**Introduction**

In the face of escalating challenges posed by forest fires in vulnerable regions, the need for effective strategies to safeguard communities and their homes has become very urgent. Recent events such as the California wildfires, burning of Australian forests, and Amazonian fires wiping out acres of land signify the urgency for fire protection. This report simulates forest fire spread and evaluates the potential of innovative interventions, specifically focusing on the use of fire blankets. Forest fires, exacerbated by climate change and human activities, pose immediate threats to lives, homes, and the environment. Understanding the dynamics of fire propagation and assessing the efficacy of protective measures is paramount for both the safety of human life and natural and animal life as well.

**Methods**

The simulation operates on a 20x20 grid representing a forested area, where cells can be empty, contain trees, fires, or houses. The simulation spans 1000-time steps, evaluating the forest's status iteratively. The simulation initializes the forest grid and sets parameters like tree growth and death rates, fire spark rate, and fire resistance. Fixed house locations are predefined within the grid (denoted as '3' in the forest grid, representing a color assigned based on a color bar). Each time step involves assessing and updating the grid cells. If a cell adjacent to a fire represents a house, it might catch fire based on fire resistance. Empty cells may spawn trees, which can catch fire or die naturally. If a cell contains fire, it burns out and becomes empty. The simulation visually represents the forest grid at each step. Empty cells are the color of the background, purple, trees are blue, fires are green, and houses are yellow, and have corresponding points to visually ease where they are located on the grid. This visual representation dynamically illustrates the forest's changing states and the status of houses and trees. Within this simulation we tested three different fire resistance levels, symbolized by distinct blankets' strengths, to observe their impact on house survival for a 1000-time step, for a population size of 3 houses. By running simulations for each resistance level, the number of surviving houses at the end of the experiment is recorded. This study aims to evaluate the effectiveness of the level of fire-resistant materials in protecting houses from fire hazards within a set time step.

**Results**

Table 1. Number of houses at the end of running the simulation with time step of 1000 for different values of “fireResistance” (resistance of the house towards burning down due to fire). The total number of houses is 3 as described in the simulation procedure.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **fireResistance** | **Number of houses at the end of the simulation** | | | |
|  | Trial 1 | Trial 2 | Trial 3 | Average |
| 0.1 | 0 | 0 | 0 | 0 |
| 0.01 | 2 | 2 | 1 | 1.6667 |
| 0.001 | 3 | 3 | 3 | 3 |

**Discussion**

It is evident by the results that fire resistance ensures house survival, with higher levels significantly improving the odds. Notably, there's a diminishing return in added protection, particularly evident between fire resistance values of 0.01 and 0.001. While 0.1 offers no defense, both 0.01 and 0.001 enhance survival rates. 0.001 stands out as the most effective, with an average of 3 surviving houses across trials. However, heightened fire protection comes with challenges, increasing cost and resource usage.

Excessive resistance levels might not justify the costs, as seen in the minimal difference between 0.01 and 0.001. In the realm of construction, these challenges extend beyond financial concerns. Abandoned houses, often burned down for expedited demolition, present a dilemma when equipped with preventative measures like fire-resistant blankets. Demolition, in such cases, necessitates significant investment in terms of money, labor, and time, adding a layer of complexity to the decision-making process. Elevated costs are a primary worry, impacting both homeowners and large projects (Emergency Vehicle Visibility and Conspicuity Study, 2009.).

Environmental considerations also arise due to the chemicals used in fire-resistant treatments, posing risks to ecosystems if not managed properly (Environmental Impact of Flame Retardants (Persistence and Biodegradability), 2009). For example, fire retardant chemicals could pose risks to ecosystems if not properly handled or disposed of.

Additionally, the manufacturing processes of these materials might contribute to pollution, questioning the worth of processing them since many of these materials might lack desirable physical properties, potentially limiting their applications. Architects and builders must carefully assess the benefits against these drawbacks, considering project needs, budgets, and environmental impacts (Ronchi & Nilsson, 2013).

The ideal fire resistance value hinges on finding an equilibrium between cost, effectiveness, and specific application contexts. In this instance, 0.01 emerges as the optimal choice for homeowners, offering substantial protection without excessive resource expenditure. For pure safety reasons, 0.001 will beat 0.01 as it doesn’t consider the drawbacks of such high resistance. Enhancing simulation accuracy entails integrating real-world factors like weather conditions, geography, and construction materials. Accounting for varying material flammability, firefighting efforts, wind, geographical topography, and other physical elements would provide a more holistic understanding of fire protection, guiding future construction practices. It is also significant to note that our sample size of houses was only three. Increasing it will provide us with more reliable data and generalizable patterns that could be used to further answer the leading questions discussed.

**References**

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