Firebreak Comparison

New Mexico

Supercomputing Challenge

Final Report

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Team 60

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Final Report:

In summary the problem that our project is looking at is what type of firebreak is better in a given circumstance: a traditional firebreak, series break, or a more natural meadow restoration. We also want to find what the tangible benefits and downsides of each type are. The questions we hope and to some extent have answered include which of these three would provide the better solution of stopping fires, what are the tangible benefits to each, and is a combination of the two the best option? The first reason why we are doing this is that it looks into ways to control wildfires using different methods that may present better efficiency in different situations. It is also to find a potential way to stop a fire from spreading without disturbing the natural ecosystem while using that ecosystem to our benefit. The final thing which can be biased but can also be answered to an extent is whether a combination of the two is the best option. We have been contacting different forest service offices as to the benefits, downsides, conditions, costs, effects, and several other things to consider for both meadows and traditional firebreaks and meadows. We have come to the general notion that if a meadow is present and has the ability to stop the fire it tends to be a better option, but this is not always the case. Through our research we have found several places that prefer meadows and others that prefer traditional firebreaks which each has their own reasons as to why. In which, a significant factor is whether that area has any established meadows to begin with. Even with these factors answered there were still some issues such as recovery time and simply stopping a fire better. We have a general plan of what we are going to do, this includes modeling the burn rate data with several weather conditions. This information was gathered from both local and out of state resources, but we stuck with information we obtained from the Yellowstone National Park. The program

itself accounts for these variables in the burn rate and the likelihood that a firebreak will stop a fire.

There were many methods used to solve the problem, one of the largest wasn't actually using the program itself but instead doing external research. The program we made was to model a lot of the research we did on the types of fire breaks. What we specifically did was take the information obtained from the Yellowstone forest service and put it into a model with basic weather conditions that were common there. From there we used a model to repeatedly test these conditions and their results to validate what was observed. The validation that we had was the fact that the data we collected closely matched several resources in the real world. There were two main results we got from the research. The first is that both firebreaks stop a fire which is a self-explanatory result. The second result was that we learned that climate conditions and the size of a fire tend to matter more when making the decision of the type of firebreak that is used. The conclusion that was reached is that meadows do work well for stopping a fire, as does a firebreak but the external conditions are what affects the true decision in what is used. For example, it was concluded that if there is heavy precipitation a meadow stops a fire really well, but if the conditions of the fire worsened to a point where it is drying the area the meadow for the most part could no longer stop the fire. The second conclusion is that the recovery time can be vastly different, but the total scale of potential destruction caused by the fire may make that recovery time insignificant. The parts of the code that were changed were the number of neighbors asked to ignite, the percentage chance of a burn through, and in the end at location of the firebreak as well. Now when I changed the general number of neighbors asked to ignite

the main result was an increase in the burn rate of a given fire. This allowed me to make several different graphs to model basic conditions such as minor precipitation or even how dry something is. Then I also changed the chances of a burn through in the model. Now the chances of a burn through whether for a meadow restoration firebreak or a traditional firebreak were kept equal. The main argument to this is since dirt doesn't really burn but carries embers well whereas a meadow or moist environment is great at stopping embers but is prone to burning. In real life these tend to be about equal for that reason. What this allowed me to do was create different extremes of environmental conditions ranging from extreme drought to flash floods if I wanted to. This led to a key change in the results and that was a simple difference in the total number of patches burned by a fire, but this pattern allowed me to put into further detail differences is the stop rate of the two firebreaks just like the natural world. Finally the last thing I changed but did not include in the given graphs was the differences in the location of the firebreak. This also allowed me to create several different graphs just not of average burn rates. It also showed a pattern that would make a huge difference if the situation was not equal. That was that a traditional firebreak does about as good at any distance but the meadow restoration firebreaks given their nature work when the fire starts closer to them. This could lead to the decision to use a meadow to stop a fire when the fire starts closer to it but if the fire is further away to just use a traditional firebreak. These were the main changes I made to get various results and resulted in several different conclusions from each variation. **Reference Appendix C for the code that allowed for this model and Appendix D for all of the code.** Those few lines of code were what allowed for the entirety of the model to function. What this did was it created the base firebreaks themselves but it also allowed me to change their location and size.

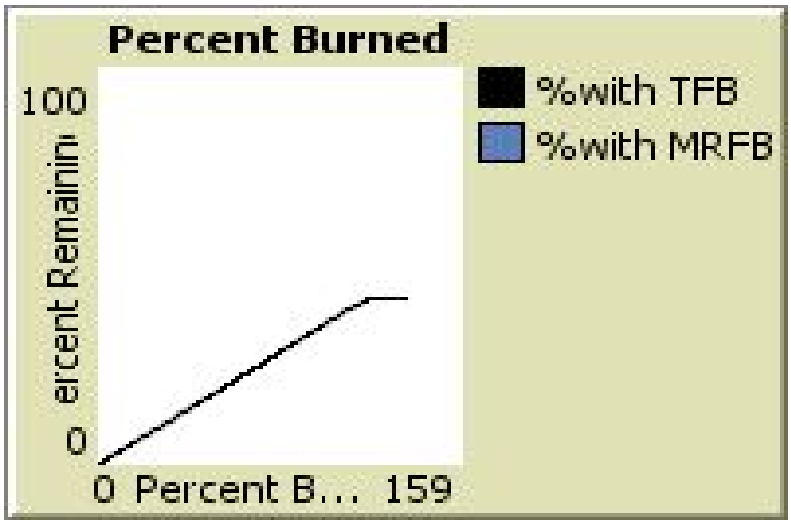
This meant that on top of the other variables I could also change the base amount that could be burned and in the case of meadows how many patches of the meadow there were to potentially burn. The other pieces of code I added were simply either adding a slider to a variable or adding an if-else statement. **Reference Appendix A and B below for the graphs.** Image A represents the traditional firebreak and the percentage burned over time specifically for traditional firebreaks. This data was collected as a total percentage throughout several different runs with several different variables to represent the average amount that was burned before a fire was stopped. TFB specifically refers to the traditional firebreak and after analyzing the data given the specific constant placement of the firebreak only about 45-50% was burned. The firebreak was placed where only 40% could be burned before contact with the firebreak. Image B shows the meadow restoration's effectiveness as a firebreak and MRFB simply means Meadow Restoration FireBreak. From the data collected and what has been graphed the meadows didn't stop the fire as effectively as traditional firebreaks. This can be seen by almost 60% being burned total before the fire stopped with only 40% being able to be burned before it reached the firebreak. There is a key reason for this, the settings that were changed to represent weather conditions present during the fire. Throughout data collection in the model two variables were changed by percentage. These were burn rate which was done by the amount of neighbors asked to light on fire and secondly the rate at which the fire would burn through the firebreak which was a percentage chance. These two variables combined allowed me to represent weather conditions to model a real world scenario. This is why the meadows had burned more because when the burn rate got to the extremes of either dry conditions or a fire creating its own weather it did not stop the fire effectively. To make things fair I had five

controlled weather patterns representing a base setting unchanged from the base model. Dry conditions were modeled with an increase in the neighbors asked to ignite now being at six. A moist environment was modeled by changing the chance of the fire burning through the break to only 5% the base was at 10%. Then to represent a wet condition the chances of burning through was dropped to 1% and the amount of neighbors asked was dropped to two. Finally there was the weather condition created by the fire itself which was a mix of representing high winds and extreme dryness. To do this I made the neighbors ask to ignite to 10 and the chances of a burn through to 30%. This may seem like it would be equal but how I programmed the meadow to work is when the fire hits the meadow it slows down till it can no longer ignite meaning it stops. So when this was sped up the chances at a burn through were greater resulting on average with each weather condition tested 25 times the meadow restoration to have more burned. There were other graphs to represent each individual weather condition as well these were more useful if you expected certain environmental conditions during a fire. The software that was used was just netlogo and the program is based off of the firebreak starter model in NetLogo which was originally authored by Uri Wilensky. The most significant achievement of the project was one learning more about coding and two educating ourselves about what actually happens during a fire and the methods used to stop them. Doing that much research in itself was an achievement but learning more about how to code was the real biggest achievement on the project. In specific the people who helped us include many people from three main forest service branches which were those in Red River, New Mexico; Angelfire, New Mexico; and those in West Yellowstone National Park, Wyoming. Then there was our advisor Ms. AnnNet Delaney who helped us with advice on the program and helped us contact different

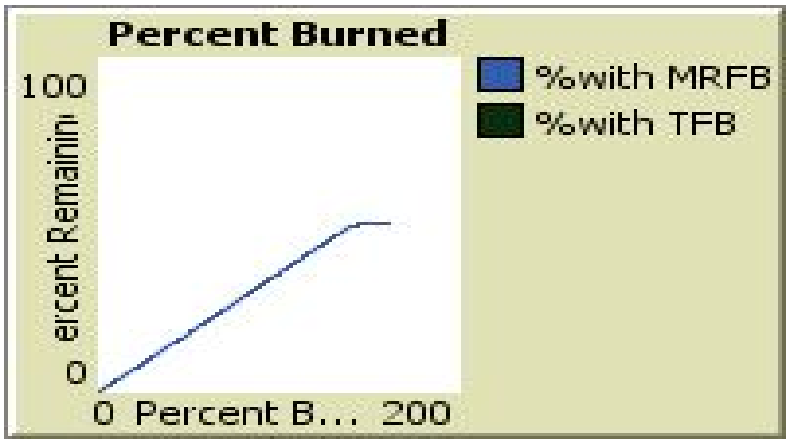
Forest Service divisions to get information about wildfires. In conclusion this project set out to find an answer to what type of firebreak is the best and what the benefits to it are. To do this many different experiments were done and a large amount of research went into it. In the end though it was found there is not one perfect solution, different factors play into which solution the traditional firebreak or meadow restorations are better.

Coding example listed below.

Appendix A



Appendix B



Appendix C

```
to fire-break
  ask patches with [pxcor <= maxsFB and pxcor > minsFB and pycor <= tallsFBmax and pycor
> tallsFBmin ]
  [set pcolor brown]
end


to meadow-restoration
  ask patches with [pxcor <= maxsM and pxcor > minsM and pycor <= tallsMmax and pycor >
tallsMmin ]
  [set pcolor blue]
end
```

Appendix D

Fire Break Model

Original author of the code Uri Wilensky

Coding as follows:

```
globals [
  initial-trees   ;; how many trees (green patches) we started with
  burned-trees ;; how many have burned so far
]

breed [fires fire]          ;; bright red turtles aka the leading edge of the fire
breed [embers ember]  ;; turtles gradually fading from red to near black

to setup
  clear-all
  set-default-shape turtles "square"
  ;; make some green trees
  ask patches with [(random-float 100) < density]
          [ set pcolor green ]
  ;; make a column of burning trees
  ask patches with [pxcor = min-pxcor]
```

```
        [ ignite ]
  ;; set tree counts
  set initial-trees count patches with [pcolor = green]
  set burned-trees 0
  reset-ticks
end

to go
  if not any? turtles
        [ stop ]
  ask fires
        [ ask neighbors4 with [pcolor = green]
        [ ignite ]
        set breed embers ]
  fade-embers
  tick
end

;; creates the fire turtles
to ignite  ;; patch procedure
  sprout-fires 1
        [ set color red ]
```

```
  set pcolor black
  set burned-trees burned-trees + 1
end

;; achieve fading color effect for the fire as it burns
to fade-embers
  ask embers
          [ set color color - 0.3  ;; make red darker
          if color < red - 3.5       ;; are we almost at black?
          [ set pcolor color
          die ] ]
end

to fire-break
  ask patches with [pxcor <= maxsFB and pxcor > minsFB and pycor <= tallsFBmax and pycor >
tallsFBmin ]
  [set pcolor brown]
end

to meadow-restoration
  ask patches with [pxcor <= maxsM and pxcor > minsM and pycor <= tallsMmax and pycor >
tallsMmin ]
```

```
  [set pcolor blue]
end
```

Bibliography

https://www.fs.usda.gov/carson/

https://www.fs.usda.gov/lincoln

https://www.nps.gov/yell/index.htm

Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.