Simulation of Forest Fire using cellular automata

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Introduction

- There are five types of vegetation in our model:
  - Grass
  - Juvenile Pine
  - Adult Pine
  - Juvenile Hardwood
  - Adult Hardwood
- The simulation is run for 10 years and each year is divided into 100 time steps.
- Moore neighbourhood
- Initial Ratios
- Fire Probabilities
- Survival Probabilities
- Lightning Probabilities

Model for Succession

Succession is the process by which the constitution of forest changes each year due to natural changes. These natural changes are change in age of the trees and changing the major population in each cell.

Rules:

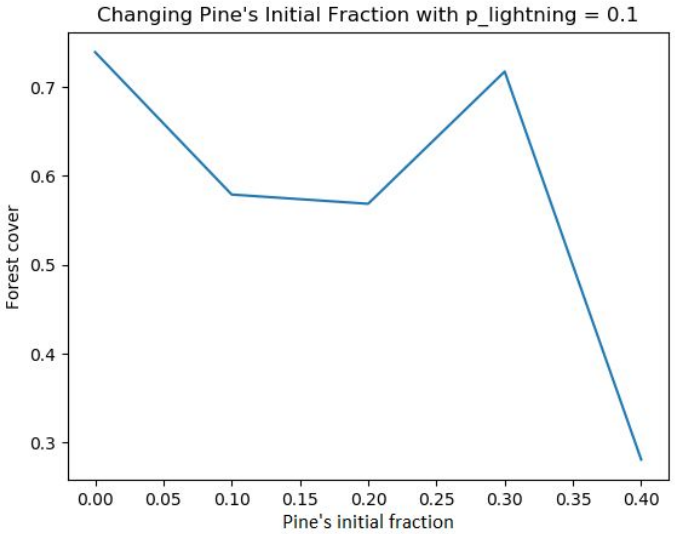
- If an adult pine is within 4 cells of a grass site, there is probability of 0.03 that at the next time step the site will have the state of juvenile pine instead of grass.
- If an adult hardwood is within 1 cell of the grass site, the next time step, the site has a 0.01 probability of becoming juvenile hardwood.
- If a site contains juvenile or adult pine with an adult hardwood neighbor there is a probability of 0.02 that at the next time step the site could have the state of juvenile hardwood.
- After each year the age of juvenile pine and hardwood is increased. If the age crosses 10 then the tree will become adult of its corresponding vegetation.

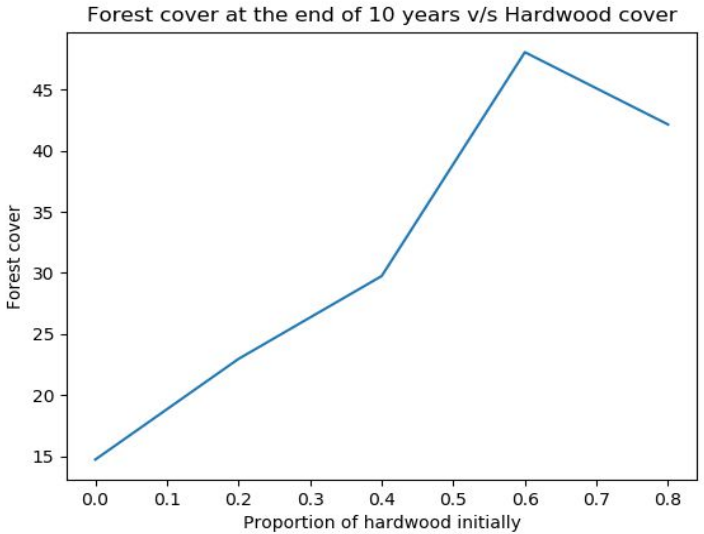
Model for Fire Spread

Rules:

- Each cell sees its neighbours at each time step.If any of them is in the burning state then it starts burning with the probability of fire probability which is described according to the vegetation. Here as Hardwood is more resistive its fire-probability is least compared to other vegetation.
- After a cell is burnt the vegetation under that cell would have survived. So for each type of vegetation a survival probability is assigned to know that with what probability the cell should have survived the fire.
- Grass succeeds all type of vegetation. If any cell has not survived the fire then in the next succession step the cell will contain grass.

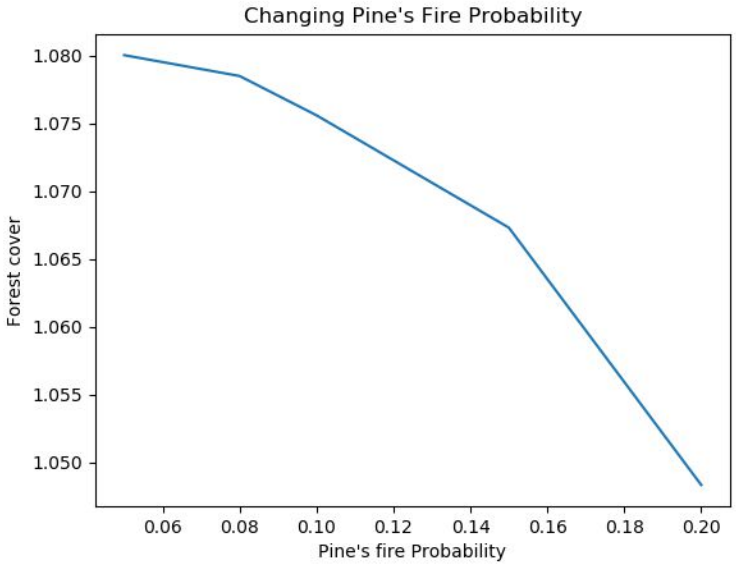
Results for change in fraction of vegetation

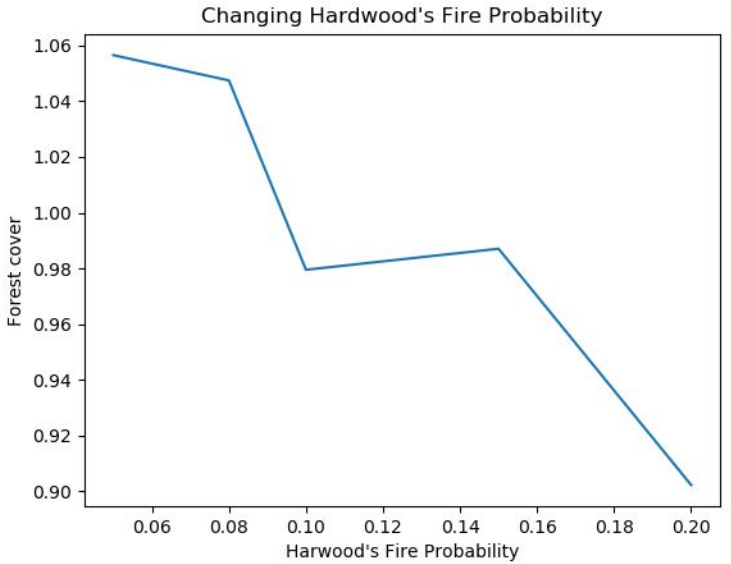




- For this experiment the required variables are: Probability of Lightning = 0.1 , Probability of catching fire: [0.4, 0.1, 0.1, 0.05, 0.05] , Probability of surviving fire: [1.0, 0.3, 0.8, 0.1, 0.2]

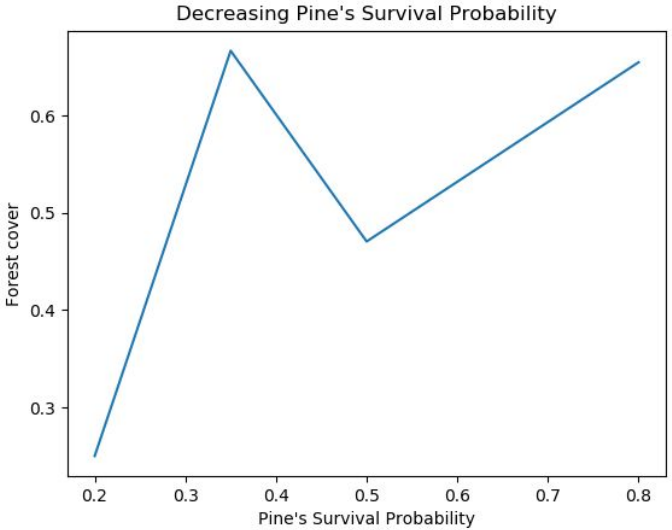
Results for change in fire probability

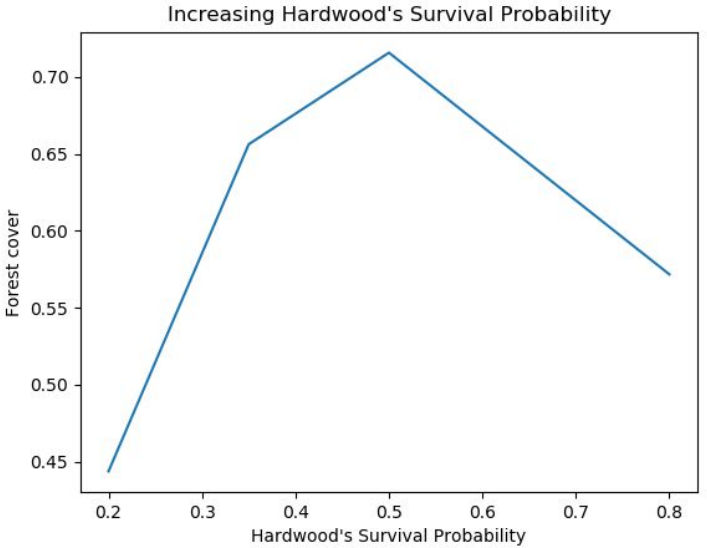




- For this experiment the required variables are: Probability of Lightning =0.1 , Probability of surviving fire: [1.0, 0.3, 0.8, 0.1, 0.2]

Result for change in survival probability





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Conclusion

- If the forest has more than 40% of resistant trees that are hardwood in our model with survival and fire probabilities mentioned before, then after a long time the forest would survive. So a measure to save the forest is to maintain the proportion of resistant trees.
- The proportion of the susceptible trees (Pine) should be less than 30%. So to maintain the forest the proportion of susceptible trees should be maintained under 30%.
- In this model the parameter that can be changed artificially is the initial ratio of tree population i.e by growing the resistant trees. As fire probabilities and survival probability can only be measured, we can run this simulation for those values of probability and can decide how to plant trees.