Introduction:

New Mexico is facing an extreme, wildfire crisis (https://nmfireinfo.com/). These fires have burned hundreds of thousands of acres and torched many towns and homes. Even long after wildfires are put out, the scarred landscapes affect their hydrology. This can lead to flooding and erosion, along with a build-up of sediment in rivers. This project looks at some of the changes in hydrology after wildfires, which can lead to higher levels of erosion, flooding, and other similar things.

Model Outline:

A model to simulate hydrology has been created using c++ to study this problem. The model compares two simulations, one before the wildfire, and one after. To simulate hydrology, the model includes different aspects such as water flow, erosion, and sediment transport. The model simulates the differences between pre and post-fire hydrology by approximating the increased water flow from various factors. This includes the loss of vegetation to absorb water, and the deceased if not removed ability for the soil to absorb water. Fires' effects on hydrology vary with multiple factors, one of those being the intensity. The program assumes a baseline fire intensity which would be fairly intense similar to the mega-fires being looked at in this project.

Research:

Research has been conducted on multiple hydraulic factors affected by wildfires. This includes groundwater absorption, and the amount of water typically absorbed from vegetation. Research has also been conducted on the environment around the location being simulated. Multiple articles have been found outlining the vegetation makeup, and the soil properties, allowing a more accurate difference between pre and post-fire water flow to be simulated. Based on the research, it is believed that post-fire erosion will be far worse than pre-fire erosion, and there will also be far more water flow after the fire due to the lack of absorption of it. This increased water flow may also lead to flooding.

Testing the Model:

The following is a mountainous scene that was eroded using the model to test it. The results of it properly show hydraulic phenomena such as couloirs, gullies, sediment deposits, and sharp ridges. The following are some examples in which the phenomena can be seen.

Figure 1: The following is a height map produced from the model, the image after this is what it looks like in 3D:

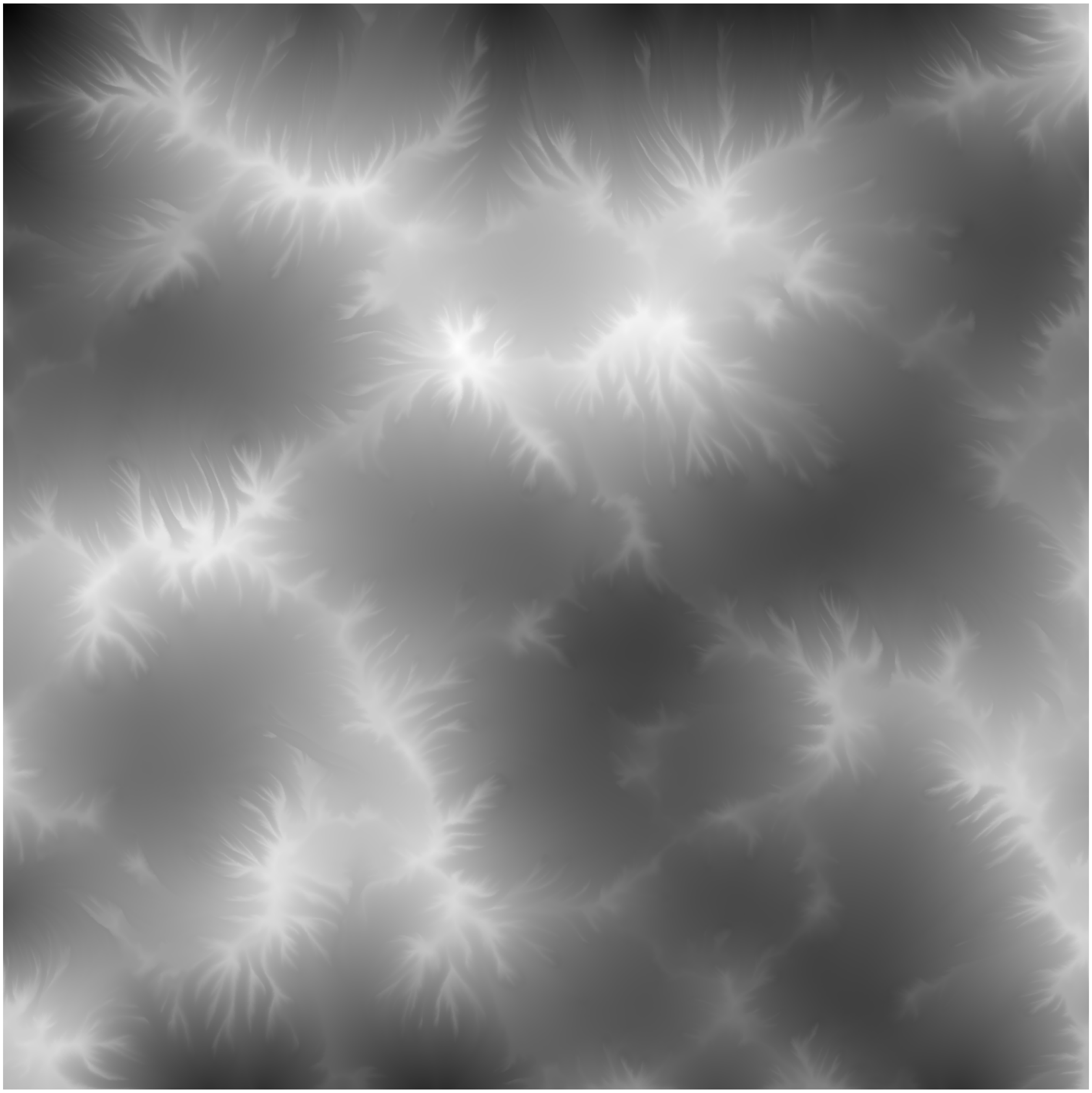
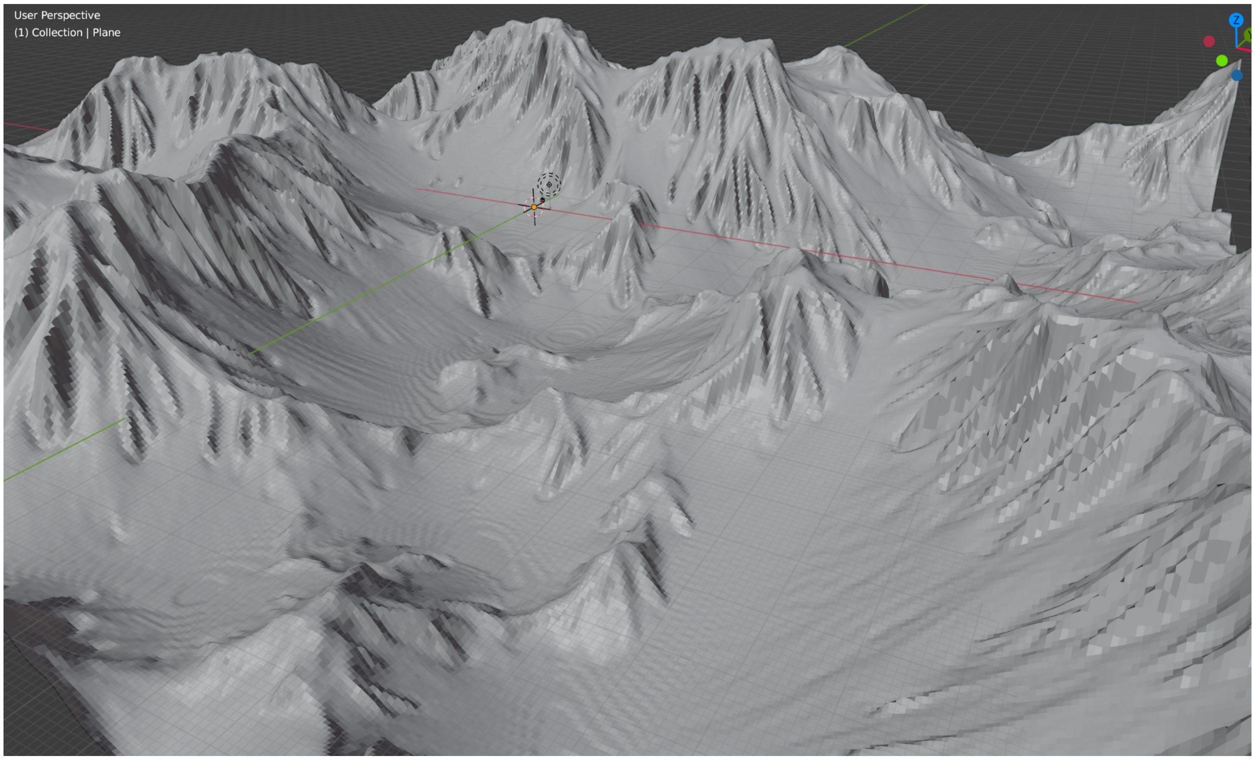


Figure 2: The following is a 3D version of the height map shown in the previous image (figure 1) visualized using Blender:



Results:

Based on the model, it has been found that post-fire erosion is much worse than pre-fire erosion. The following are results from the model showing how the erosion eroded the landscapes it was provided with. The terrain used was procedurally generated to look similar to areas of the simulated region using a gradient noise algorithm known as Perlin Noise.

Figure 4: Here’s the pre-fire terrain erosion:

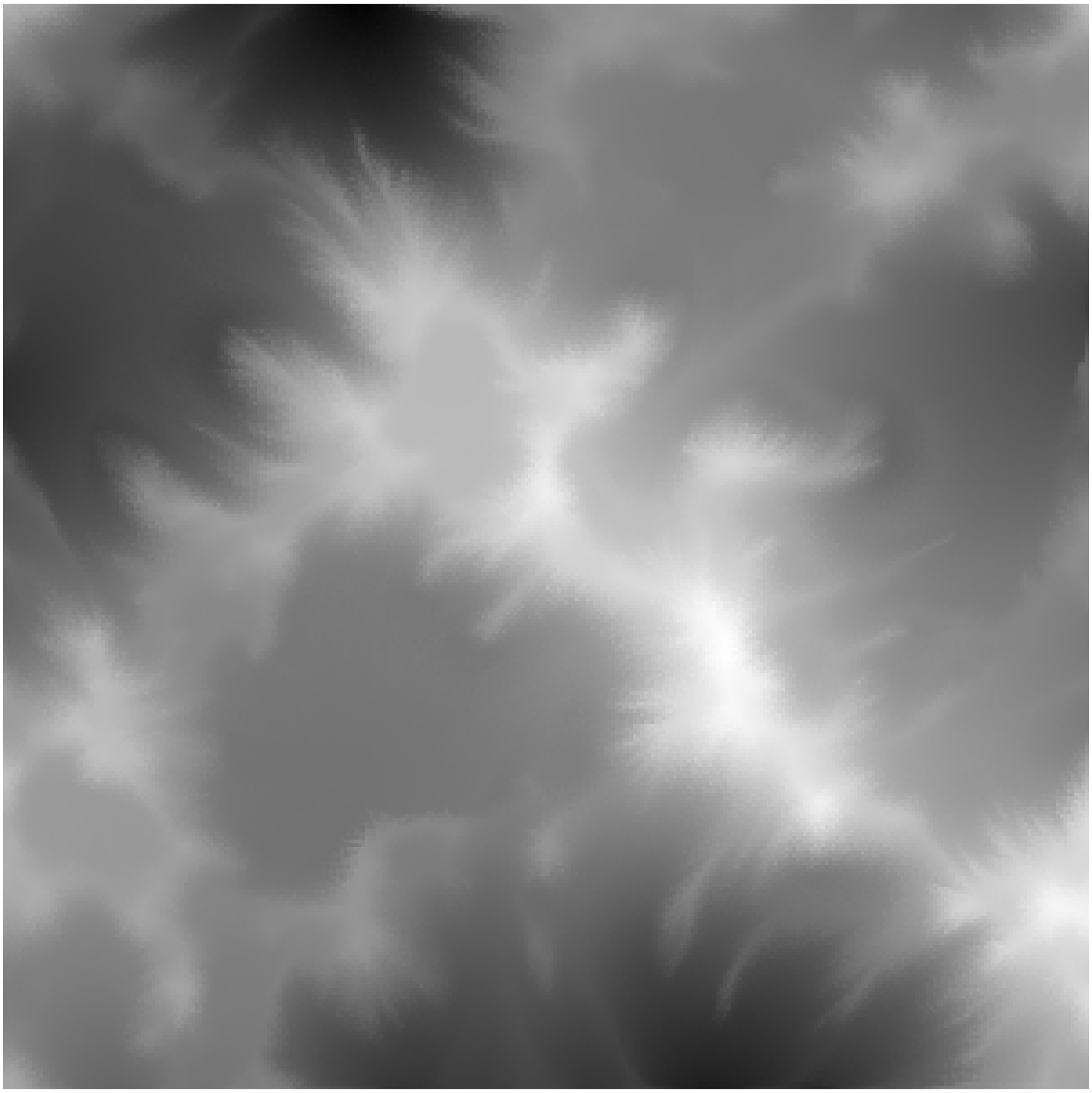
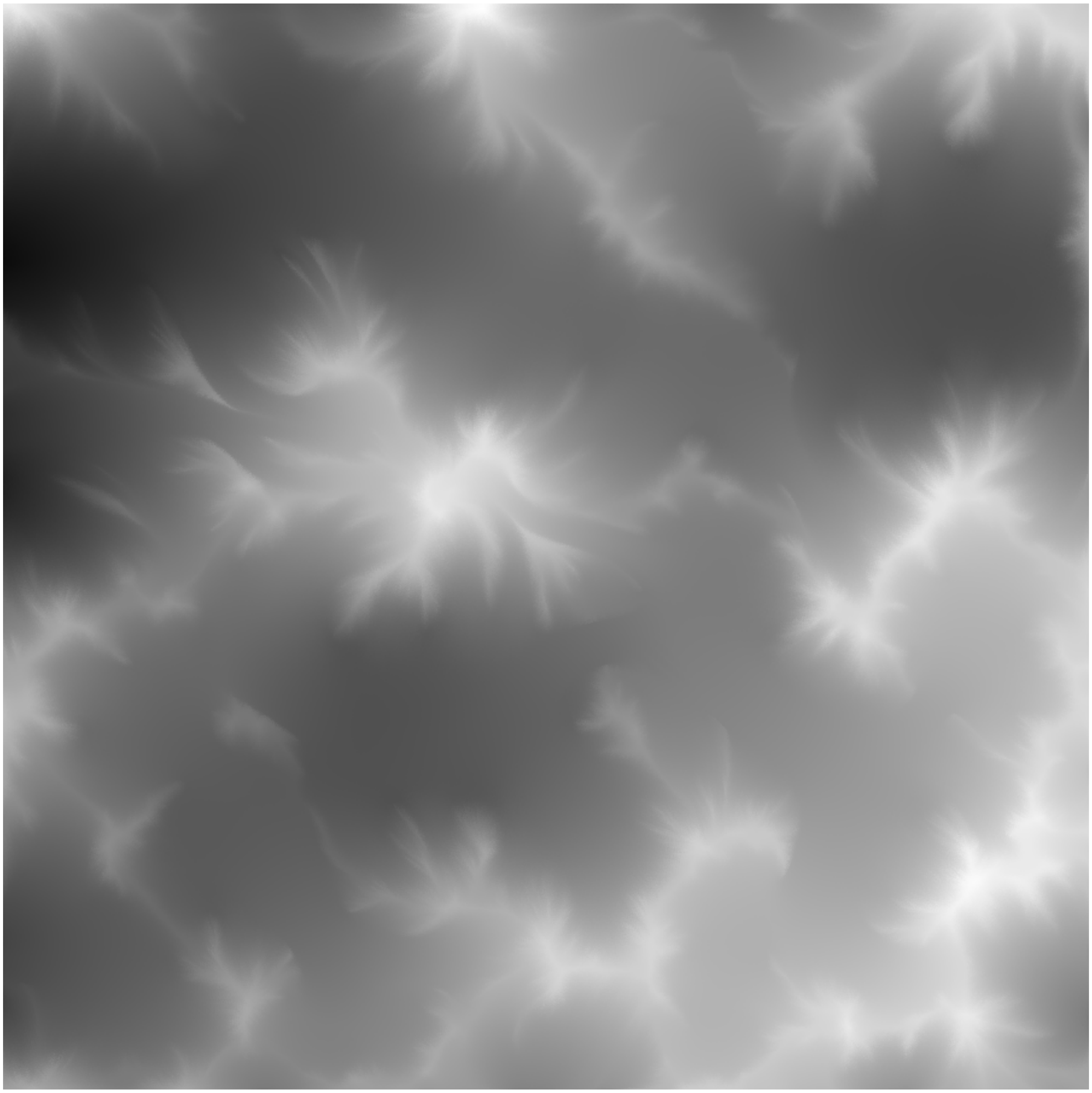


Figure 5: Here’s the post-fire terrain erosion (slightly different terrain):



As seen in figures 4 and 5, post-fire erosion was worse than pre-fire erosion.

Sources:

- https://nickmcd.me/2022/04/15/soilmachine/
- https://nhnm.unm.edu/sites/default/files/nonsensitive/publications/Muldavin_etal%202010_BAND%20veg%20map%20NRTR.pdf
- https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5300086.pdf
- https://en.wikipedia.org/wiki/Landslide
- https://www.harwichwater.com/community/outdoor-water-use/soil-improvement.html#:~:text=A%20combination%20of%20sand%2C%20silt,than%202%20inches%20per%20hour
- https://www.sciencedirect.com/science/article/abs/pii/S0022169414001528
- https://www.youtube.com/watch?v=eaXk97ujbPQ&t=95s

Additional Information:

Some parts of the model can be found on my GitHub (https://github.com/AndrewDMorgan).