Quantifying impacts of recreational users on trails Grindstone 100 UTMB

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This study was undertaken in partnership with UTMB / IronMan group in conjunction with their Grindstone trail running event in Harrisonburg, Virginia.

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 3 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 terrane, ecosystem, slope, aspect, and usership 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.

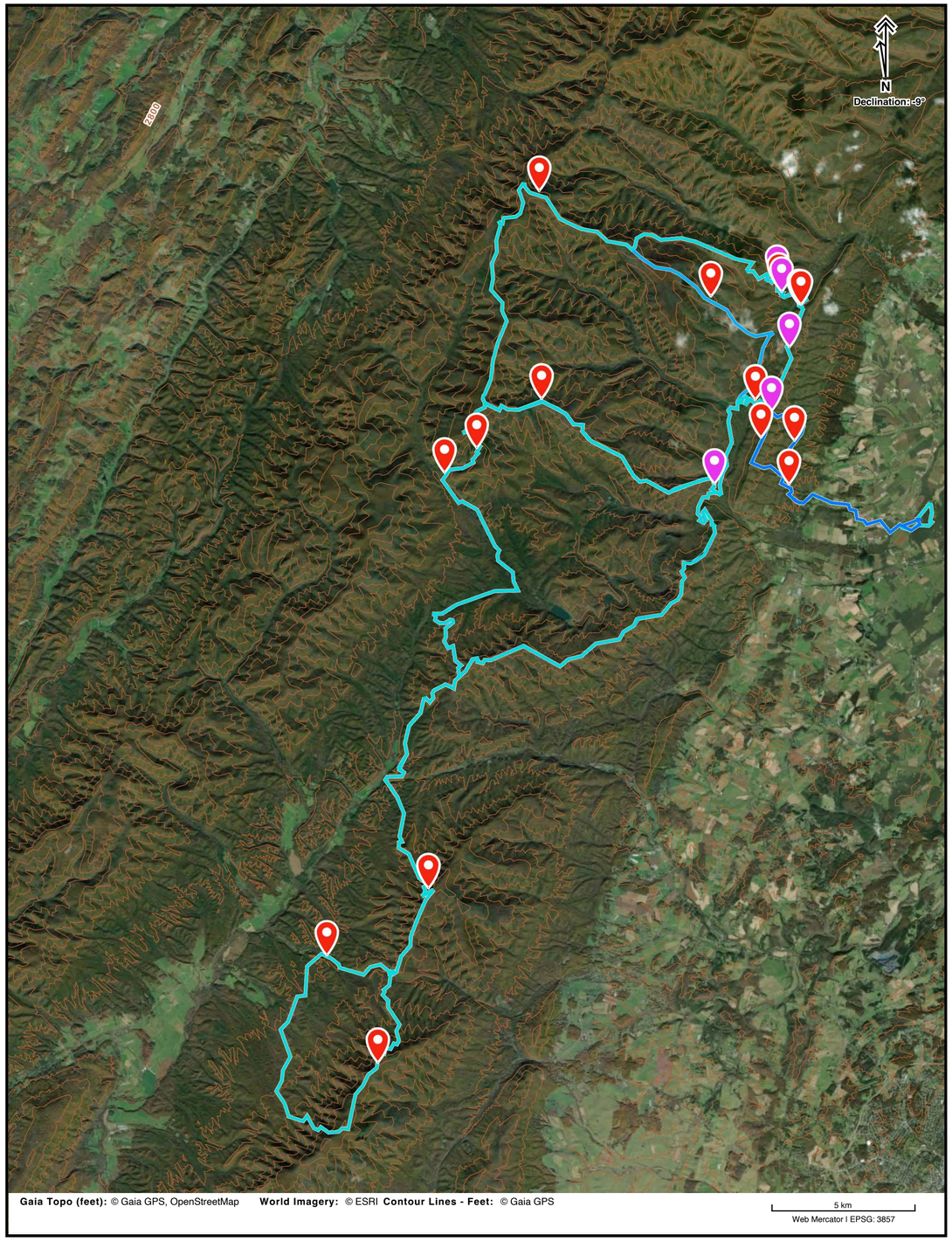
This data serves to better inform discussions between event organizers and land managers in order to set participant limits, course design, and community engagement.

Setting & methods

The regional settings studied for the event weekend included 100 mile, 100 km, and 21 km 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 400 runners cause significantly more impact than 200 runners under the same factors.

The light blue course on the map figure denotes the section run by all 100 mile course participants, with subsections run by all other entrants.

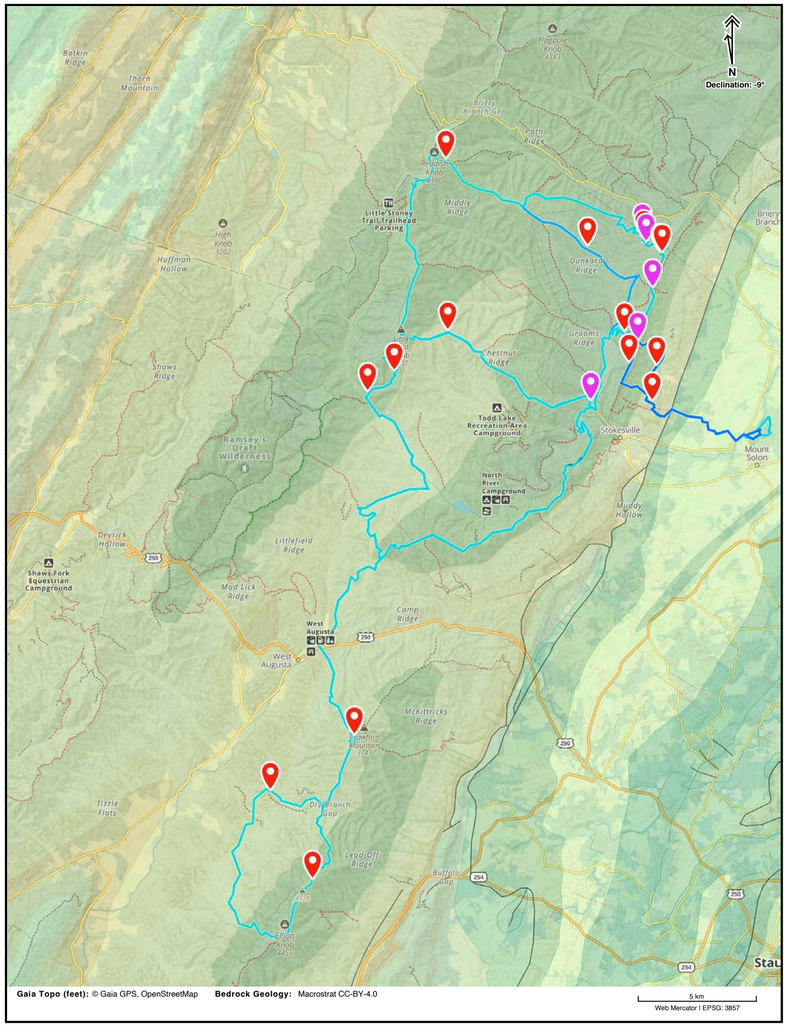
Red & pink markers are placed on LiDAR scanned study sites, while the entirety of the course was surveyed pre and post event for additional analysis. **Of note are the differences in use - with portions of the course occurring on multi-use hike, run & bike trails as well as on OHV trails.**

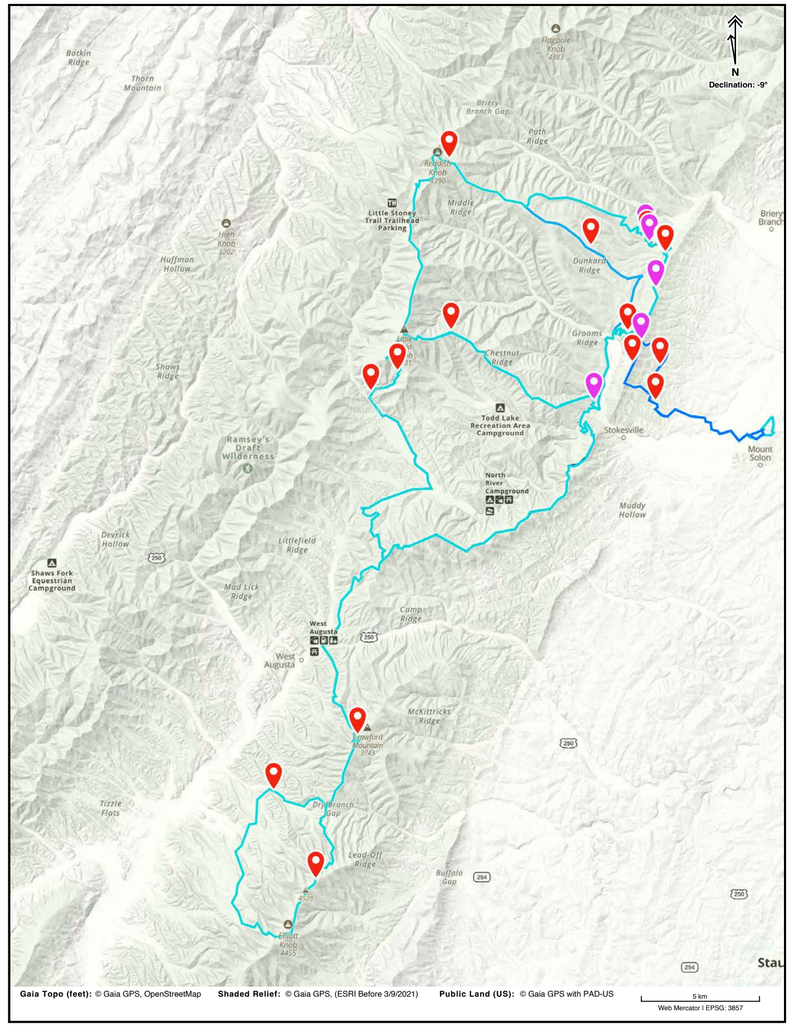


Environmental Factors

Geology lies on the overarching Poconos Formation, with the Chemung & Hampshire formations acting as sub-set Sandstone & shale lithologies (350 million years old). Ecosystems on these geologic Provences range from forest to meadow, primarily within eastern white pine and chestnut forest.

Topography, driven by geology and climate, consists of intersecting folded canyon terrane, with contrasting slopes largely around 25 degrees. This topography impacts trail degradation as steep trails without drainage tend to entrench and are impacted to a greater degree by heavy usage. This is seen frequently within the historic trails used in the events course.

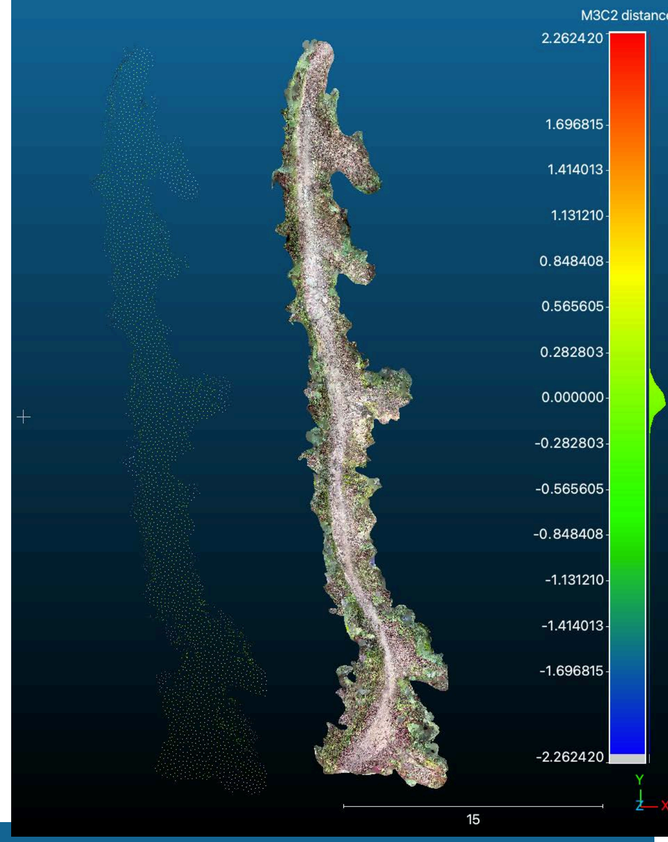


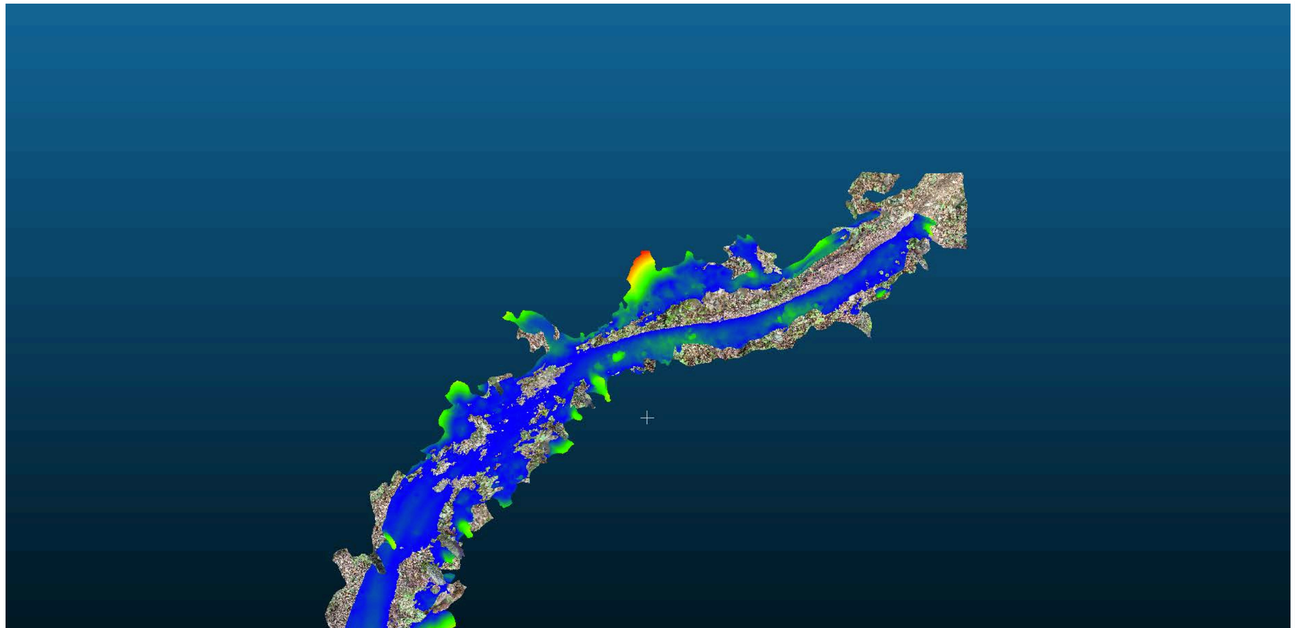


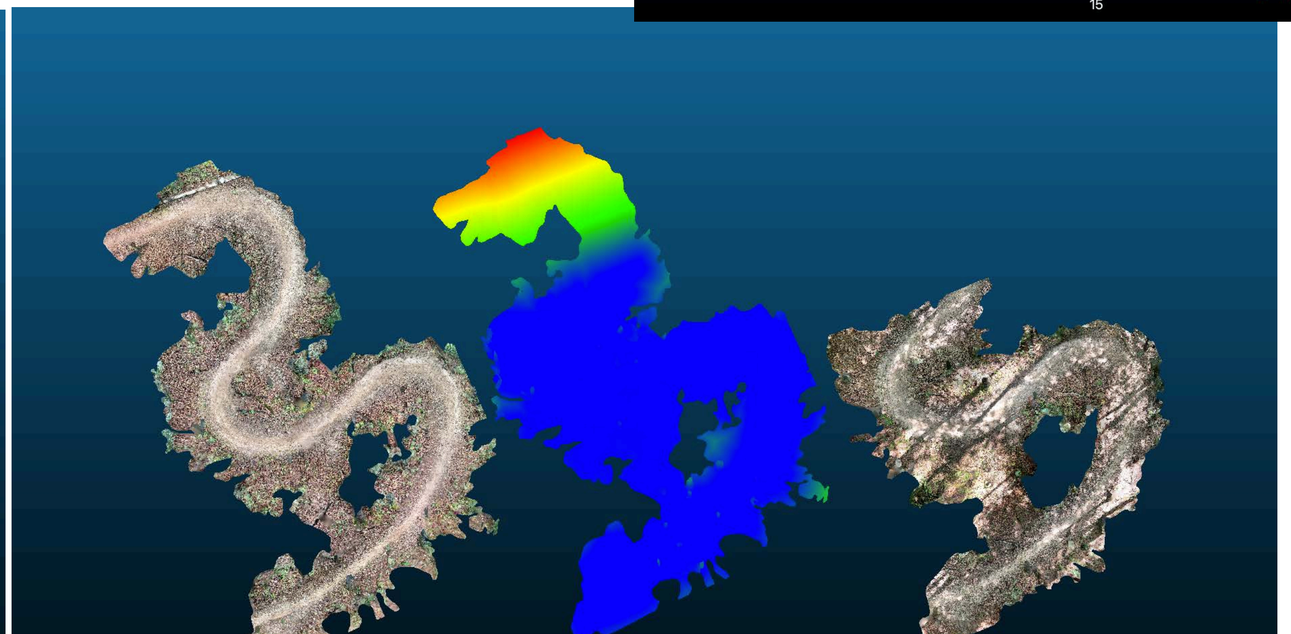
Methodology

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

35º trail pitch

Focusing on primary study areas of concern an analysis of sedimentation, erosion, root degradation and trail widening was undertaken on a steep section nearing 35º slope of R716 (Wild Oak Trail).

No evidence was found regarding erosion, ecological impact, or further disturbance of the trail throughout the study area, even as the ground was sufficiently moist from a passing storm causing precipitation of over 1” on the study area simultaneous to runner use.

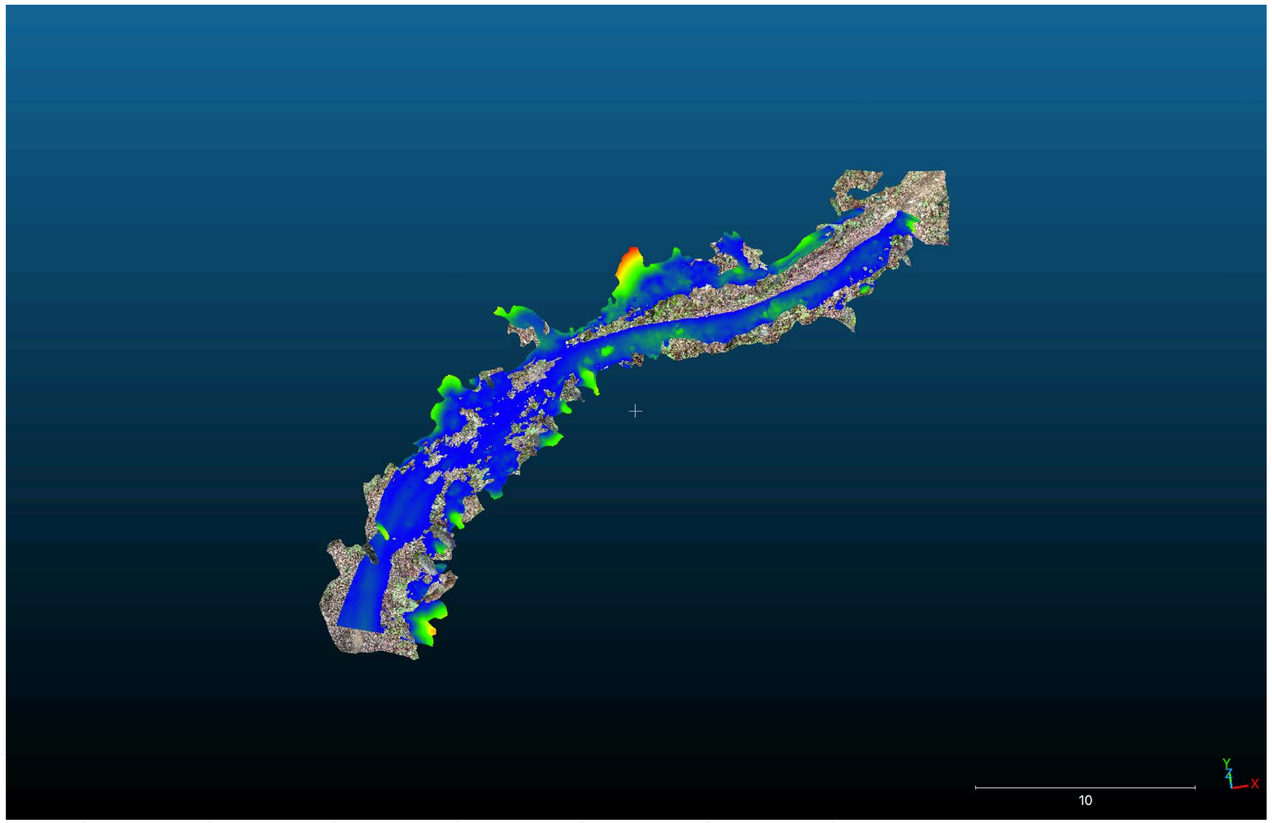
No evidence was found suggesting further erosion around tree roots or of incision into the trail on the steeper uphill portion of the trail here.

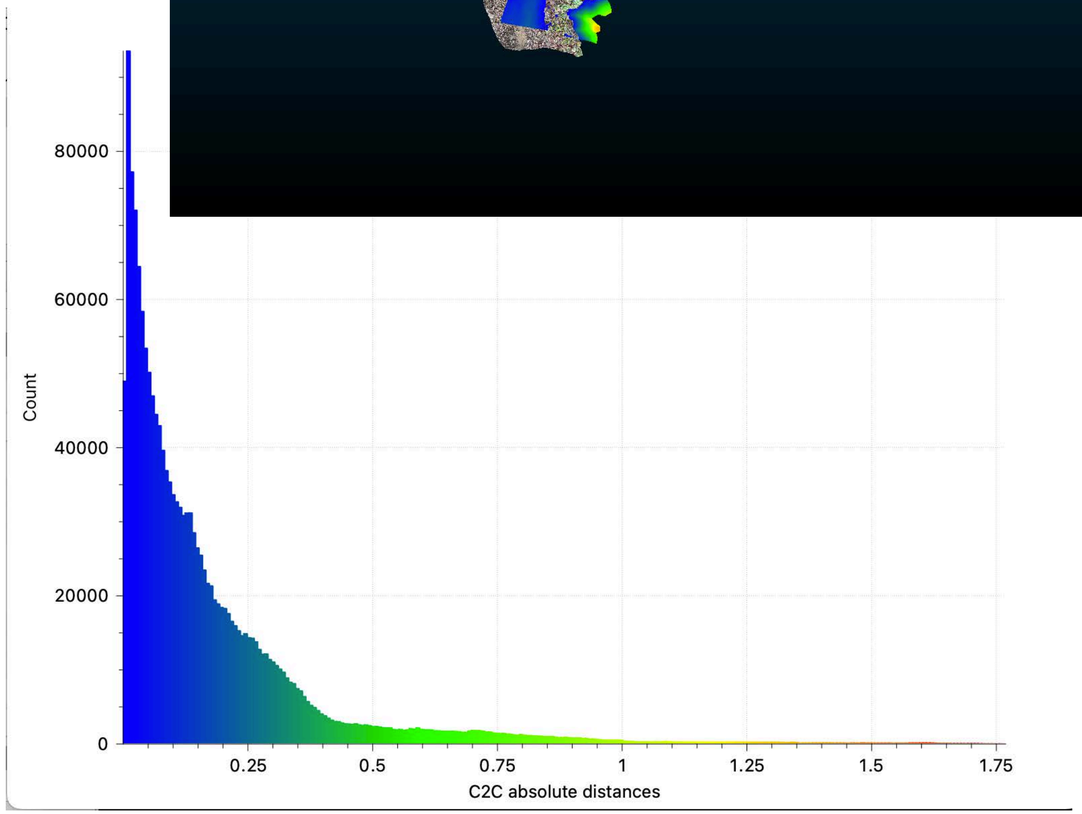
Primary concerns for the trail, which all existed prior to event occurrence include: trail braiding, poor drainage, and fallen tree limbs (sawyering).

Results

Looking at the steepest and most soil dominated portion of the course (found on Tower Trail 432), the figure to the right displays a color scaled change in surface model. Even after the passing of runners from the 100 mile, 21km and 100km races, this section of the course experienced minimal erosion and deposition with a maximum of 0.75cm of change to the soil surface. Additionally, no trail widening was observed on this steep trail.

It is likely that the rocky nature of this trail, and recently cleared drainage features helped sustain this section even in the face of precipitation and use.



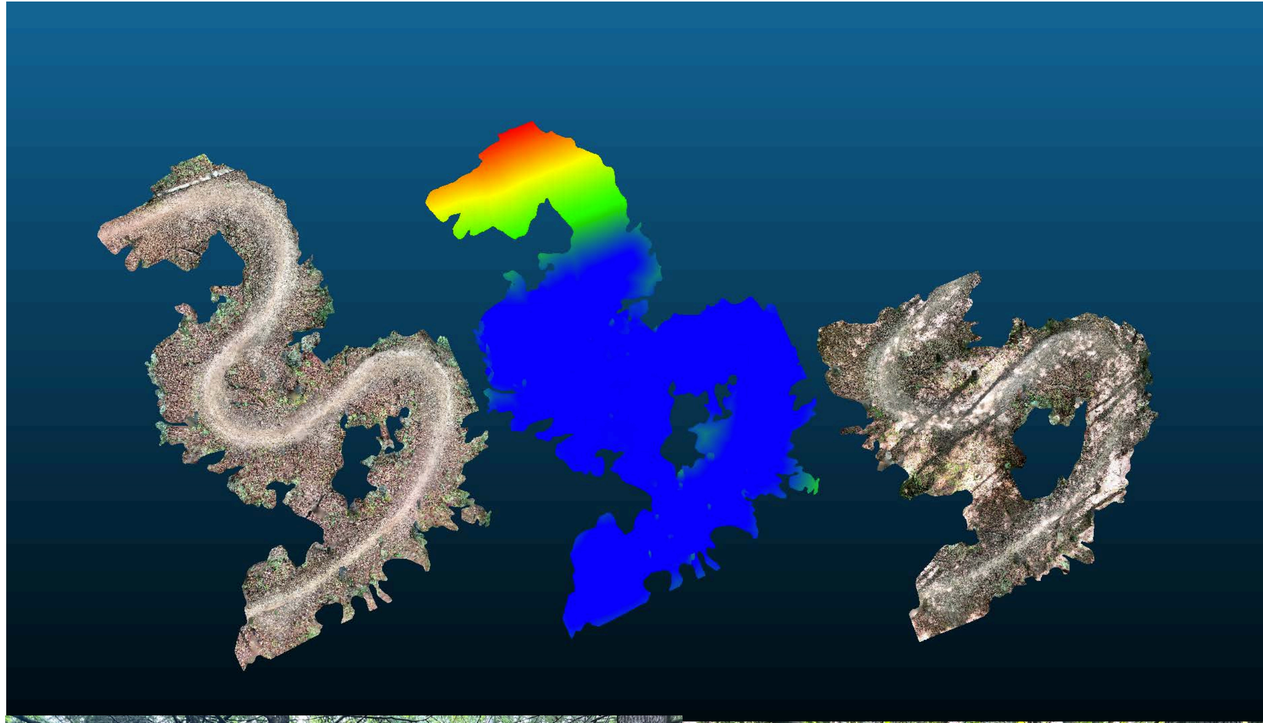


Results

In contrast to the steep sections of trail, it is worth studying several unique sections of trail, built/refashioned in the last decade specifically with the intention of sustainability and recreational enjoyment.

Trail R439 (Tillman) received RTP (recreational trails program) funding for trail enhancements, copartners included Shenandoah Valley Bicycle Coalition, DCR, USFS, USDOT and more. Improvements to this trail included rolling grade reversals, armored drainage dips, low gradient averages, and other modern trail development standards.

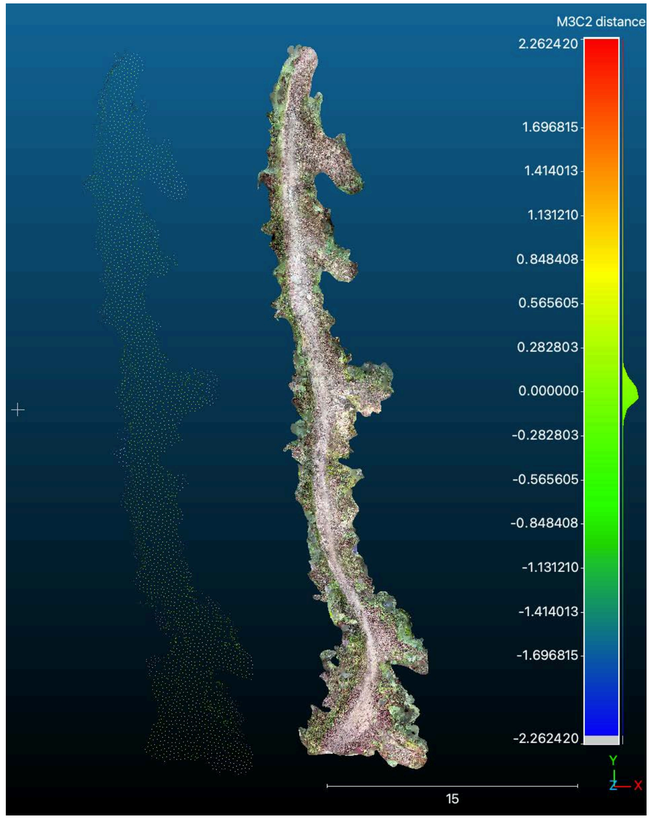
Trail sections studied across all sections that received this enhancement work showed little if any signs of damage from use. This is both a sign of the applicability of design, as well as a reflection of the rocky terrane, which is seen elsewhere on non-updated trails.

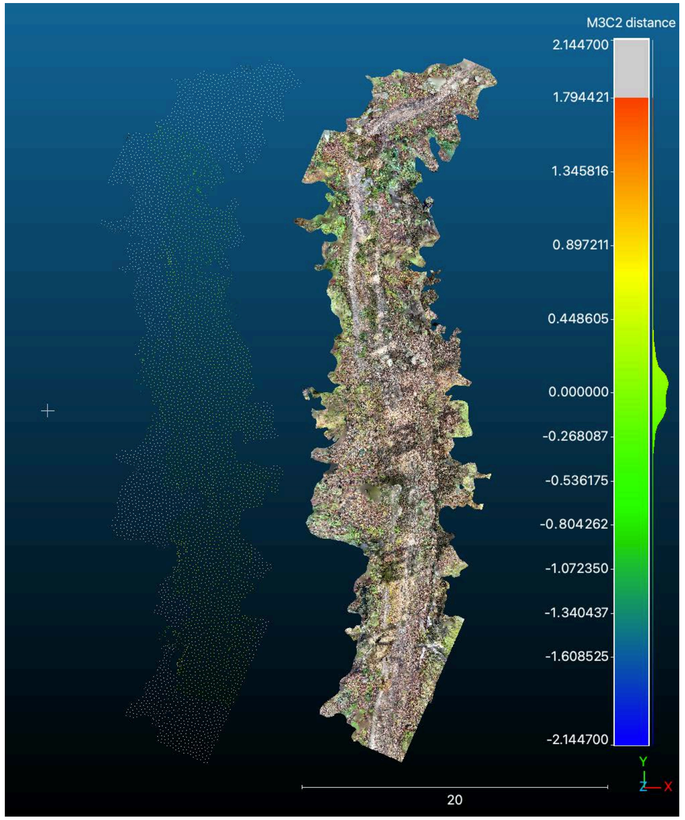


Results

Along Trail R378 (Wolf Ridge Trail) - a historic trail dating back several decades to centuries, far older than many of the other trails utilized on the course. Incised trail can be seen where the trail leaves the Ridgeline and descends to the East. This incision; however, has been slowed drastically by drains built and applied to the trail corridor in recent years.

This trail saw less than 1/4 cm of change in any given area along its length, within the bounds of error. This is to say, that hardened trails with so many years of use do not show evidence of discreet impact from singular events.



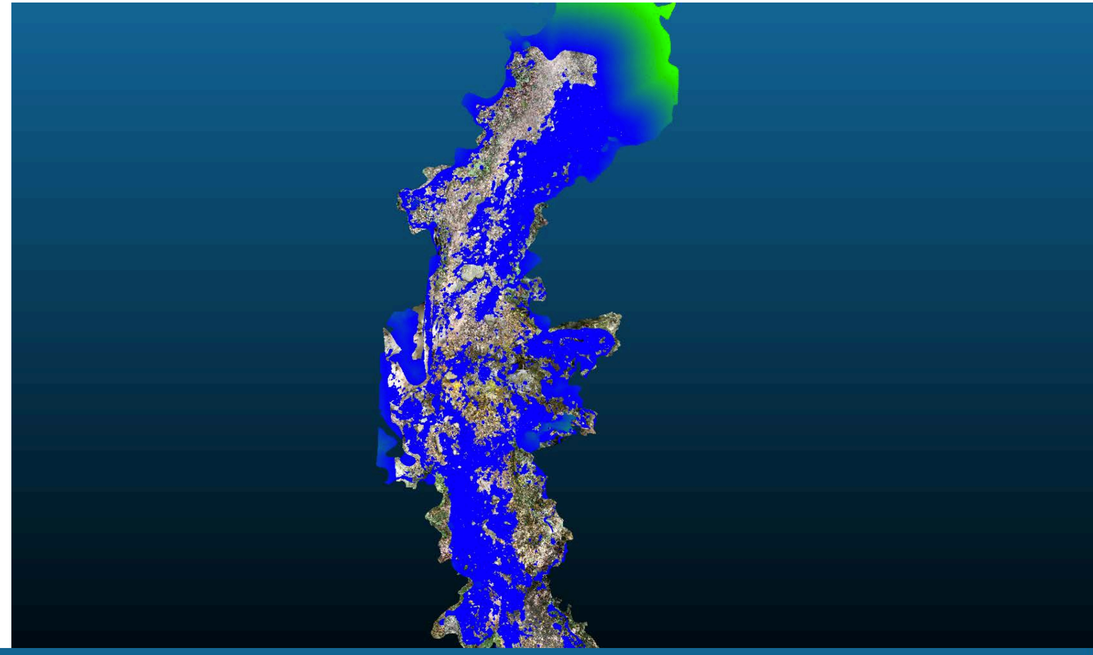


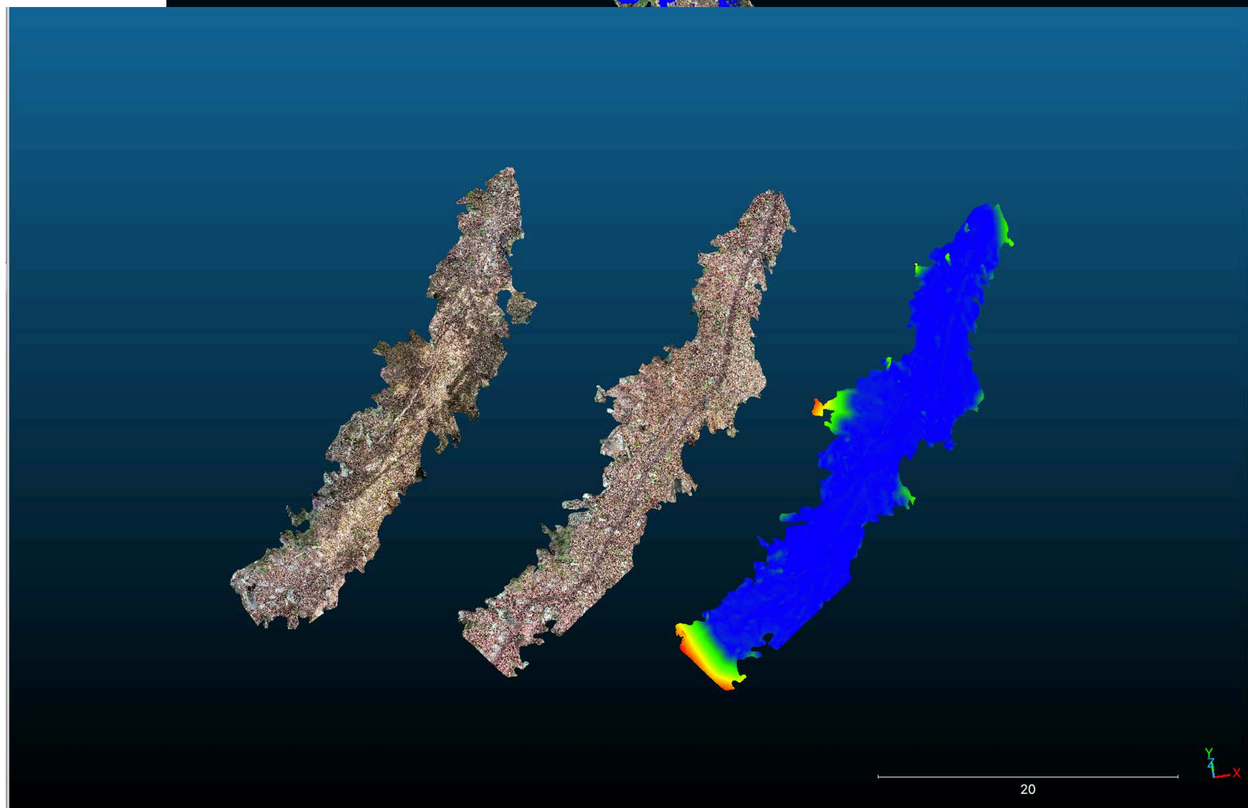
Results

A major question mark exists on the single segment of non-inventoried trail used on the course, which lies between two segments of the gravel portions of Narrowback Road. While not signed, the trail does show up on US Topographic maps and as such has existed for some time.

Studying the trail, little to no erosion can be found from event use. The only notable change is a shift from the trail being covered in leaf litter prior to the event, and a clear delineation of path being established post event. This is not erosive in any manner.

The mapped, yet un-inventoried nature of this trail suggests it may be part of a greater group of trails in the region that appear to have been erased from some official maps over the last decades, likely as a result of declining maintenance capacity and a need to reduce inventory.





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 significant changes / erosion was noted at any creek crossing sections of the course.
- Roots and emplaced rocks on trail were not significantly altered - 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 (600+ 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.
- The event immediately preceding this event (Shenandoah Mountain 100 mountain bike event) & the Grindstone event itself encouraged / required a total of over 1600 hours of volunteer trail maintenance by participants for the benefit of USFS trails. **This work provided over $45,600 worth of volunteer labor to recreation as calculated by the VSA act.**

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.

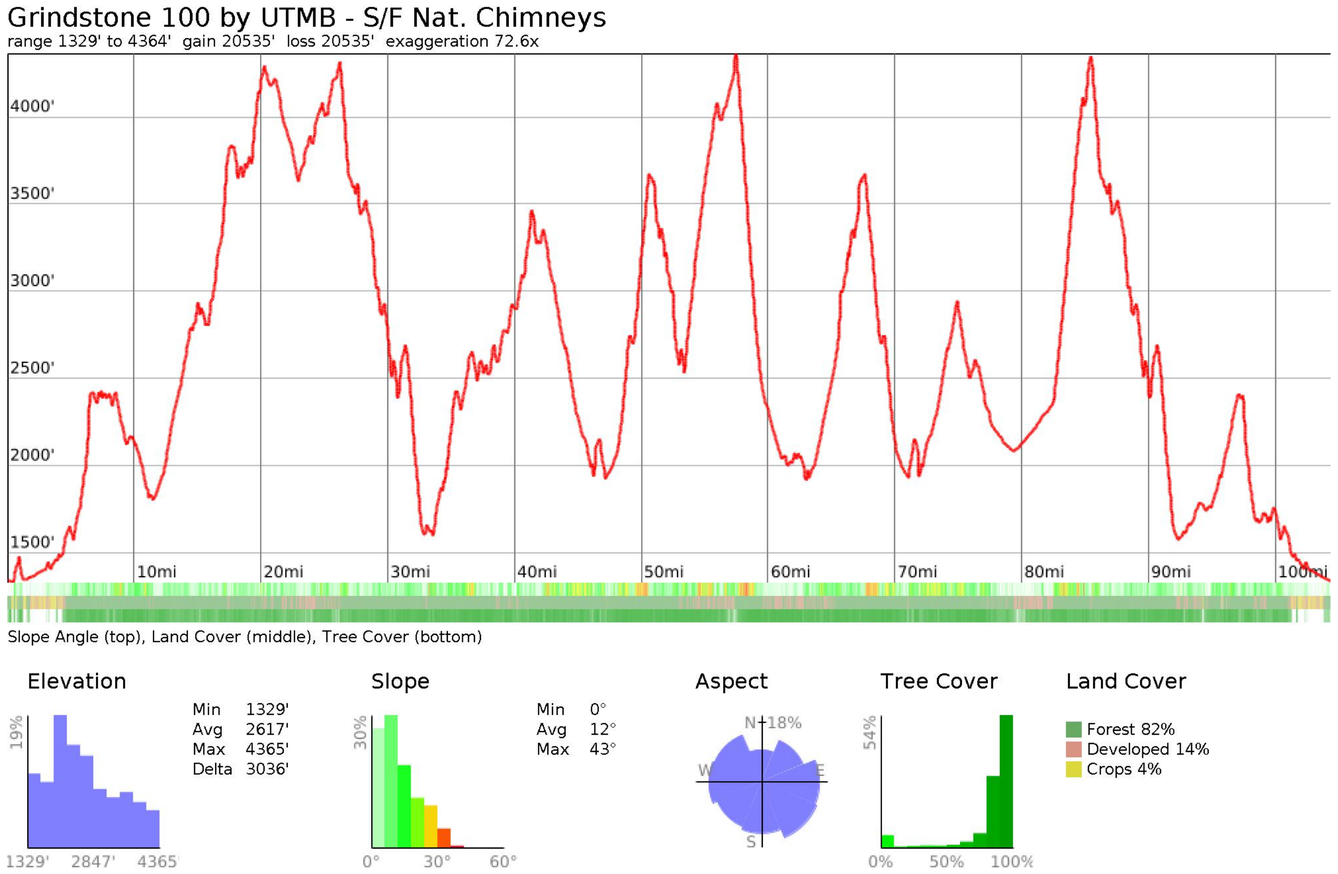
Course load

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.

It is important to re-convey, if each 100 mile course runner performs 8 hours of trail stewardship as part of their entry, a higher course load would lead to an even greater positive benefit. A cap of 500 runners for each event would provide in excess of $100,000 worth of volunteer hours to the forest.



Study Conclusion

Over the 100 mile course, more than a mile 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 600 runners caused little more than a reduction in the amount of leaf litter along a 200 meter section of trail, and caused no calculable trail widening across the course. The amount of erosion calculated was less than the erosion estimated to occur after a single tropical storm. (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 rock drainage structures. Neither did 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.

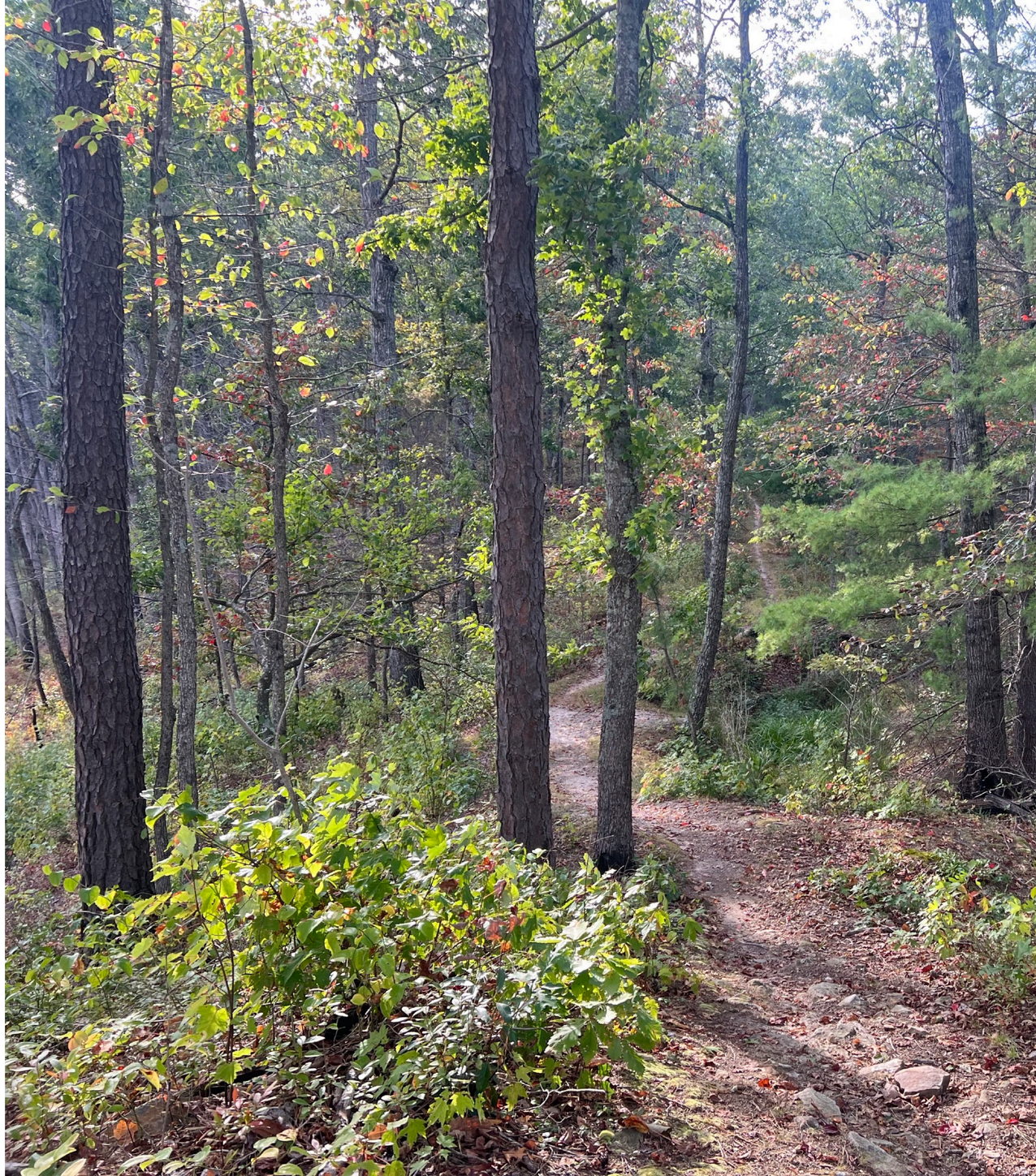
The only notable solution to lessening the impact of an event in this landscape is to utilize less steep trails, as that appears to be the primary factor for erosion in this geology and terrane; however since in this locale the steep trails are so old, their wear has slowed due to a lack of remaining soil cover.

Numbers

Over 100 miles of course:

- ~30 miles 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 1 mile traversed meadow ecosystems - environmental impact reduced
- No raw stream crossing impacts 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.
- 600 individual runners ran over 2 days, which is ~2% of total running traffic the trails in this portion of the National Forest see in a summer (Strava metro data) & less than 0.05% of the impact these trails see between bikes and foot 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 2500+ 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.



Opportunities

In historical comparison of various vintage maps, as well as through discussions with local trial builders and stewardship directors (Thomas Jenkins, Shenandoah Valley Bicycle Coalition, Trail, Elevated Trail Design, and more), it is clear that tremendous opportunity exists in the George Washington National Forest. More than double the miles of trail used in the event exist on the USFS map and on the ground; however, most are lacking in maintenance, becoming encroached by brush, drains filling with sediment and leading to erosion, and timber blocking access.

Leveraging the event as a source of volunteer income for the local USFS district ranger office would go beyond offsetting the small (if any) impact that the event has as a result of its number of participants. By selecting trails to consciously restore and maintain, the event could have clear tangibles of improvement to share with participants, land managers, and the local community.

2000 participants:
16,000 hours volunteer trail maintenance = ~$500,000 value
=~$25,000 proceeds for Land Manager
Could lead to further economic impacts through tourism, and fund needs such as parking lots, restrooms, deferred maintenance etc that land manager has.