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Quantifying impacts of recreational users on trails

This study was undertaken in partnership with UTMB / IRONMAN Group in conjunction with their SpeedGoat Mountain Races event in Snowbird, UT.

Through the application of LiDAR (Light Detecting and Ranging) on study sites across the course profile, microscale measurements were taken to quantify the erosion & ecological impact of trail runners during the 2 day event. Pre and post scans (3 million + point meshes) were taken of each site, allowing for erosion, deposition, and trail widening measurements to be taken at an error range of <1mm.

These sites spanned geologic terrain, ecosystem, slope, aspect, and user ship model of trails along the course, allowing for overarching understanding of event impact & planning for future mitigation and improvement.

Along with geomorphological analysis, on site observation was practiced during the event to connect psychological / behavioral data with findings - this included watching participants at stream crossings, rocky technical terrain, and in forested single track.

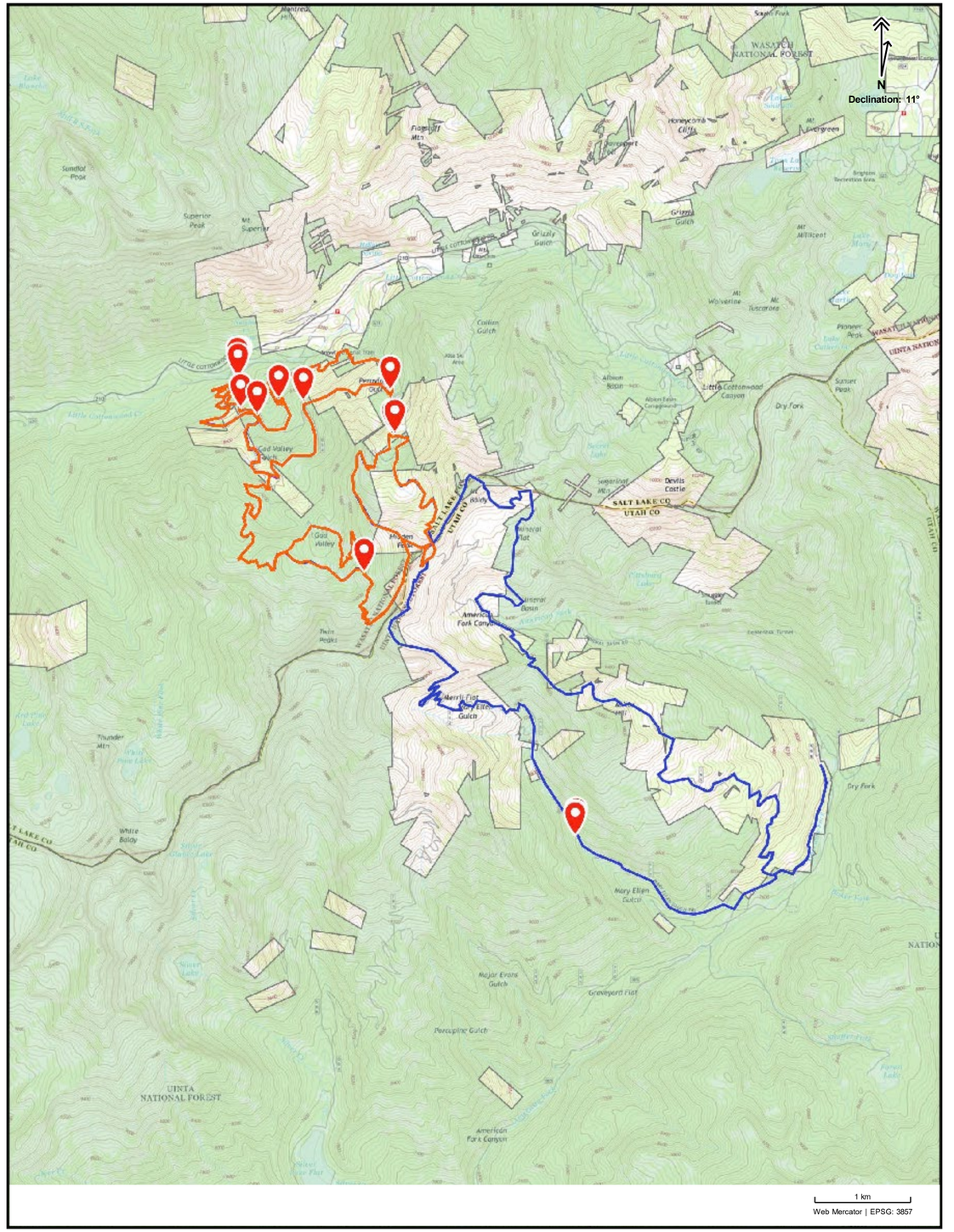
This data serves to better inform discussions between event organizers and land managers in order to set participant limits, course design, and community engagement.

Setting & methods

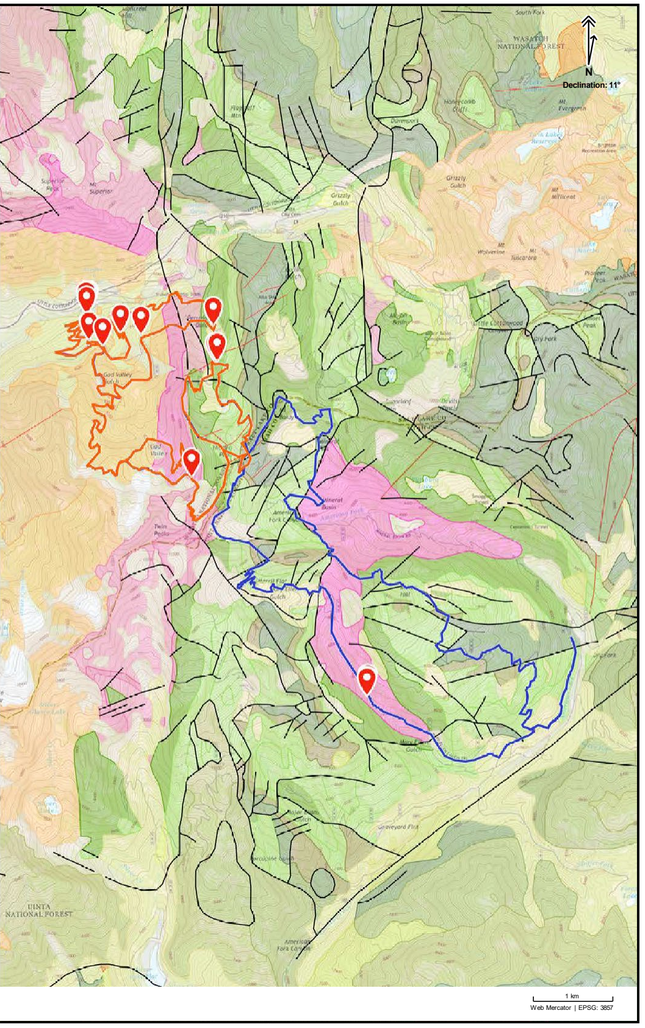
The regional settings studied for the event weekend included 11km, 28km, and 50km courses, in which each of the larger distances included the course for the shorter distances. This allowed for comparison between the number of runners that crossed a given study site - IE did 200 runners cause significantly more impact than 400 runners under the same factors.

The red course on the map figure denotes the section run by all 3 course participants, while blue was only run by the 50km participants.

Red markers are placed on LiDAR scanned study sites, while the entirety of the course was surveyed pre and post event for additional analysis. **Of note are the differences in use - with the NW (Wasatch NF) red line being on multi-use hike, run & bike trails (with several trails being hike / run only) and the SE (Uinta NF) blue occurring on multi use OHV & human powered trails.**

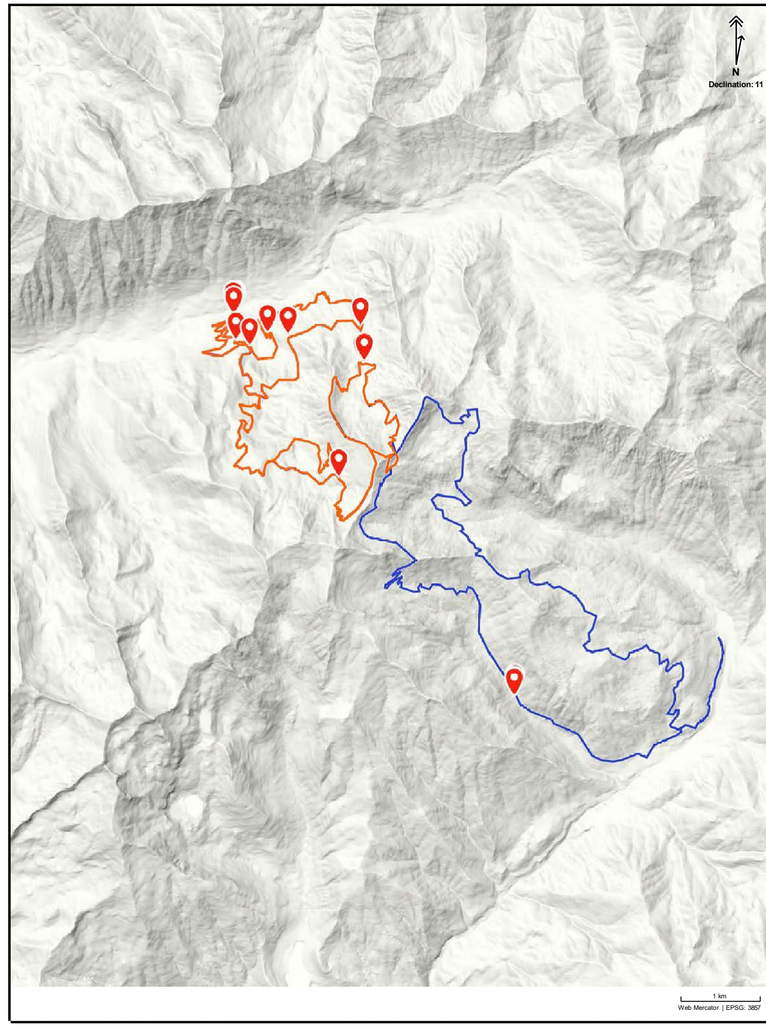


Environmental Factors



Geology lies on the overarching Little Cottonwood batholith. (26 million years old) of quartz monzonite, which was then eroded by glacial activity over the last 2.5 million years (Pinedale). Ecosystems on these geologic Provences range from alpine talus to deciduous forest & riparian meadows.

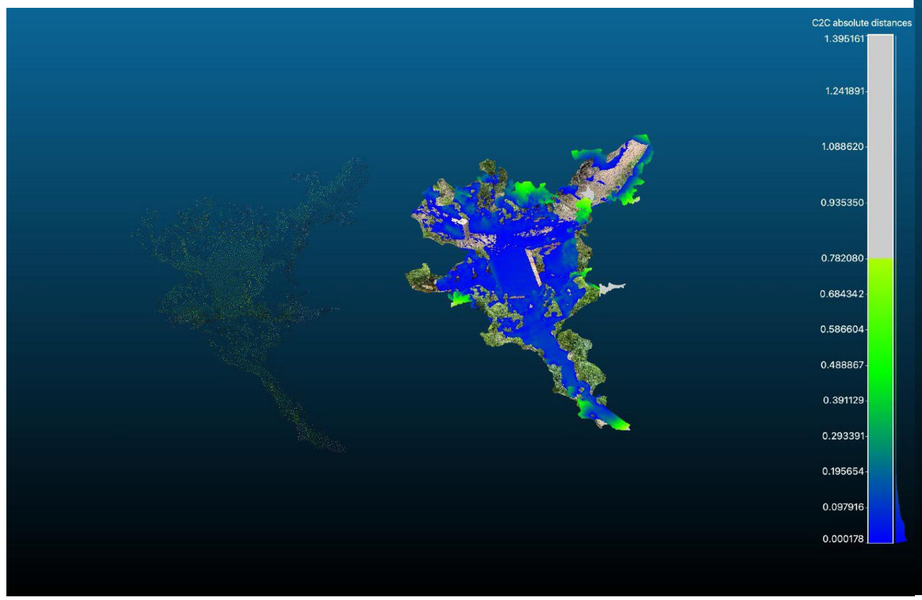
Topography, driven by geology and climate, is dramatic, with extensive slopes over 40 degrees. This topography impacts trail degradation as steep trails without drainage tend to entrench and are impacted to a greater degree by heavy usage.

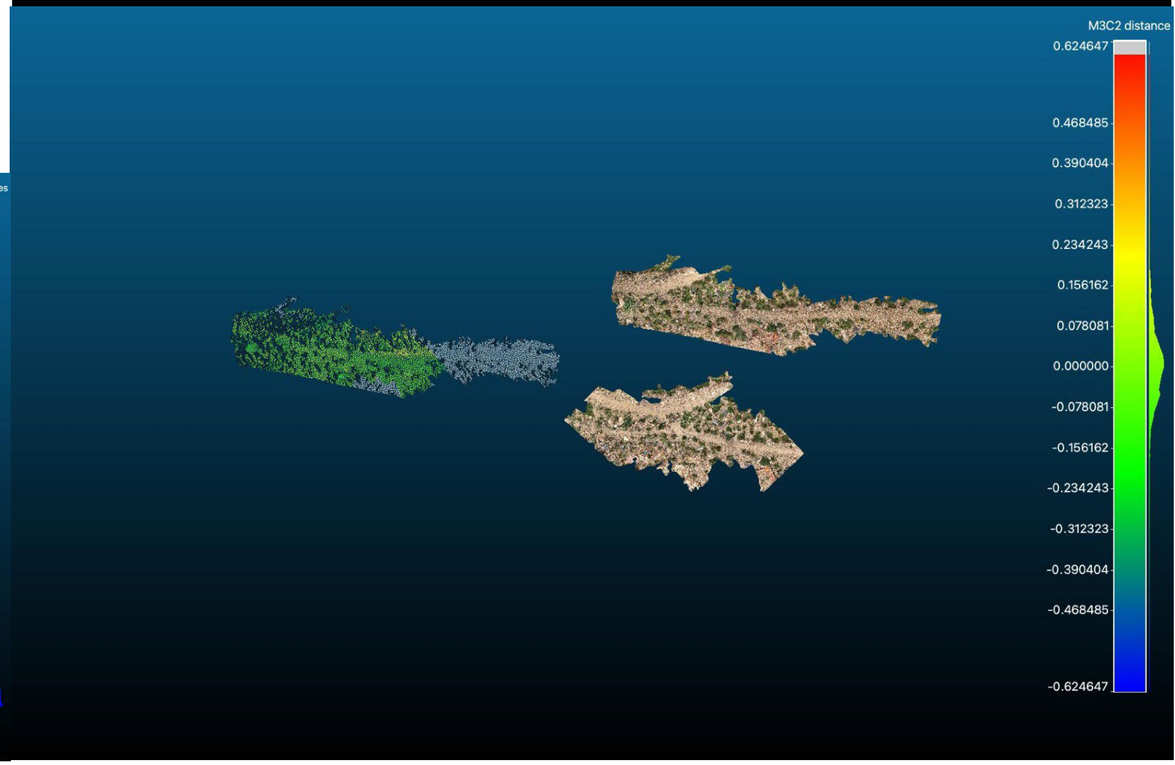


Methodology

LiDAR data from study sites (both before and after event participants passed through) was transferred to the computer computational program Cloud Compare & Structures From Motion. Point clouds made up of millions of geolocated laser light pulses are plotted in 3D and connected into a mesh. Photographs taken from the same position are then referenced and overlaid onto the mesh to present a model of the study site accurate to 1mm.

Within cloud compare, the pre and post models are laid atop one another and a difference model is used to calculate change in erosion both for trail widening and entrenchment. Changes in ecological impact are also measured.



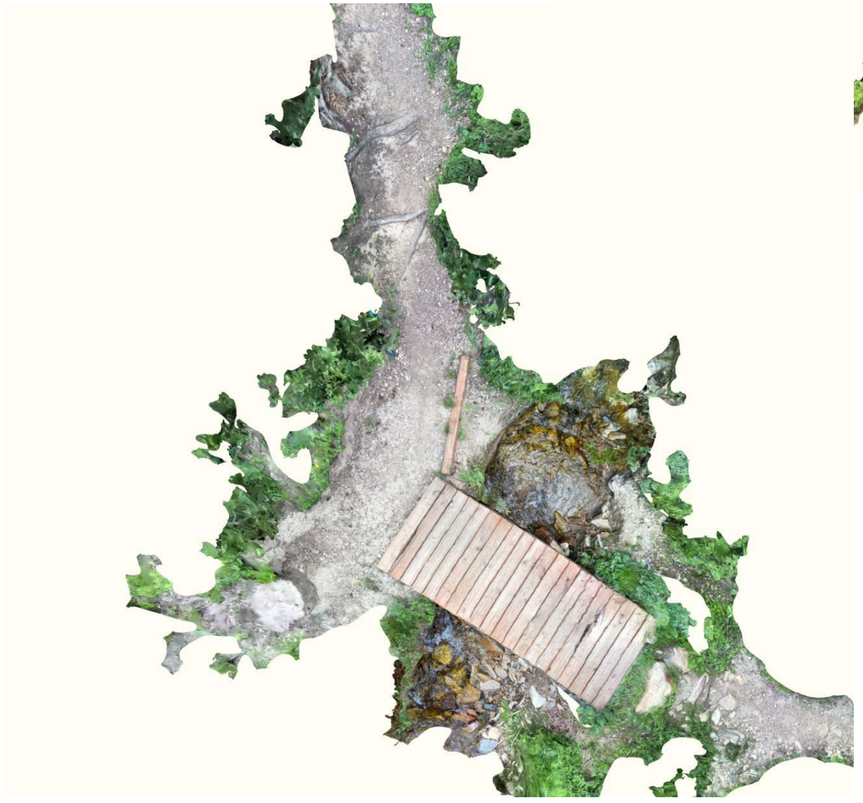


Results

Looking at the Bridge crossing specifically, which transitions from a wetland to steep trail through deciduous forest, an analysis of sedimentation, root degradation and trail widening can be performed.

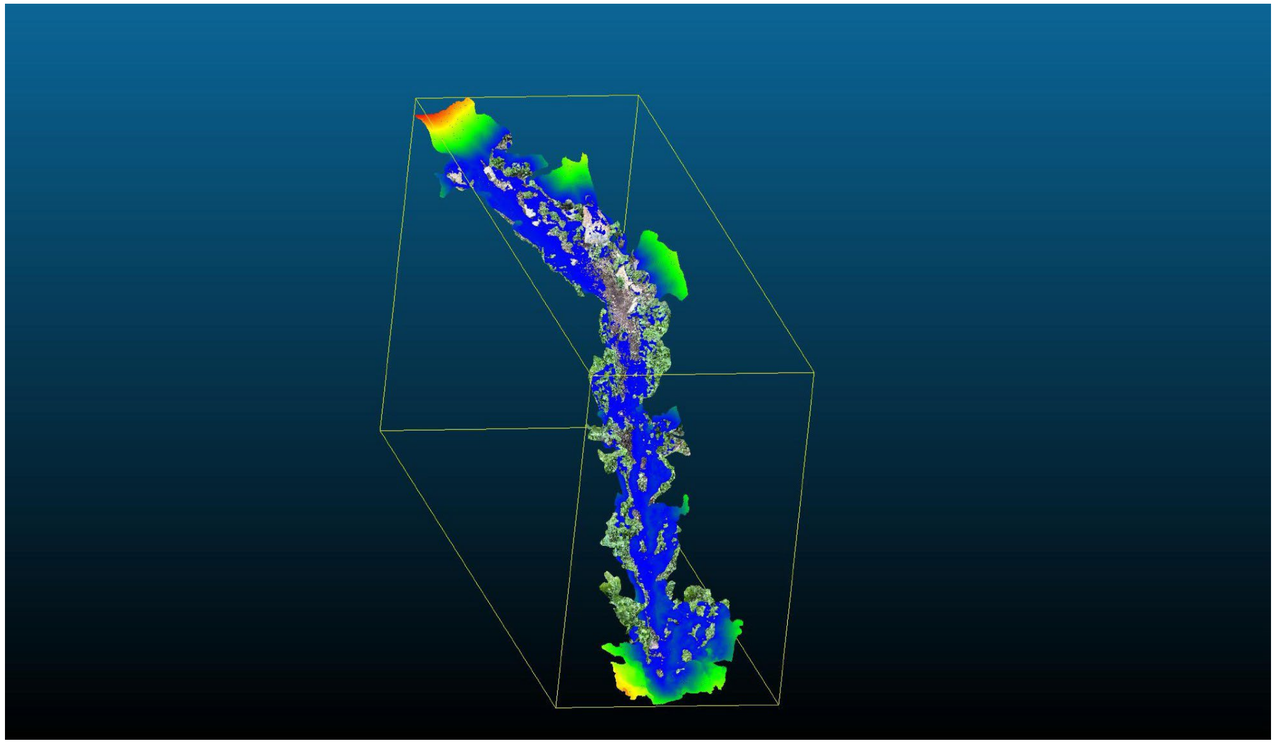
No evidence was found regarding erosion, ecological impact, or disturbance of the stream channel throughout the study area.

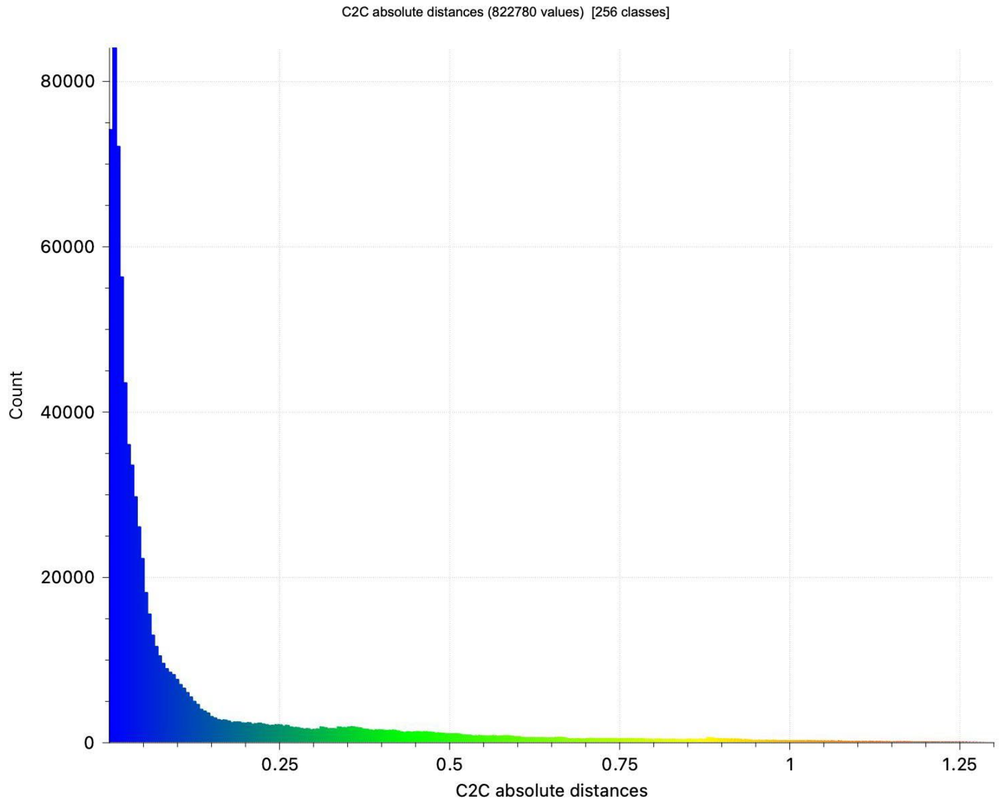
No evidence was found suggesting further erosion around tree roots or of incision into the trail on the steeper uphill portion of the trail here.



Results

Looking at the steepest and most soil dominated portion of the course (found in Peruvian Basin), the figure to the right displays a color scaled change in surface model. Even after the passing of runners from the 28km and 50km races, this section of the course experienced minimal erosion and deposition with a maximum of 0.75 cm of change to the soil surface. Additionally, no trail widening was observed on this steep trail.



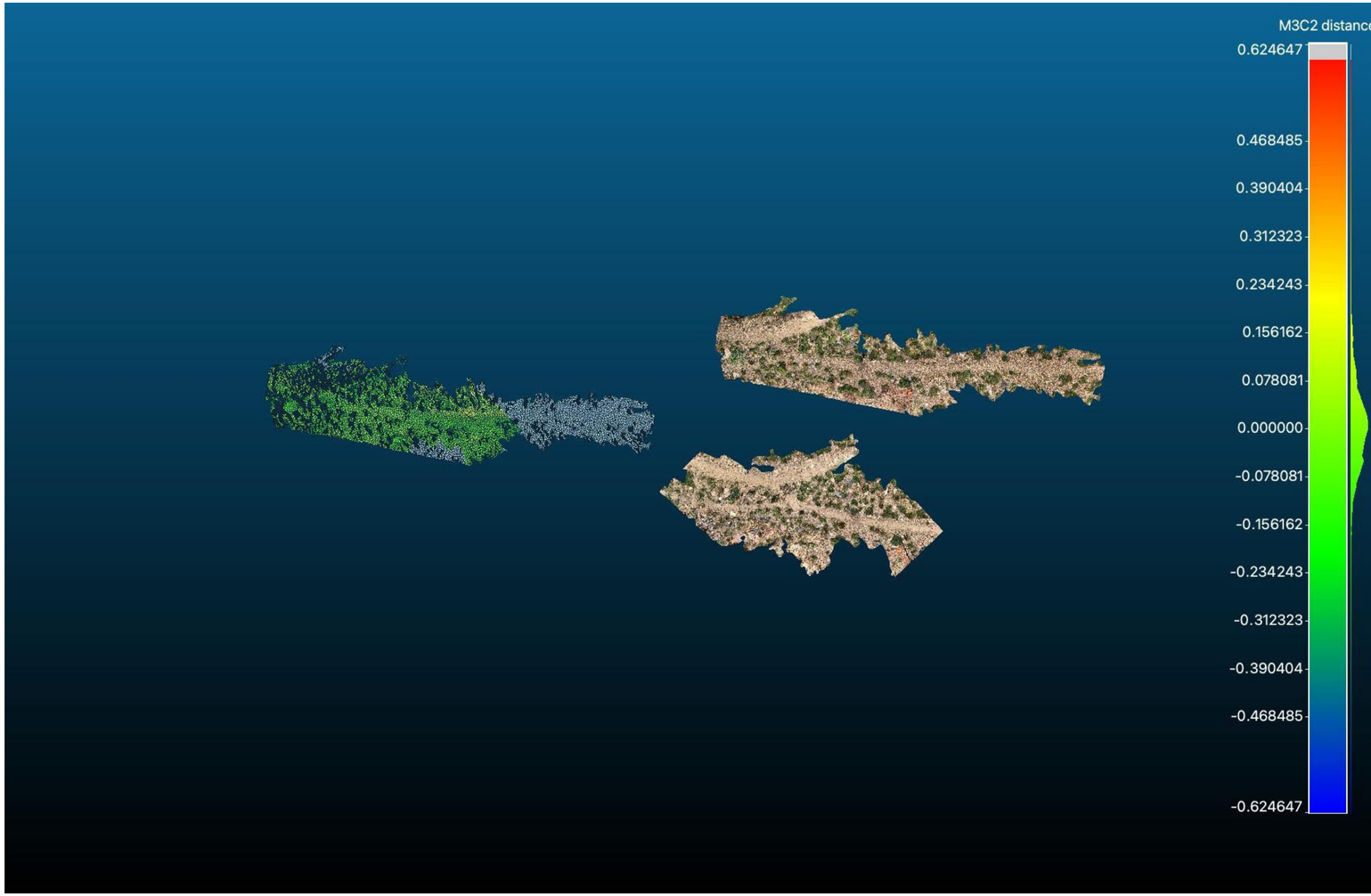


Results

Looking at the upper, rockier alpine portion of the course, some trampling impact can be observed where course flagging brought runners off of the existing trail corridor. Roughly 10 meters of 0.6 meter wide trail was “established” and compacted where only vegetation existed before.

Due to the geology in this location, no erosion or deposition was recorded alongside the vegetation impact.

It is expected that due to seasonality, snow coverage in the winter will encourage vegetation regrowth and recovery.



Results

The backcountry portion of the course recorded no differences in erosion or deposition, likely due to both the shared use case between OHV / motorized vehicles and human powered recreation as well as the alpine ecology / rock dominated nature of the trails. It has been established that soil loosening via motorized travel exacerbates erosion through the displacement of surface soil particles to a greater degree than hiking or running, even when the use of hiking poles in included (ref 1,2,3,4)

On the Northern aspect of the course, the small amount of erosion and deposition recorded did display several positive notes:

- no trail widening on existing trail was recorded, suggesting that runners stayed on trail and in single file
- No runners were observed skipping around a bridge feature - suggesting that sedimentation was minimal
- Roots and emplaced rocks on trail were not significantly altered - aspen grove and pine forest derived exposed roots were in the same condition before and after the event
- No trash was observed on trail post event
- The number of participating runners in the event (635 individuals) was less than the number of recorded users on bike (Strava data) for the year thus far, suggesting the impact of this event is less than that of standard use.

References

1. Thurston, E. & Reader, R.J. (2001). Impacts of Experimentally Applied Mountain Biking and Hiking on Vegetation and Soil of a Deciduous Forest. Environmental Management, **27(3)**: 397-409.

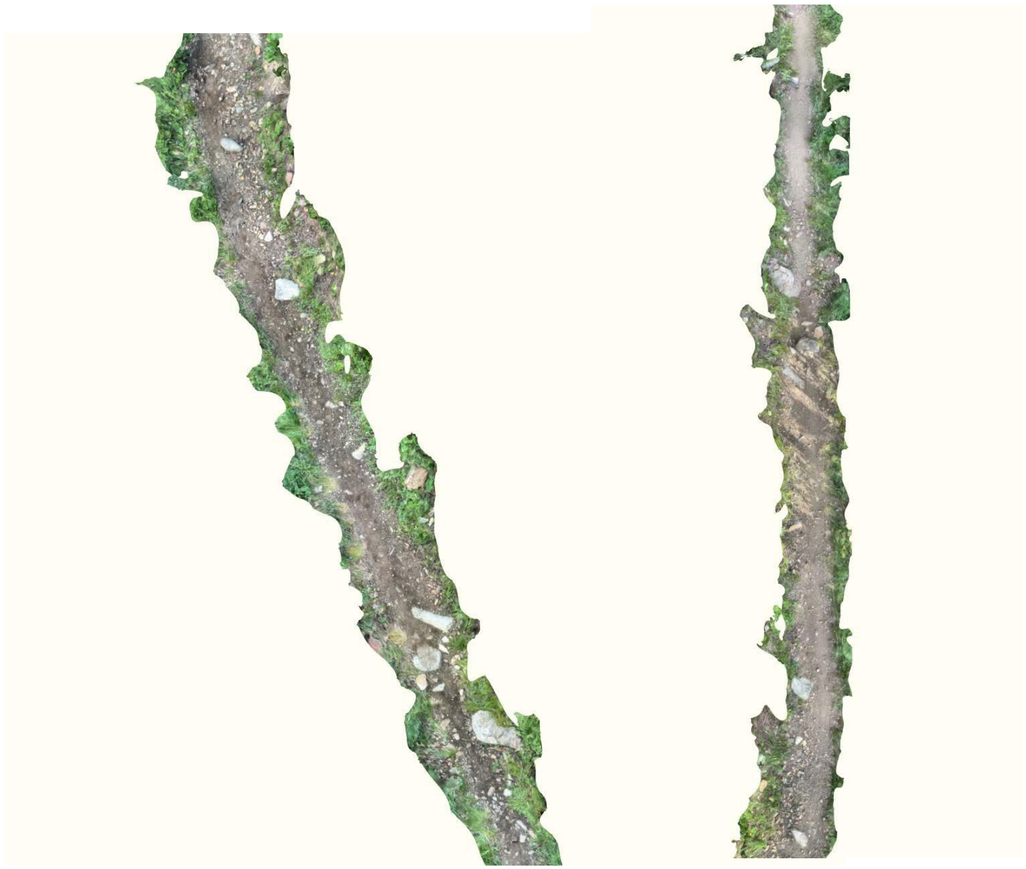
2. White, D.D., Waskey, M.T., Brodehl, G.P., & Foti, P.E. (2006). A Comparative Study of Impacts to Mountain Bike Trails in Five Common Ecological Regions of the Southwestern U.S. Journal of Park & Recreation Administration, **24(2)**: 21-41.

3. Pickering, C., Castley, J. G., Hill, W., & Newsome, D. (2010). Environmental, safety and management issues of unauthorised trail technical features for mountain bicycling. Landscape and Urban Planning, **97(1)**: 58-67.

4. Pickering, C. M., Hill, W., Newsome, D., & Leung, Y. F. (2010). Comparing hiking, mountain biking and horse riding impacts on vegetation and soils in Australia and the United States of America. Journal of Environmental Management, **91(3)**: 551-562.

Results

Observing impacts to the aspen groves further down towards SnowBird, no relationship can be found that indicates runner numbers (the full 635) left a traceable impact on this section of trail. No large rock displacement was found in comparison scans, no additional root exposure was observed through erosion, and no trail widening can be measured through model comparison.

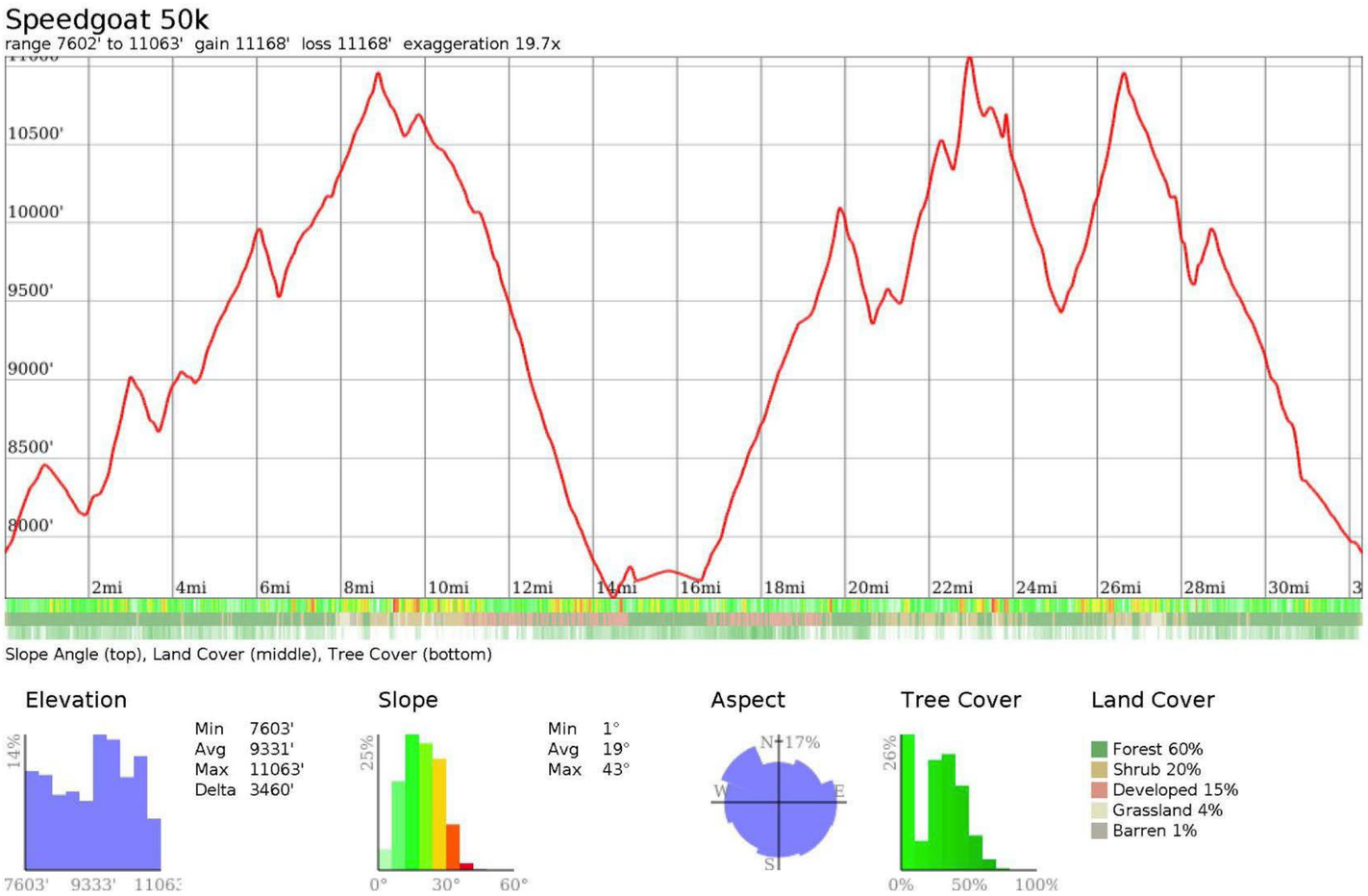


Course load

Based on the course variables (geology, trail design, seasonality, aspect, ecology) and referenced literature - the study results suggest that soil loss is not linearly attributed to the amount of use (number of visitors), but rather most related to local geomorphic conditions. *The portions of the course that saw different numbers of runners did not vary in impact, meaning that impact is not purely related to unique visitors.

Vegetation impact noted in the study results also appears in line with previous research (Liddle, M 1997 ecological impact of ecotourism) that suggests the number of passes over vegetation was not enough to permanently shift the ecology, and that a similar vegetation regime will regrow.

The figure to the right shows the courses current profile including slope angles, aspects and ecology. Based on the profile and impact study, it is not out of the question to query for a larger event size in subsequent years, especially as the rate of outdoor user ship increases as responsibly managed events offer a pathway to stewardship and reduced impact.



Study Conclusion

Over the 50km course, more than a km of linear trail was scanned with LiDAR equipment, and the entirety of the course was observed in person both before and after the event. Across the data collected and analyzed, the impacts noted are not great enough to discern from the other non-organized uses of the landscape.

Over nearly 700 runners caused the trampling of fewer than 30 meters of vegetation, and caused no calculable trail widening across the course. The amount of erosion calculated was less than the erosion estimated to occur after a week of monsoon season (Wilcox, B. 1996 - Runoff & Erosion - Los Alamos NTL Lab).

No significant geomorphological impacts were noted from the event, which would have included the failing of trail features such as retaining walls or the appearance of additional root structures as erosion took place.

In a well controlled and responsibly organized race environment, the impact of recreational users - even in high numbers - is less than that of unorganized participants over a season.

The only notable solution to lessening the impact of an event in this landscape is to utilize less steep trails, as that appears to be the primary factor for erosion in this geology and terrain.

Numbers

Over 50km of course:

- ~30km were either trails open to OHV use or used by vehicle traffic as service roads - these uses far outweigh the potential impact of runners
- Less than 1km traversed meadow ecosystems - environmental impact reduced
- No raw stream crossings were observed
- No trail widening was calculated or observed
- The amount of erosion on non-motorized multi-use single track trail was negligible compared to the natural geomorphic erosion the landscape experiences.
- 635 individual runners ran over 2 days, which is ~5% of total running traffic SnowBird trails see in a summer (Strava) & less than 0.01% of the impact urban trails in SLC see in a year.

If the course is maintained in its existing format, especially if steeper sections of trail can be avoided or improved through trail maintenance, than a two day load of 1000+ runners daily is unlikely to impact the environment in any significant manner more so than the current event structure does. If the event can leverage land managing partners to educate users on sustainable recreation, than the positive benefits of such an event would outweigh its impact on the landscape.