Tri Canyon Trails Master Plan

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In Coordination With:

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USFS – Salt Lake Ranger District

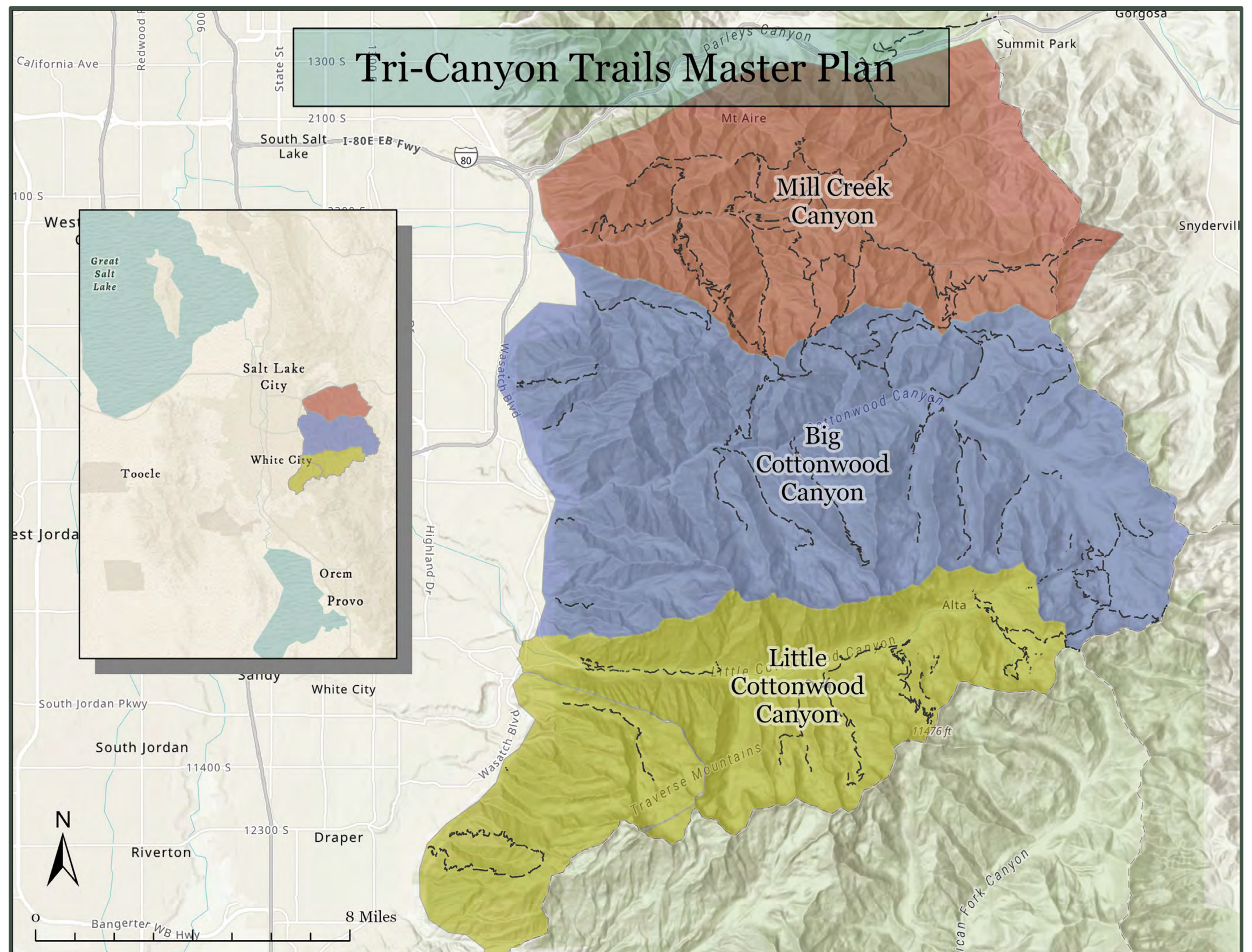


Figure 1. Tri Canyon Trails Master Plan Study Area – Big Cottonwood, Little Cottonwood and Millcreek Canyons, Just Southeast of Salt Lake City

OBJECTIVES

The objective of the Tri-Canyon Trails Master Plan is to provide a variety of high-quality trails in Big Cottonwood, Little Cottonwood and Millcreek Canyons (Figure 1), while minimizing impact on the watershed and natural resources. This plan is about halfway through a four-year process intended to address the growing demands and trail usage in the central Wasatch. This capstone project supports the overall objective by providing replicable trail analysis and stakeholder interaction opportunities. The results include analysis processes and categorization of trails based on attributes in three categories: Overall Sustainability, Recreational Opportunity, and Areas of Concern, though primary analysis focus is on overall sustainability (Table 1). The analysis has been captured in an ArcGIS Pro ModelBuilder for future replicability due to the incomplete and changing nature of the trails library maintained by the US Forest Service. The trail analysis layers have been uploaded and visualized in an ArcGIS Online web map to interactively communicate results to stakeholders – namely the public.

Overall Sustainability	Recreational Opportunity (Trail Attributes)	Areas of Concern (Trail Conditions)
- **Trail Gradient:** The average surface slope along the trails assigned to 5 and 10 meter segments of trail - **Side Slope:** The average slope of the terrain the trail crosses, looking at 10 meter segments of trail and 5 meter buffers on either side (10m x 10m boxes) - **Slope Ratio:** The trail gradient divided by the side slope, which gives a ratio indicating whether the trail crosses the steepest possible incline (slope ratio closer to 1 and less sustainable), or whether it crosses a relatively less steep grade (slope ratio closer to 0 and more sustainable) - **Land Cover:** The soil composition of the area the trail goes through – categorized by type, and by range of gradients it supposedly can maintain sustainably.	- **Elevation Change:** The sum total of gain across trail in one direction. This does not factor in elevation loss, and is ***not*** the maximum elevation minus the minimum elevation. - **Trail Gradient:** The average trail gradient across an entire length of trail. - **Length:** Three dimensional length of trail. - **Aspect:** The average direction the side slope of the trail faces (North, East, South, West, etc.)	- **Tread:** Classified tread patterns of trail such as braiding or erosion. - **Damage:** Qualitative notes on existing damage to the trail. - **Actual vs. Intended Use:** Primary current and potential future uses of trail (i.e. dog-walker, family outing, mountain biking). - **Trail Maintenance and Infrastructure:** Suggested maintenance types and timeframes. Suggested future infrastructure and likely benefits - **Private Property:** SITLA land ownership layer

Table 1. Explanation of Various Analyses Carried Out Addressing Each of the Three Objectives Assigned to this Project.

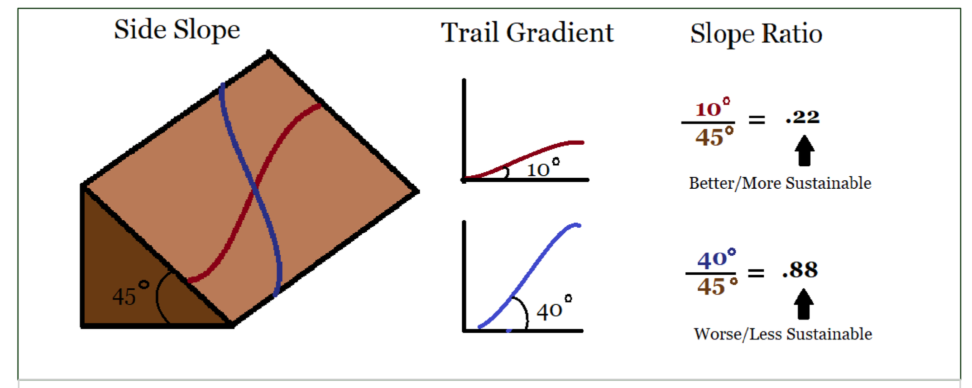


Figure 2. Side Slope is a ratio of trail gradient to side slope. Trails up the steepest fall line (blue) are less sustainable, and slopes more along the side hill are more sustainable (red).

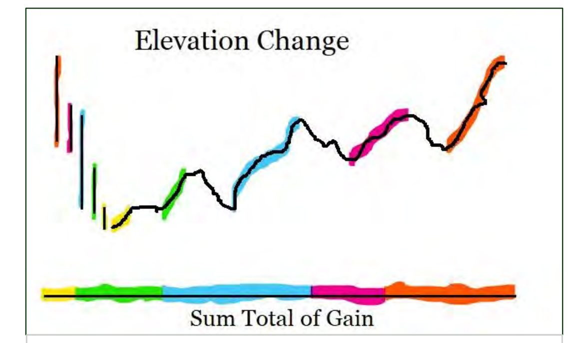


Figure 3. Example of Elevation Gain calculation, it is the sum of all the gain along a trail, ignoring any loss, in one direction

METHODOLOGY - ANALYSIS

Each of the analysis techniques that were applied to the trail layers or trail area are described below in detail (Figure 5). Every technique was completed using a Geoprocessing (GP) tool in ArcGIS Pro, with the exception of the elevation gain. The elevation gain analysis was completed using a custom python script based on a csv which was exported from the ArcGIS Pro project. These are all incorporated into a ModelBuilder so they can be automatically run by the partner when there is a new trails layer. Training will be provided to the USFS partner to ensure seamless transition to their ArcGIS account and ArcGIS Pro Project.

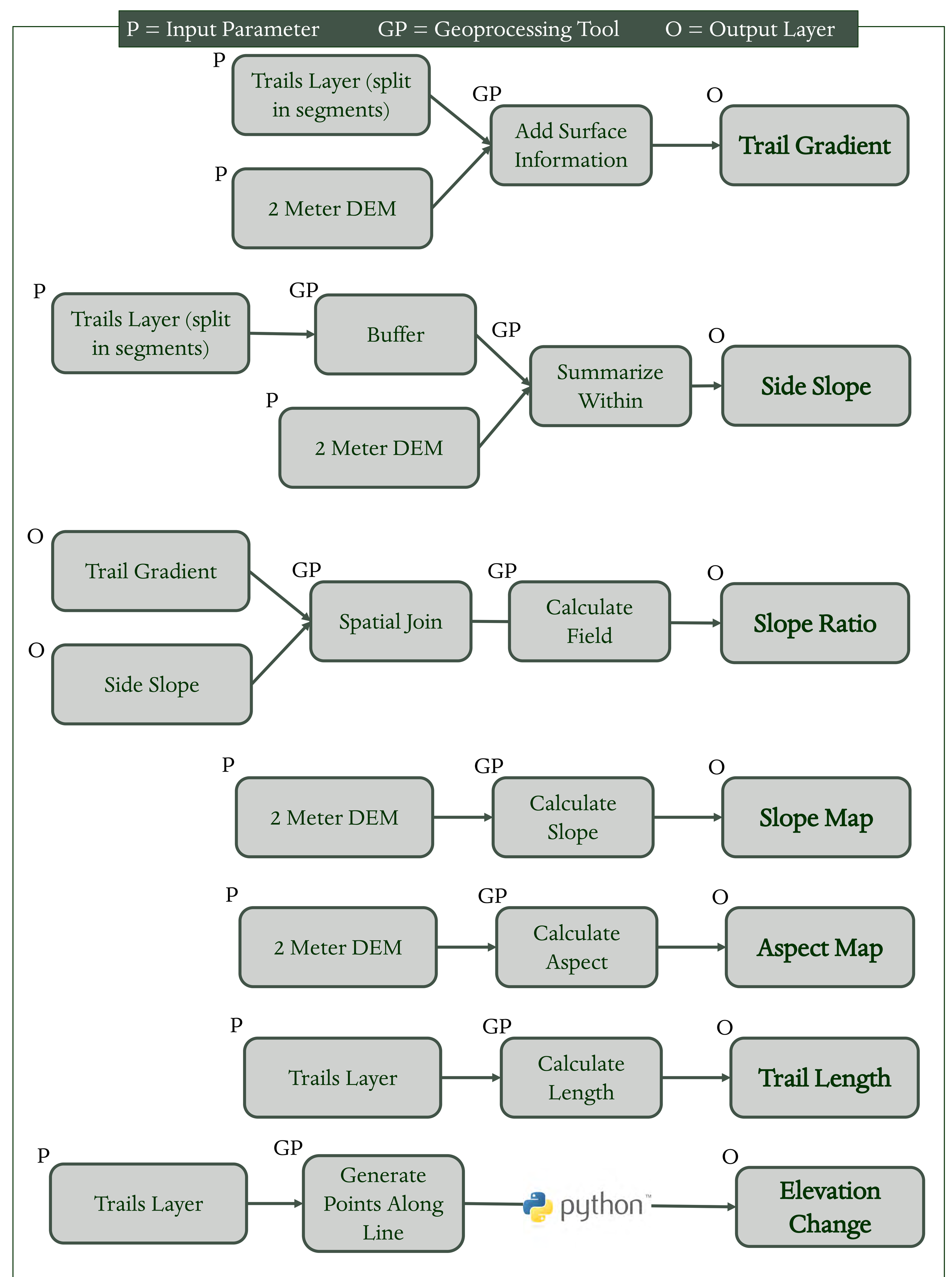


Figure 4. Trail Conditions Dashboard: When a Segment of Trail is selected from the list on the right, the map zooms to the segment and the right panel updates with attributes and pictures associated with that segment.

ACKNOWLEDGEMENT and REFERENCES

I would like to thank the US Forest Service, Salt Lake Ranger District – and specifically Chelsea Phillippe for allowing me to be a small piece of this important project, and for guiding my efforts to best serve the overall goals.

Marion, Jeffrey L., and Jeremy Wimpey. "Assessing the influence of sustainable trail design and maintenance on soil loss." Journal of Environmental Management 189 (2017): 46-57.

Leung, Yu-Fai, and Jeffrey L. Marion. "Trail degradation as influenced by environmental factors: A state-of-the-knowledge review." Journal of soil and water conservation 51.2 (1996): 130-136.

METHODOLOGY - VISUALIZATION

Most of the attributes in the final product are visualized based off of a grouped categorization (Figure 6). The categorization metrics were determined by the USFS partner, but can be altered in future visualizations if necessary within the ArcGIS Online WebMap. The final map has custom pop-ups that are more easily digestible for the public (Figure 4), as well as unique layers for each attribute to be visualized for easier comparison and filtering. A dashboard has been created for ease of navigation and summary.

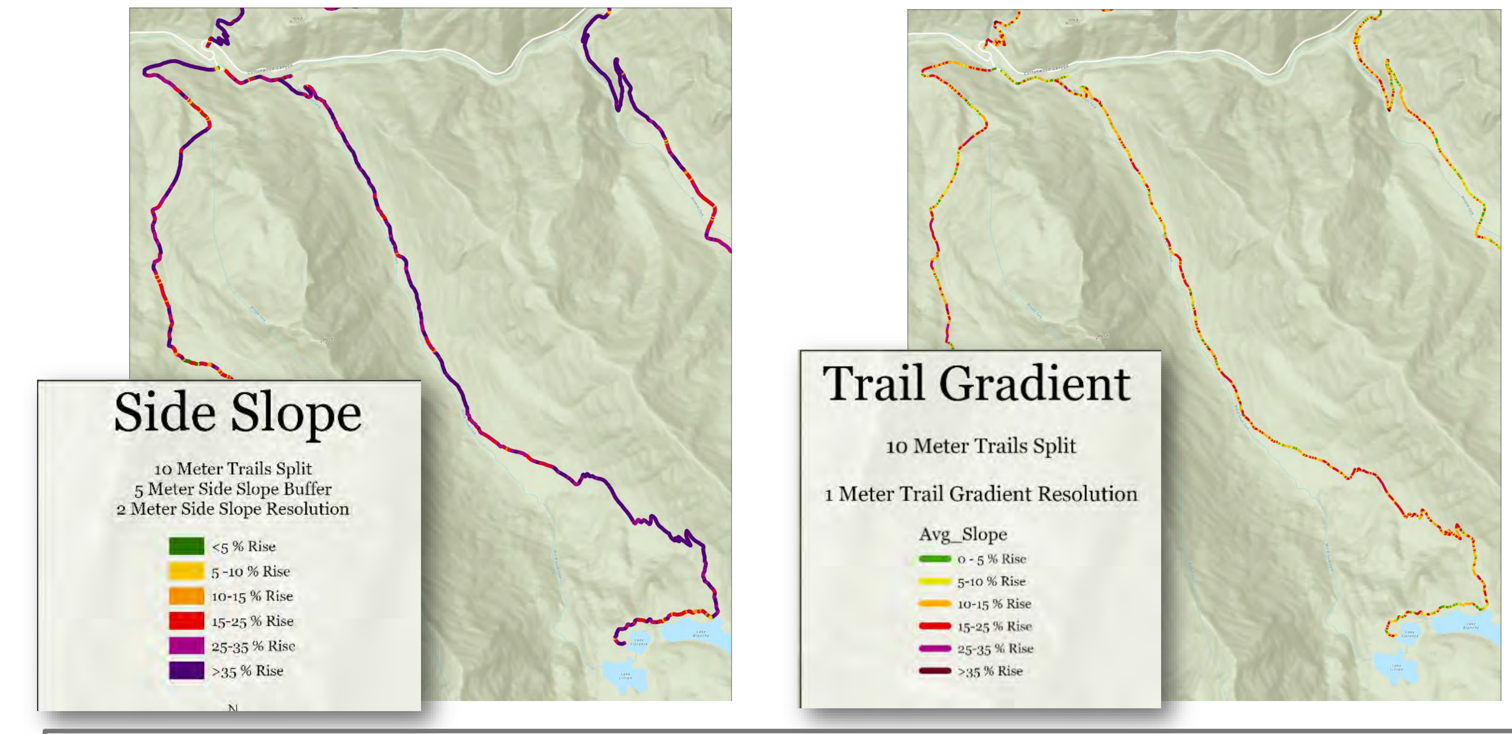


Figure 6. Maps Visualizing the Analysis Results with Green Showing the Lowest Angle Slope and Dark Purple Showing the Highest Angle Slope

ArcGIS Online Web Map and Dashboard

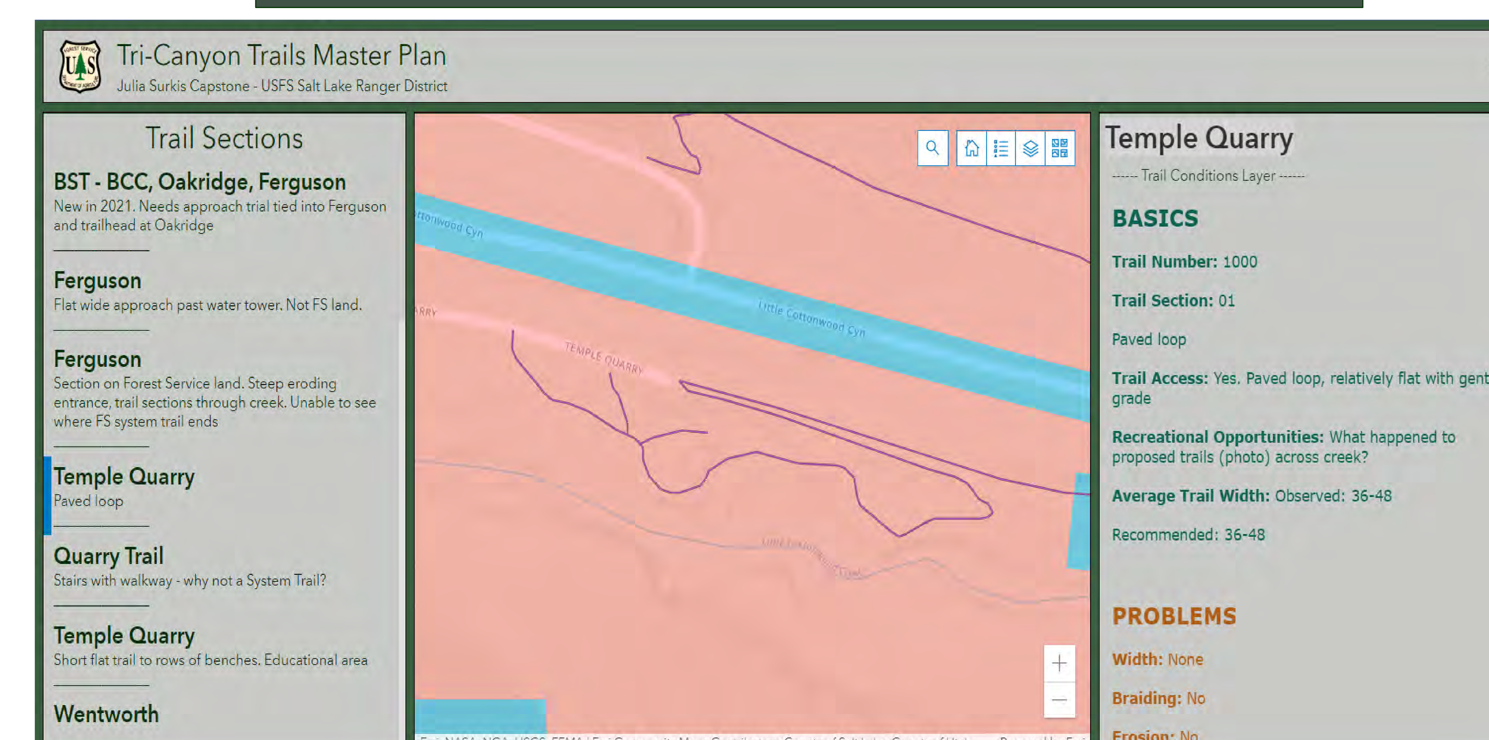
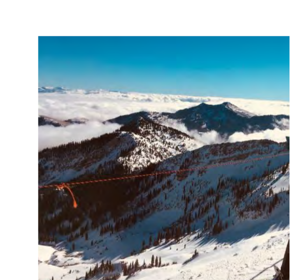
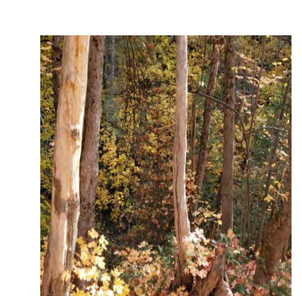


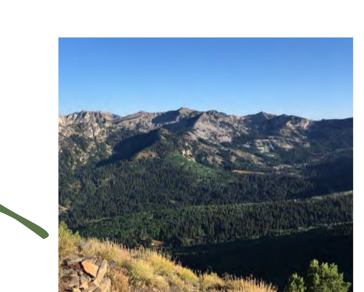
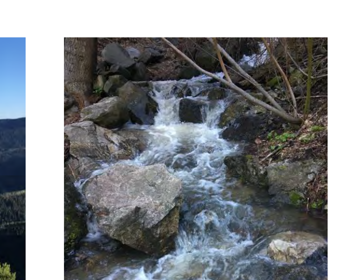
Figure 5. Sample Flow of Geoprocessing Tools Used in ModelBuilder

DISCUSSION

There are many factors that are assessed when planning for sustainable and complete trails. Research shows that trail gradient, side slope, and the subsequent slope ratio each have a measurable affect on the amount of soil loss experienced by the trail – a key indicator in sustainability. However, there is limited research indicating appropriate resolutions to use while calculating. In the past, the suggested resolution was the best that was available, but with modern technology and freely available high-resolution DEMs, a significant portion of this project was dedicated to testing and assessing the most appropriate resolution to analyze trail sustainability. In addition, the length of trail to look at for trail gradient, and the width to look at for side slope buffer have not yet been standardized in the field of trail sustainability analysis. It was determined that a 2 meter by 2 meter Digital Elevation Model (DEM), as well as 10 meter trail segments with 5 meter trail buffers would be the most appropriate, based on visual assessment by trail experts, as well as minimal errors when completing spatial analytical calculations. This resolution was compared against half meter, 1 meter, and 5 meter DEM alternatives, as well as 5 and 10 meter segment and buffer combinations.

The intention of this project was not to come up with a specific recommendation for trail planning, but instead to come up with a repeatable process that allows trail planners to refer to and share with the public. To meet this goal, various geoprocessing tools were run and recorded in ArcGIS Pro ModelBuilder, with output layers published to and visualized in ArcGIS Online. Training on future implementation with additional trails will be provided to the USFS partner.

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