# Studying the Role of Disturbances on Woody Plant Encroachment in Southwestern US using a Coupled Landlab Ecohydrology Model

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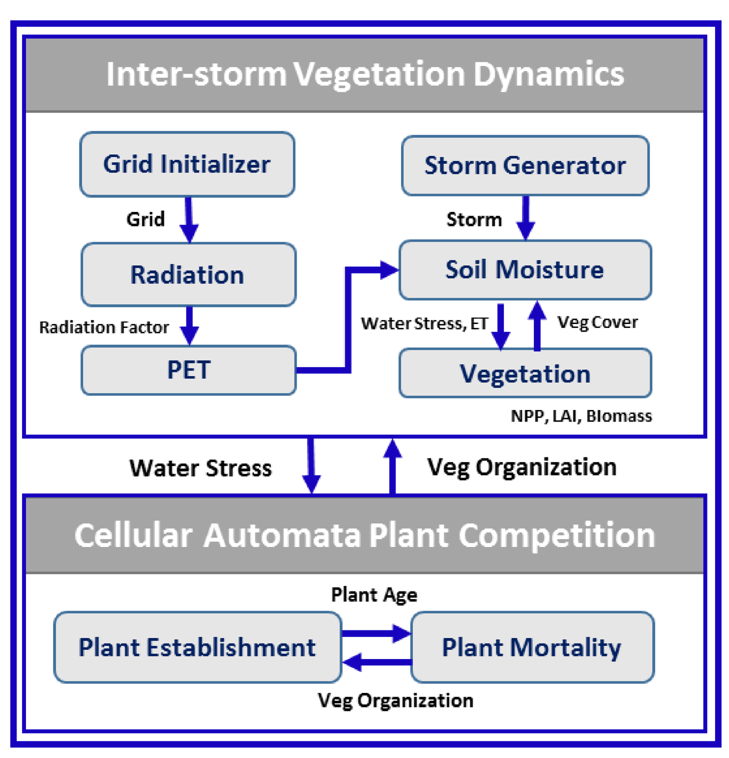
## Objective:

- Woody Plant Encroachment (WPE), an increase in density, cover and biomass of trees or shrubs in native grasslands, has dramatically altered arid and semiarid grasslands of southwestern US over the last 150 years
- Overgrazing, reduced fire frequency, and climate change drive WPE
- WPE is considered as a major form of desertification
- In Landlab, ecohydrologic plant dynamics, wildland fires, grazing, and resource distribution (erosion/deposition) are represented in separate components
- Landlab has two existing cellular automata Ecohydrology models, built using these components, to study the impacts of WPE on the evolution of vegetation patterns
  (i) Physical Ecohydrology Model (ii) Two State Variable Cellular Automata (CA) Model
- In this work, we coupled these two models to investigate the role of disturbance (fire) in a climate driven dynamic ecohydrologic context

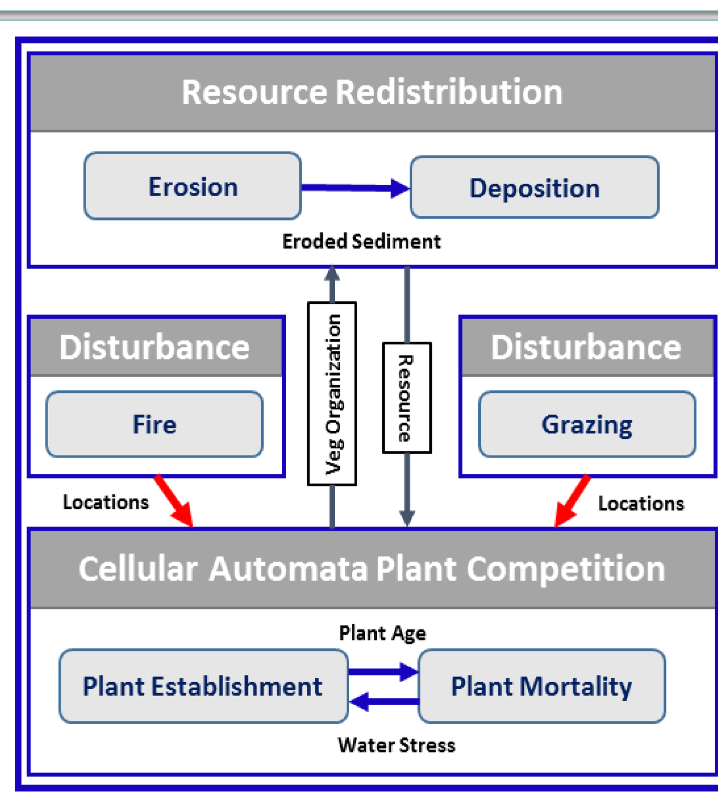
## Physical Ecohydrology Model:

In this model, physically based vegetation dynamics model is used to simulate biomass production based on potential evapotranspiration and local soil moisture driven by daily simulated weather, coupled with a cellular automata plant establishment and mortality rules. Spatial dynamics of disturbance propagation (e.g., fire spread and intensity) is not explicitly modeled.



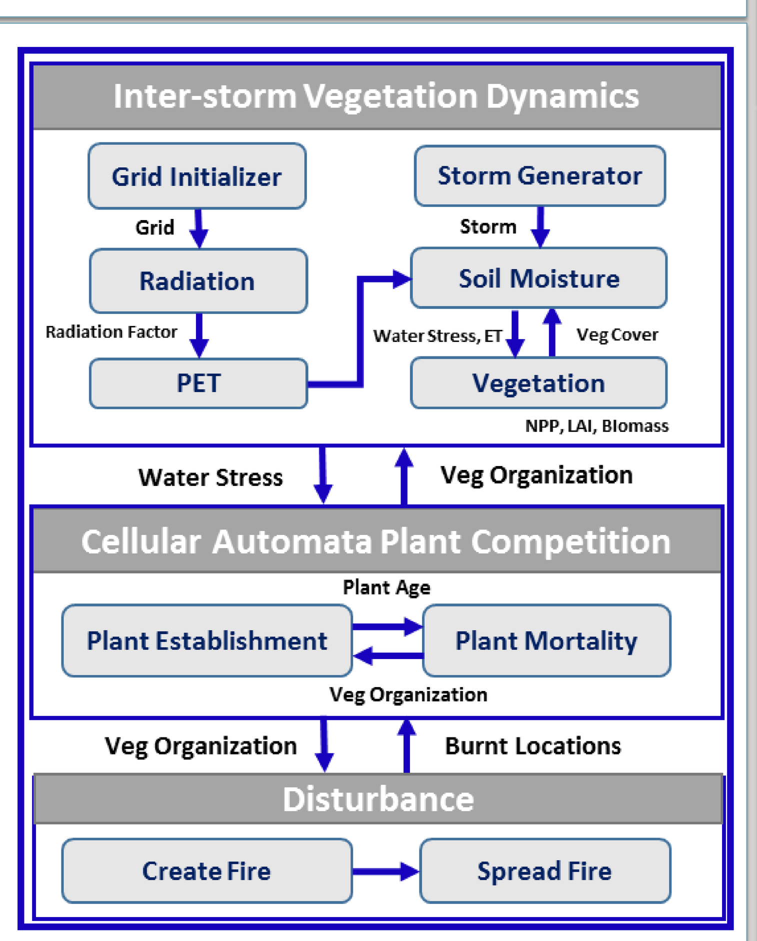

## Two State Variable CA Model:

In this model, a simple stochastic cellular automata model with two state variables, vegetation cover and soil resource storage, are used to model resultant vegetation patterns based on probabilistic establishment-mortality interplay, mediated by post-disturbance resource redistribution, while explicit roles of climate are neglected.




## Coupled Ecohydrology Model:

In this coupled model, daily- weather driven physically based vegetation dynamics model simulates biomass production based on local soil moisture and potential evapotranspiration. Disturbance, i.e. spatial fire dynamics model, initiates fire at random location occupied by grass and spreads to vegetated neighbors limited by specified fire size. Cellular automata plant establishment and mortality model further re-organizes the vegetation.




## Study Area – Sevilleta National Wildlife Refuge (SNWR):

The catchment used in this study is located in SNWR, Socorro county, New Mexico. The mean annual precipitation (MAP) is ~ 250 mm. This catchment is characterized by distinct vegetation patterns. Flat landscapes and south facing slopes are dominated by shrubs (creosotebush). Trees (Juniper) and grass (black grama) co-exist on North facing slopes.

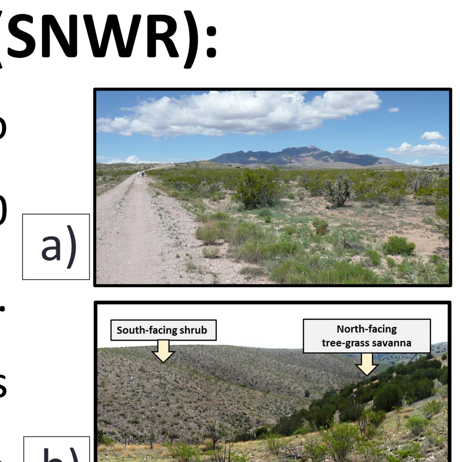



**Fig 1: a)** flat landscape near study site; **b)** study site

## Application on Flat Topography: Influence of Fire Return Period

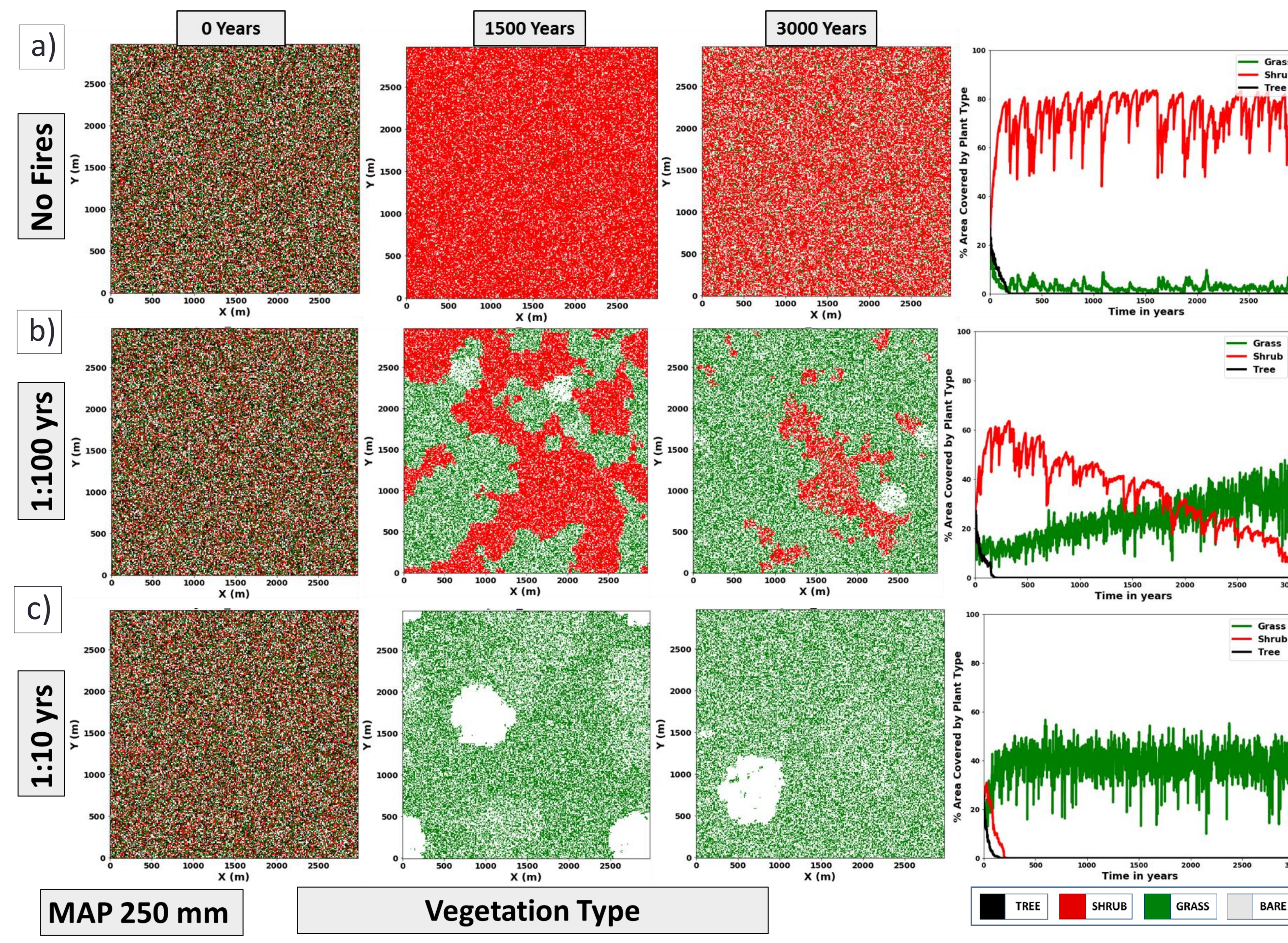



**Fig 2: a)** plot 1 and map 1: no fires – baseline for sensitivity analysis; **b)** plot 2 and map 2: fires (1/100 yrs) – post European settlements; **c)** plot 3 and map 3: fires (1/10 yrs) – natural fire regime

## Application on Flat Topography: Sensitivity to Precipitation

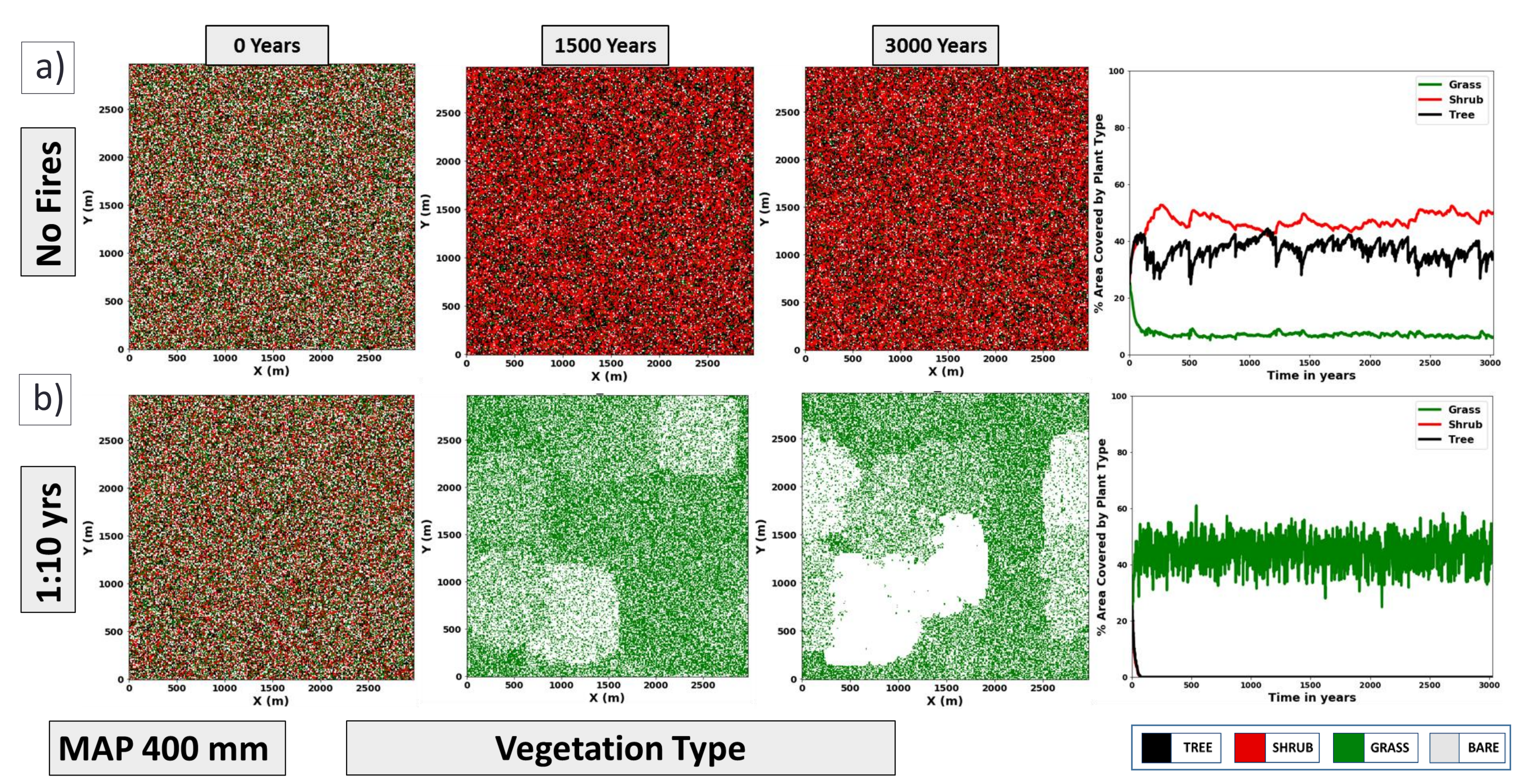



**Fig 3: MAP 400 a)** plot 1 and map 1: no fires; **b)** plot 2 and map 2: fires (1/10 yrs)

## Application on Actual Topography: Influence of fires and runon

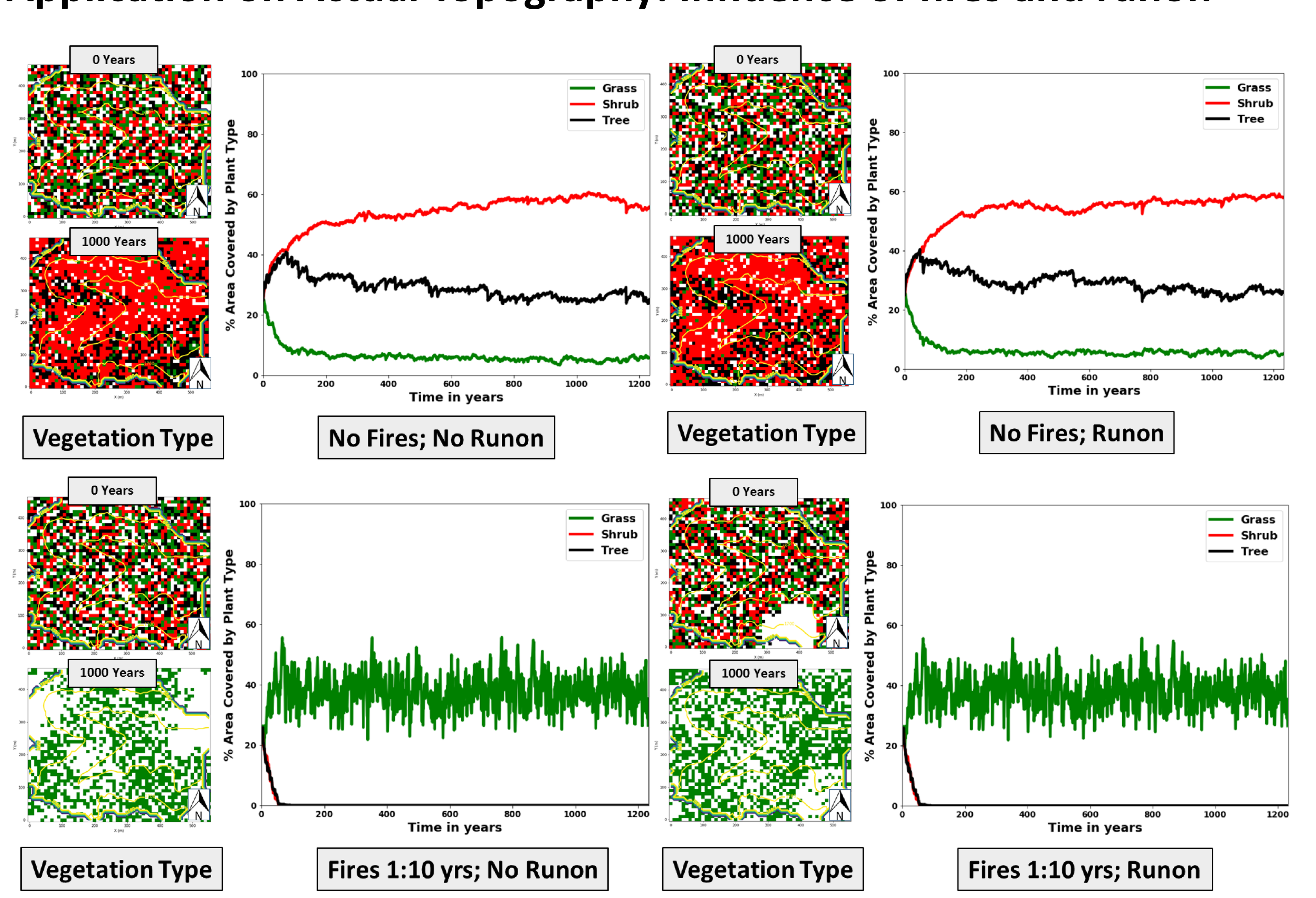



**Fig 4:** Sensitivity to fires and runon on actual landscape (Fig 1b)