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**Background of our project:** wildfire spread based on flammability distributions

**Disciplines:** Ecology, complex systems, environmental studies

**Which model:** Cellular Automata (Li and Magill, 2000)

**Emergent phenomenon of focus:** Self-organization, Critical point, Percolation, Power law?

**Research Question:** How does the density in plant growth with different flammability distributions influence the critical point of a wildfire spreading during a dry season that follows a moist wet season.

**Hypothesis:**

* The critical density for a forest with fluctuating flammability lies higher than 0.41%
* For initial flammability drawn from a normal distribution, we expect a low amount of fires during the beginning of the model but because the overall flammability increases over time we expect there to be a big outbreak of fires
* For initial flammability drawn from a continuous distribution, we expect there to be constant outbreaks of fires over time.
* For initial flammability drams form a bimodal distribution, we expect there to be big fire in the beginning of the model, but large pieces of the forest will continue to stand until the end of the forest

**Abstract:** Li and Magill (2000) modelled forest fire spread under different environmental influences using a 2-dimensional Cellular Automata (CA). In their work, different variables are taken into account, the most important of which are bush density and flammability. Bush density here refers to the general density in which the 2D CA is filled in, where a density of 59% is the critical value for percolation (41% if diagonal spread is also allowed). Flammability depends on 2 factors: bush flammability and heat conditions. Heat conditions refer to the control variables such as temperature and rainfall. Bush flammability describes the general characteristics of a bush which defines its tendency to catch fire or not. In Zylstra (2011), bush flammability can be further divided in 3 separate categories relating to the intensity, ease of ignition and duration of fire for a certain type of bush. However, this requires detailed knowledge on the types of plants present in an area. Magill and Li simplify this however, by picking a random number between 0 and 100. We want to combine both frameworks by adjusting the probability distribution of bush flammability to allow for different starting assumptions. For example, a higher proportion of trees in the forest (less bush flammability), a higher proportion of shrubbery (more bush flammability), etc. Based on these different CAs we can then examine how the critical density changes.

**Model Assumptions**:

* Grid representing a forest
* Forest density is random and determines how many plants are placed. Its variable (we want to experiment with this variable)
* Bush flammability density (0-100%)
  + Different distributions: Uniform (Li and Magill), Normal, Bimodal, with the same mean and min / max value, meaning that we adjusted the standard deviations for the latter two probability distributions (where bimodal is the sum of two normal).
  + Changes over time per timestep: (X\_(t+1) = ((0.02\*X\_(t)) +1) \* X\_(t)
    - So if X\_(t) = 0.5:

X\_(t+1) = 1.01 \* 0.5 = 0.505

* + If a cell burns it burns for one time step
  + No reincarnation, whats death stays death
* Fires can spread to neighboring cells using the probability as suggested by Rick
* 90 time steps in total ( as to cover one summer)

**Main literature:**

* Li, X., & Magill, W. (2001). Modeling fire spread under environmental influence using a cellular automaton approach. *Complexity International*, *8*(1), 1-14.
* Zylstra, P. J. (2011). *Forest flammability: modelling and managing a complex system*. University of New South Wales, Australian Defence Force Academy, School of Physical, Environmental and Mathematical Sciences..

**Preliminary Results:**

Results are displayed on the poster that we present(ed) during the last session of the course.

When looking at the last stage of the fire:

To do:

Model validation:

We want to check the side and bond percolation of the model.

To check the side percolation we make our system a 100% flammable and check at which density we see percolation. Since we also take into account the diagonal neighbors we expect to find a critical density around 0.41%

To check the bond percolation we want to check the critical flammability. We populate the entire grid and check at which flammability we see percolation.

Planning:

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| 16-06-2021 | First setup of model done |
| 18-06-2021 | Model done, and verified with real data (could be done over the weekend also) |
| 21-06-2021 | Finish model after feedback from Rick |
| 22-06-2021 | Validate model by checking side and bond percolation. |
| 23-06-2021 | Look at the SOC aspects of our model. Average flammability over time and Burned trees over time. |
| 24-06-2021 | Finish up the poster and prepare the presentation. |

## Presentation scheme

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| --- | --- |
| 1,5 | Introduciont/ Theoretical Background |
| 1 | Questions and Hypothesis |
| 2 | Model |
| 0,5 | Distributions |
| 3 | Demonstration |
| 1 | Side and bond percolation |
| 3,5 | Results |
| 1 | Conclusion and Discussion |