the landscape

Stochastic variability across realisations reveals that contingency matters – identical parameterisations can produce divergent outcomes. Human fire use can be a critical part of that contingency, as well as partly reduce its effect, expanding the climatic range over which stable mixed states can persist. Modern forest-savannah boundaries may be as much a legacy of millennia-long human fire and land management as of climate.



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