Mechanisms of Shrub Encroachment explored in Southwestern United States using Landlab Ecohydrology

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INTRODUCTION

- Semiarid and desert grasslands have changed dramatically over last 150 years due to woody plant encroachment

- Shrub encroachment is considered as a major form of desertification

- It is driven by overgrazing, reduced fire frequency, and climate change

- In Landlab, we represent ecohydrologic plant dynamics, fires, grazing, and resource distribution (simple erosion/deposition) in separate components

- In this work, we demonstrate their utility for studying shrub encroachment

- a simple stochastic cellular automata model with two state variables, vegetation cover and soil resource storage, is used to model shrub patterns based on probabilistic establishment-mortality interplay , mediated by resource redistribution

LANDLAB: PHYSICAL ECOHYDROLOGY MODEL
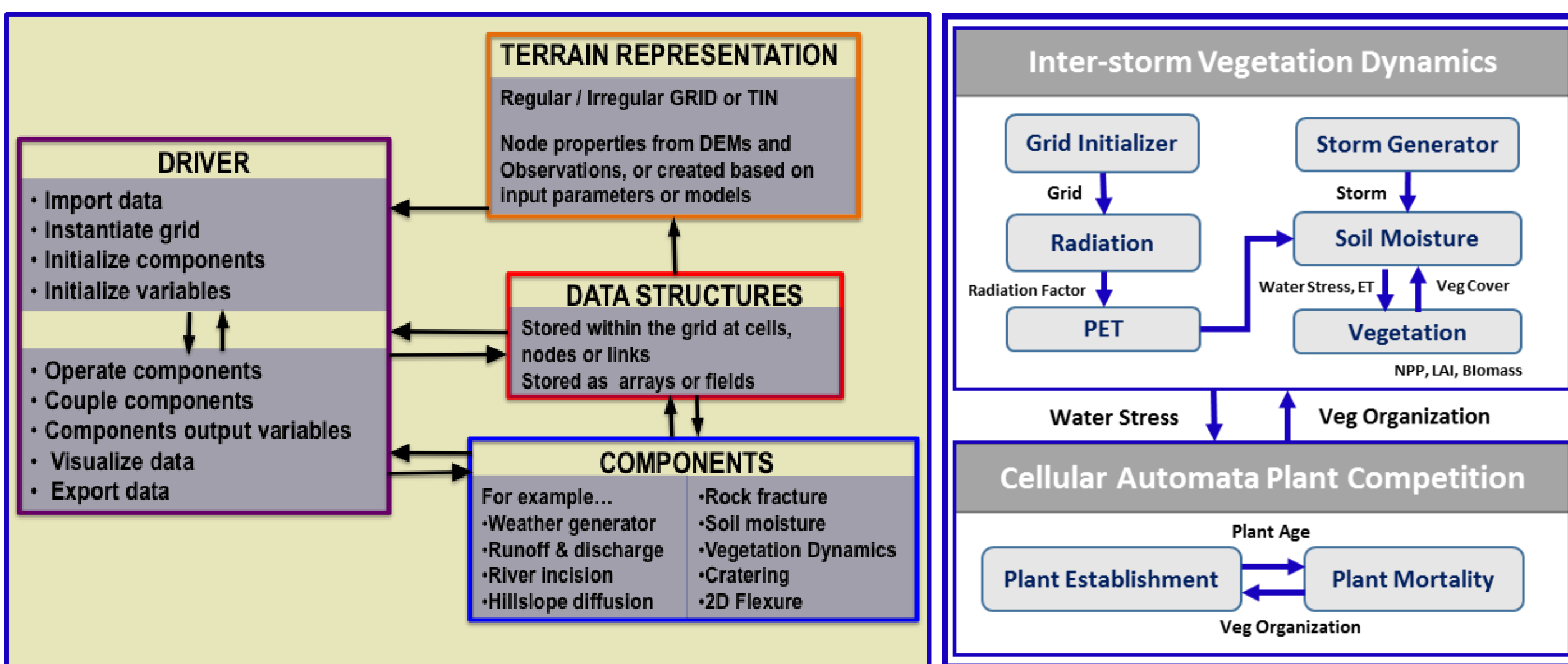
CELLULAR AUTOMATON: TWO STATE VARIABLES
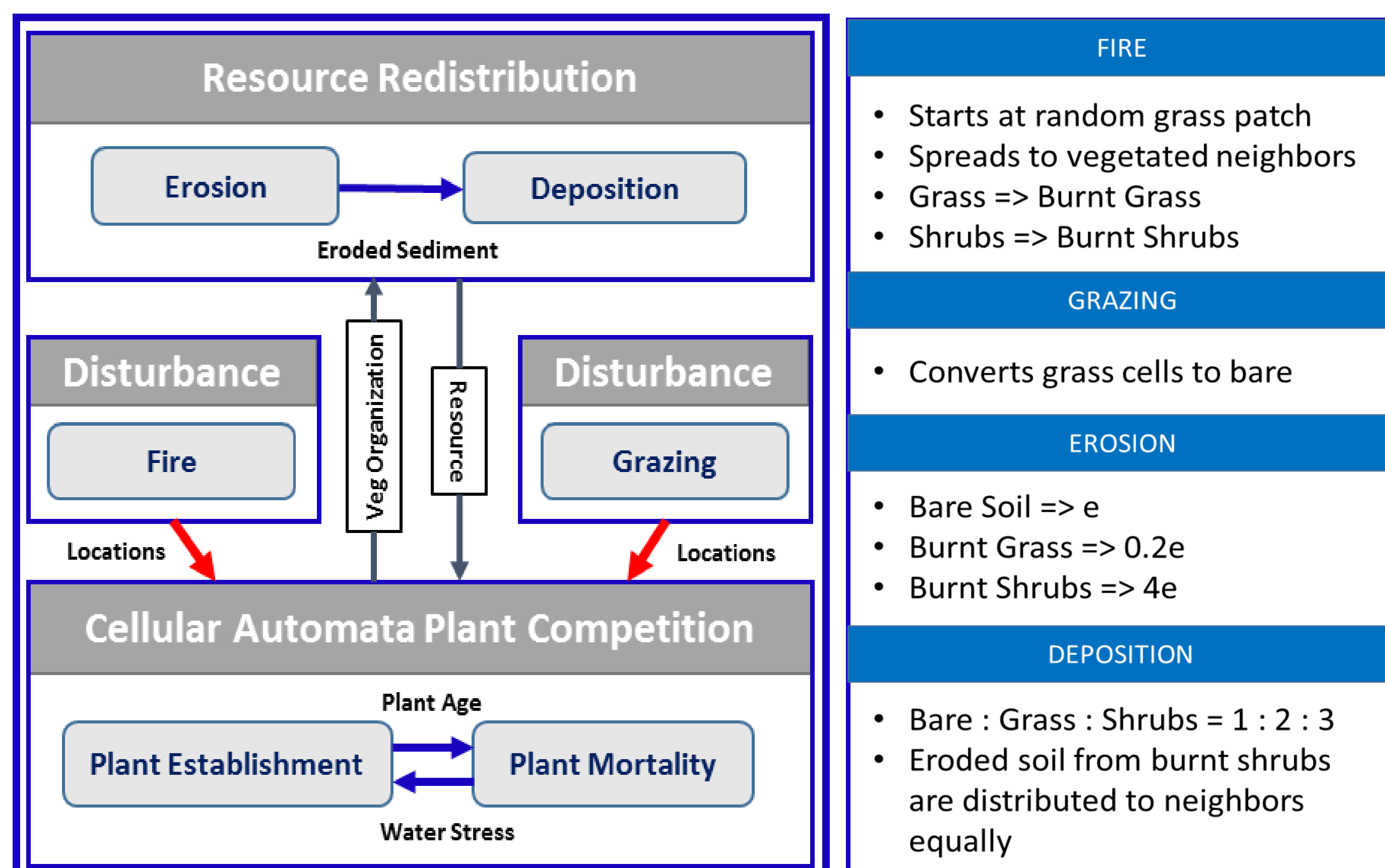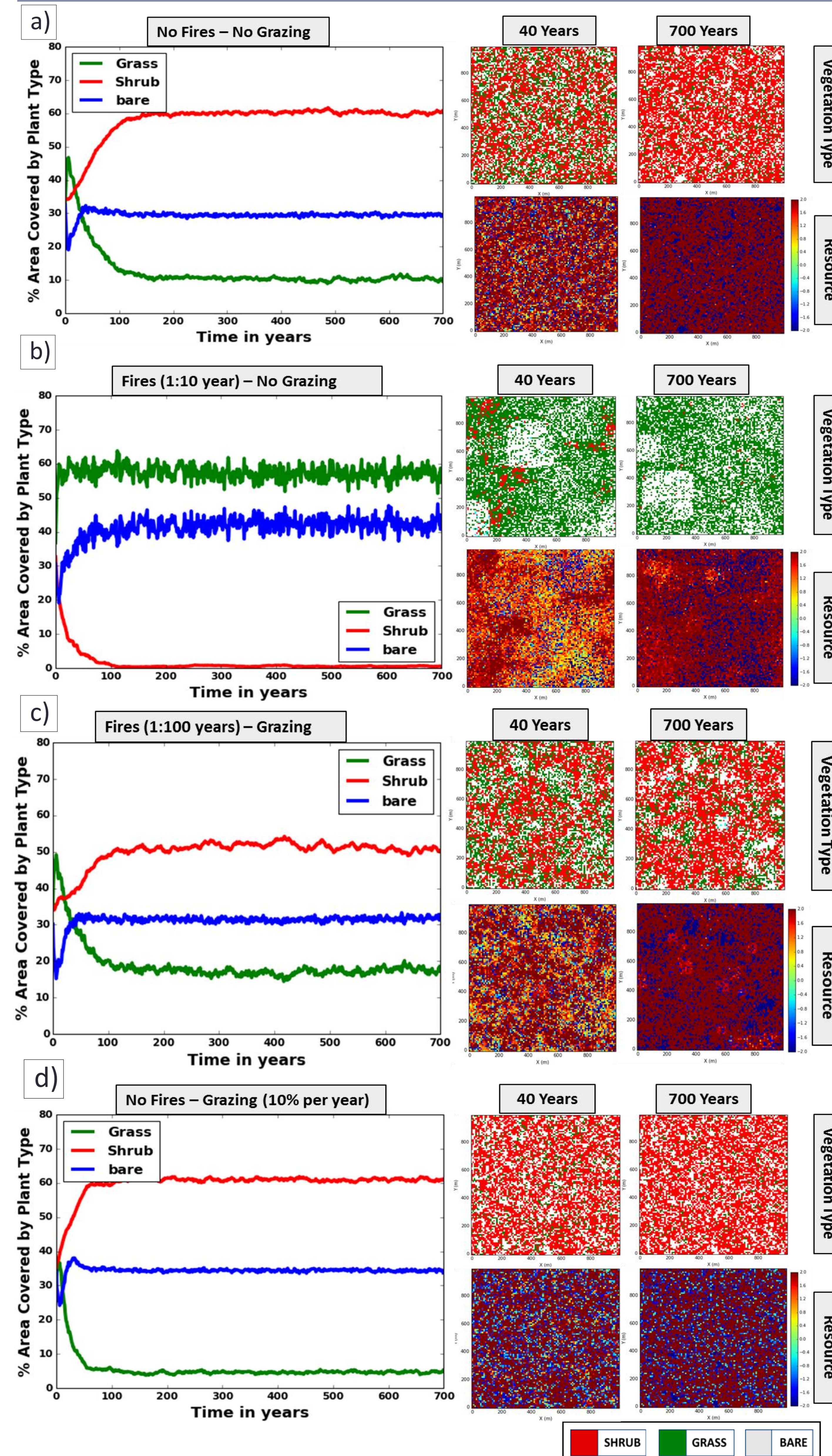

CELLULAR AUTOMATON: CALIBRATION

Fig. 1: a) plot 1 and map 1: no fires , no grazing - base line for sensitivity analysis, b) plot 2 and map 2:natural fire (1/10) regime and no grazing - pre-Euroamerican settlement, c) plot 3 and map 3:fires (1/100) and grazing - post Euroamerican settlements , d) plot 4 and map 4:no fires and grazing - sensitivity to fires

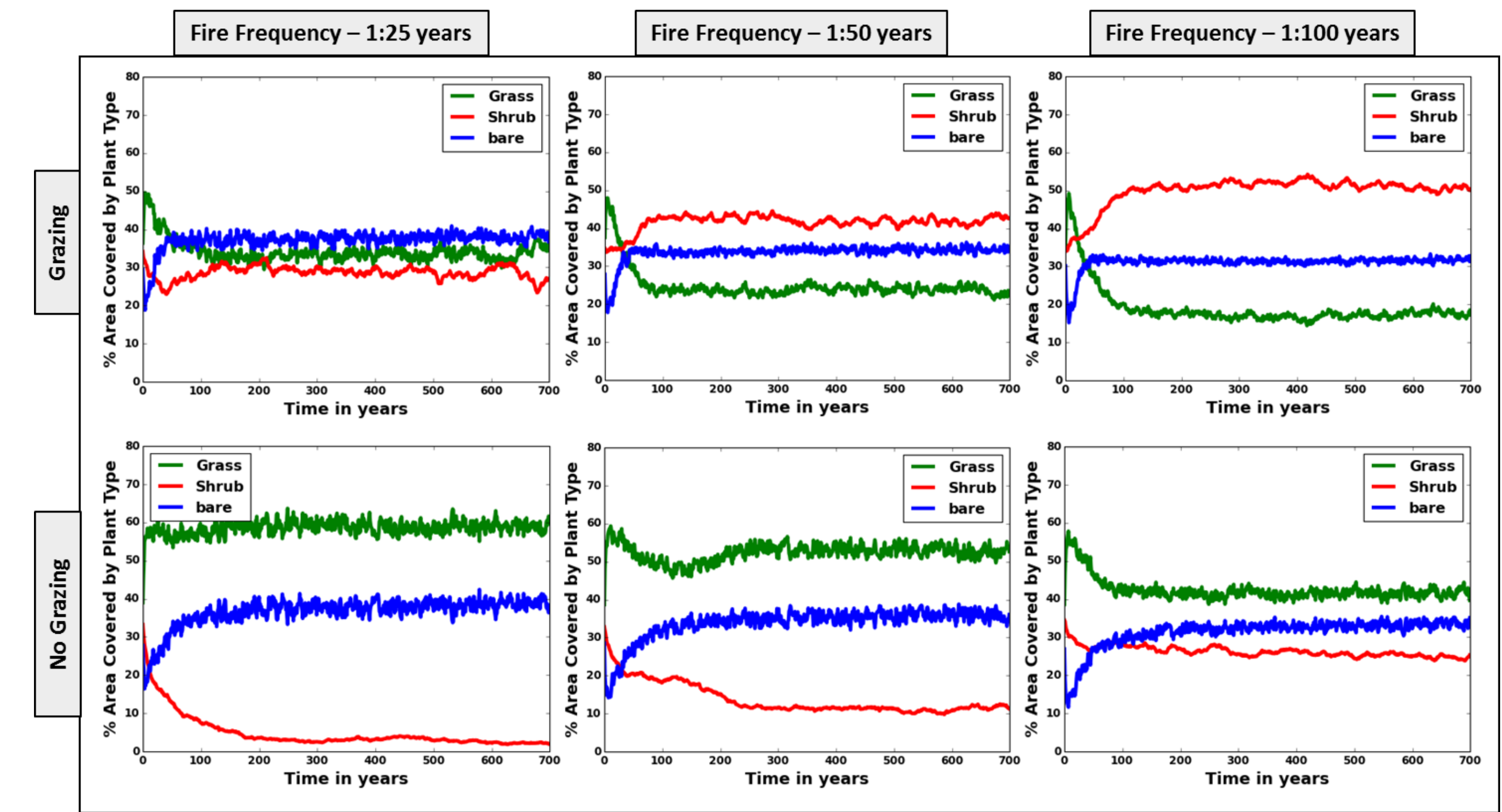## INFLUENCE OF FIRE FREQUENCY AND GRAZING

Fig. 2: Sensitivity of the system to fires and grazing
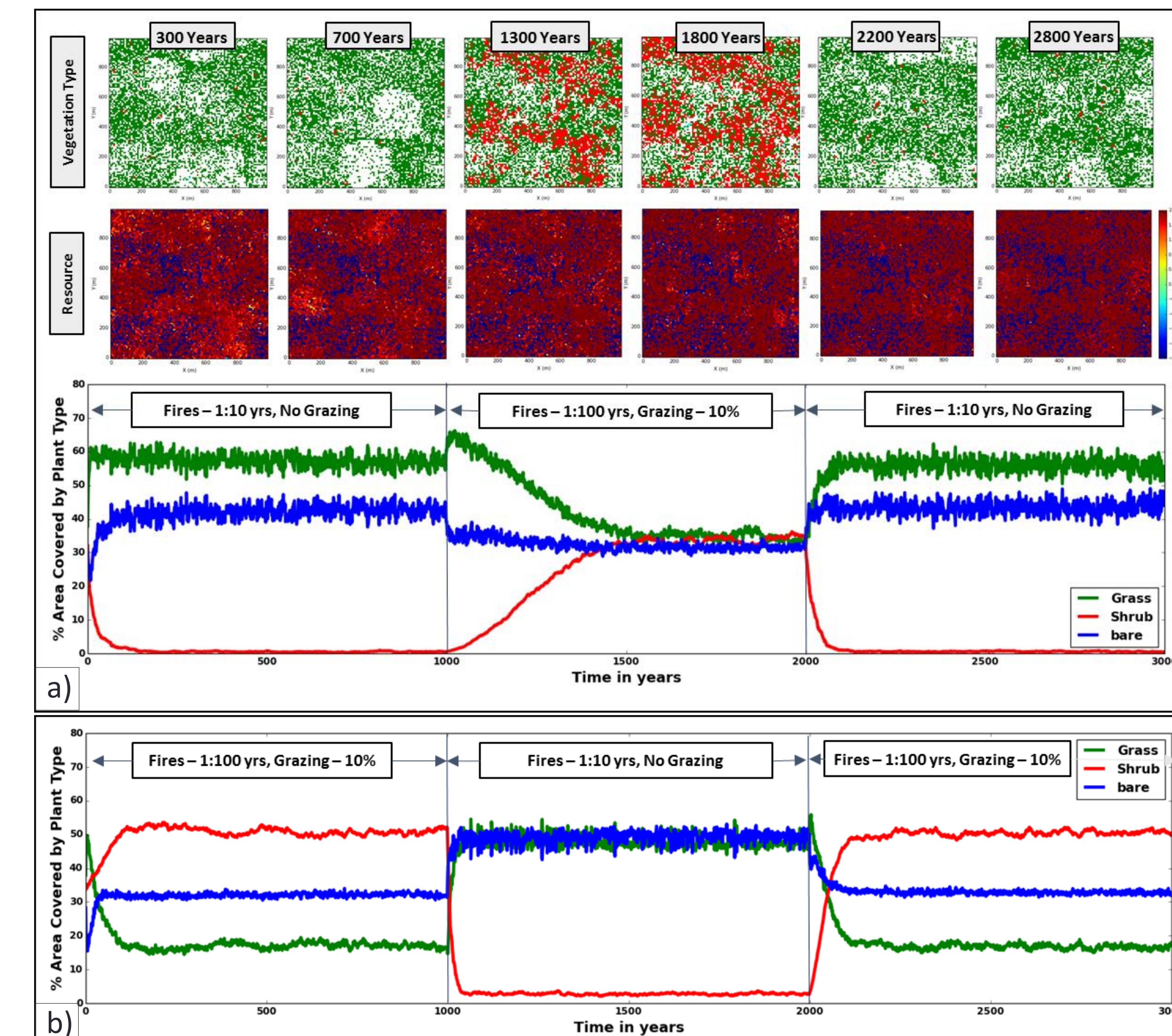
SYSTEM RESPONSE TO CHANGE IN ENVIRONMENT

Fig. 3: a) Scenario with natural fire regime followed by post-Euroamerican settlement fire regime followed by natural fire regime, b) Post-Euroamerican settlement fire regime followed by natural fire regime followed by post-Euroamerican regime

CSDMS Annual Meeting 2016

References: 1. Ravi, Sujith, and Paolo D'Odorico. "Post-fire resource redistribution and fertility island dynamics in shrub encroached desert grasslands: a modeling approach." "Landscape Ecology 24.3 (2009): 325-335.
2. Zhou, Xiaochi, Erkan Istanbulluoglu, and Enrique R. Vivoni. "Modeling the ecohydrological role of aspect-controlled radiation on tree-grass-shrub coexistence in a semiarid climate." Water Resources Research 49, no. 5 (2013): 2872-2895.