

Project Topic: Q

Modeling Forest Fire Dynamics

Forest fires are a striking example of how local interactions can lead to large-scale, often unpredictable outcomes. A single spark may die out quickly or, under the right conditions, ignite a large region. The spread of fire depends on many factors, such as forest density, landscape structure, weather conditions, and human intervention. Despite its apparent simplicity, this system displays rich and complex behavior, including threshold effects, self-organized criticality, and chaotic spreading patterns. Understanding the mechanisms behind these processes can help us explore strategies to prevent or contain wildfires and to protect valuable areas such as cities or infrastructure.

In this project, you will simulate and analyze forest fire dynamics using computational models. You may start from a simple model where burning trees can ignite nearby ones, for instance using a grid-based representation of the forest, but you are also free to explore alternative ways of representing the forest and the fire-spread process. From this starting point, you can extend the system in several ways to make it more realistic. Possible directions include adding stochasticity to the spreading probability, introducing spatial heterogeneity such as terrain slope, and incorporating external factors like wind speed and direction. You may also explore the effect of fire management strategies, such as introducing firebreaks of different shapes, implementing firefighting actions (e.g., extinguishing a limited number of burning sites per time step), or introducing a delay before the firefighting actions can start. Further extensions could include prioritizing the protection of certain regions, such as urban areas. Research questions could involve identifying conditions that lead to large fires, testing which prevention strategies are most effective, or analyzing how landscape structure influences the size and frequency of burn events.

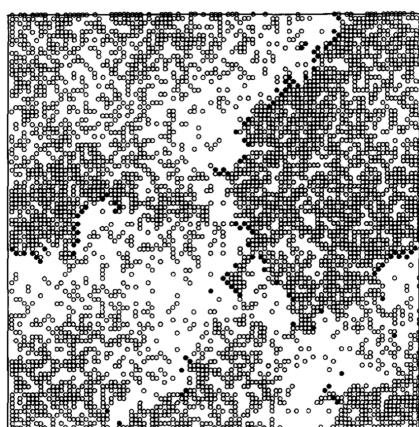


Fig.1 Snapshot of forest fire in a 100x100 grid system. Empty

circles: Live trees; black circles: burning trees.

Image source: Bak P, Chen K and Tang C. *A forest-fire model and some thoughts on turbulence*, Phys. Rev. A 147 (1990)

Reference: Tonini, M.; D'Andrea, M.; Biondi, G.; Degli Esposti, S.; Trucchia, A.; Fiorucci, P. A Machine Learning-Based Approach for Wildfire Susceptibility Mapping. The Case Study of the Liguria Region in Italy. *Geosciences* **2020**, *10*, 105.

<https://doi.org/10.3390/geosciences10030105>