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Hollister Hills SVRA

Trail Erosion Surveys

Summer 2020

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Recreational Vehicle Area

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Executive Summary

In accordance with the Soil Conservation Guidelines set for State OHV parks, environmental scientists at Hollister Hills State Vehicle Recreation Area (SVRA) issued a report in 2012 which ranked a trail's condition based on a three-level sustainability scale. Based on visual assessment and professional judgement, the environmental scientists categorized trails as green (acceptable), yellow (marginal), or red (action needed) to prioritize trails for best management practices. A varied subset of 18 trail segments was selected to conduct yearly detailed topographic surveys to quantify trail erosion. Within the trail sustainability index, the sample sites are also characterized by trail use: single-track, all-terrain vehicles (ATV), and road; and soil type: clay or granitic. All 18 sample sites were surveyed in 2013 using a programmable total station to produce a baseline digital elevation model (DEM). In 2020, site DEMs were created using total station ground control points (GCPs) and UAV photogrammetry processed in Pix4D. Changes in elevation were computed by raster subtraction in ArcMap and R was programmed for statistical analysis. This report discusses the 2020 trail surveys through annual and cumulative comparative analysis.

The results for the 2020 trail erosion study are summarized in the table below. The units are meters. These results are in the context of 14.11 inches of rain, close to average for the SVRA. Half of the sample sites were managed. While a few trail categories showed minor (0.01 m) of erosion or deposition, the averages of both managed and unmanaged sites were 0.00 m.

2019-2020

Averages	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Managed Sites	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	-0.01	0.00
Unmanaged Sites	0.00	0.00	0.01	0.00	-0.01	0.01	0.01	0.00	N/A

Cumulative results for the seven-year study indicate that red sites erode more than yellow and green sites. Soil type and trail type do not markedly influence erosion rates. Trail management markedly reduces erosion rate.

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1 Introduction

In 2012, Hollister Hills State Vehicle Recreation Area (SVRA) (Fig.1) created a trail sustainability index to objectively categorize trails as green (acceptable), yellow (marginal), or red (action needed) according to physical context and condition (HHSVRA 2012). This index created a standardized system which prioritizes best management practices on trails with the most erosion potential, optimizing soil conservation within the park, and follows the guidelines from the California Department of Parks and Recreation Soil Conservation Guidelines/Standards for Off-Highway Vehicle Recreation Management (CDPR 2008).



Figure 1. Hollister Hills State Vehicular Recreation Area is northeast of Salinas.

In collaboration with California State University–Monterey Bay (CSUMB), SVRA staff began a study to determine the annual erosion as it pertains to the sustainability index. In 2013, a representative subset of 18 sample sites were chosen with variability in soil type (clay or granitic), trail use (single-track, ATV, or road), and sustainability (green, yellow, or red) (Fig. 2). The first site surveys in 2013 provided baseline digital elevation models (DEMs) (Teaby et al. 2013). In the same year 3D benchmarks were created for yearly survey reproducibility. Yearly surveys were conducted to analyze annual and cumulative elevation change of each site (Silveus et al. 2014; Chow et al. 2015, 2016; Smith et al. 2016; Morris et al. 2018, Smith et al. 2019).

Erosion prevention methods have been used on a different set of sites every year beginning in 2015. In the 2019–2020 time period 9 of the 18 sites were “managed”, which includes for our purposes, grading a site either mechanically or by hand. In 2016, the Rancho site (Fig.2) gained 1m of elevation due to managed sediment deposition from the Lodge Lake sediment basin, so that site was excluded from the 2016 annual analysis.

The methods used to process data have developed since 2013. A programmable total station was used in the first two years of the study. To create a denser data set and more accurate result, low altitude photogrammetry (~3m) using a DJI Phantom connected to a large pole captured images of the trail sites. These images were processed in Agisoft PhotoScan for survey years 2015 through 2017. From 2018 to present, the image processing was done through Pix4D software to create the DEM and orthomosaic.

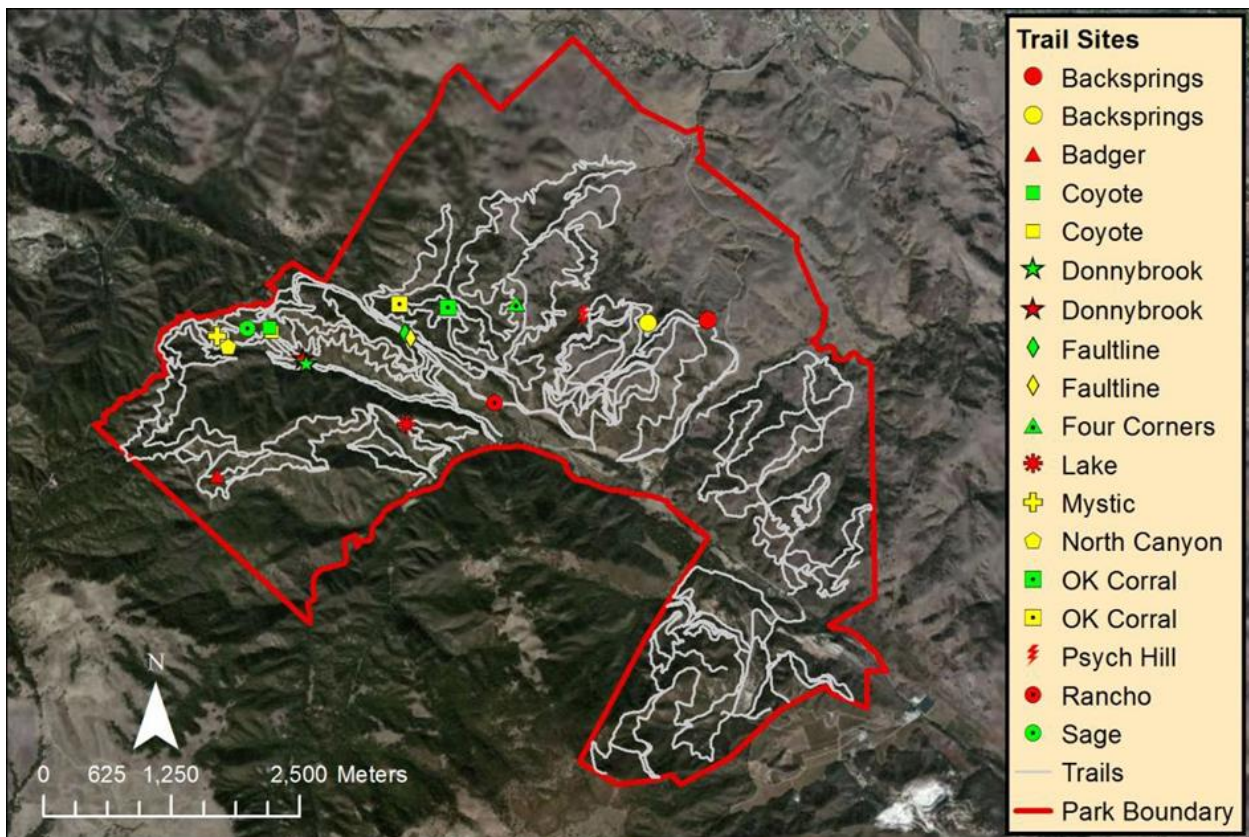


Figure 2. Trail site locations within Hollister Hills State Vehicular Recreation Area, Hollister, CA. Legend colors correspond to sustainability index.

The annual rainfall from the 2019–2020 water year was 14.11 inches, which is close to the average rainfall over the 10–year record from the Radio Ridge rain gauge at the SVRA (Table

1). The total rainfall from the previous year is slightly below the mean, 14.83 in (Fig 3). Monthly precipitation was obtained from the Radio Ridge Hollister Hills Weather Monitoring Station within the park SVRA (Western Weather Group 2017).

Table 1. Hollister Hills SVRA precipitation data obtained from Western Weather Group's Radio Ridge rain gauge (2020).

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
2011	0.89	2.29	4.15	1.81	4.07	4.57	0.20	1.11	0.37	0.00	0.00	0.00	19.46
2012	0.83	1.96	0.11	2.28	0.62	2.62	2.18	0.03	0.06	0.03	0.00	0.00	10.72
2013	0.27	2.54	4.35	0.98	0.75	0.60	0.21	0.00	0.00	0.00	0.00	0.08	9.78
2014	0.11	0.28	0.34	0.20	2.72	1.56	0.76	0.00	0.00	0.00	0.00	0.08	6.05
2015	1.05	0.51	5.23	0.00	1.26	0.17	1.14	1.24	0.00	0.02	0.06	0.08	10.76
2016	0.18	3.42	2.97	5.67	0.88	5.23	0.87	0.08	0.00	0.00	0.00	0.00	19.30
2017	2.76	1.53	2.20	9.70	6.27	1.91	1.55	0.06	0.06	0.00	0.00	0.05	26.09
2018	0.23	1.43	0.29	2.48	0.27	4.62	1.43	0.00	0.00	0.00	0.00	0.00	10.75
2019	0.30	3.78	1.94	3.54	7.56	2.35	0.30	1.48	0.00	0.00	0.00	0.00	21.25
2020	0.00	1.62	6.62	1.00	0.00	3.00	1.51	0.36	0.00	0.00	0.00	0.00	14.11

Monthly Average	0.66	1.94	2.82	2.77	2.44	2.66	1.02	0.44	0.05	0.01	0.01	0.03
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Annual Average 14.83

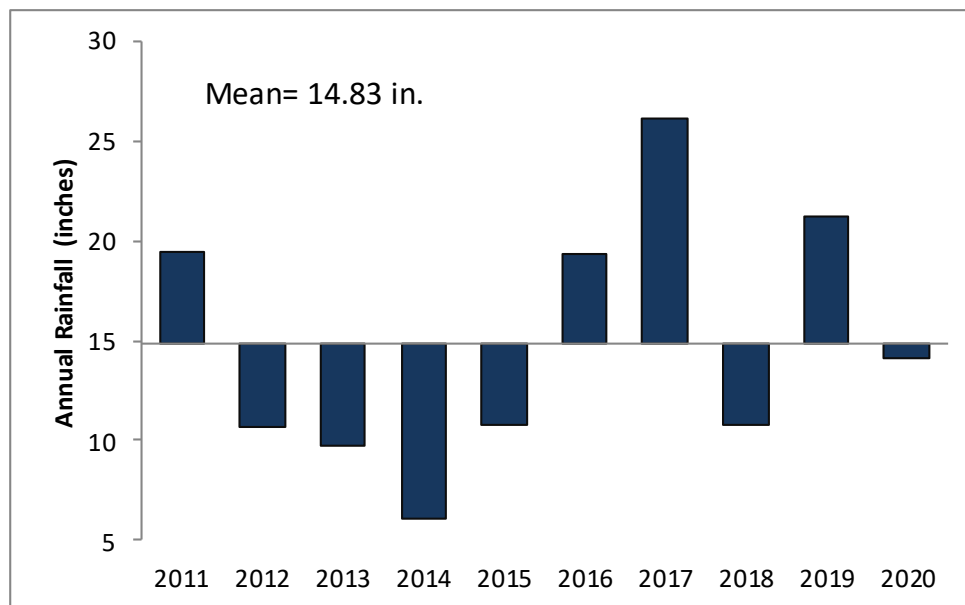


Figure 3. Annual precipitation at Hollister Hills SVRA. Values shown with respect to the mean value of 14.83 inches.

2 Methods

2.1 Field Survey

All 18 sample sites were surveyed in summer of 2020. The previously created benchmarks were used to recreate the local survey framework. At each site, one benchmark with assigned 3D coordinates was used as the position for the 3" Nikon total station. The other benchmark at the site was used to set local false north for horizontal control.

Ground control points (GCPs) were placed within the sample site to improve the accuracy of image processing. The GCPs were 10 cm x 10 cm, dual colored squares that were temporarily nailed into the ground in a zigzag pattern. The total station was used to survey the coordinates for each GCP within the local framework.

Images were captured using a Hero 3+ GoPro attached to a gimble on a DJI Phantom Drone. Low altitude aerial photos were taken approximately 3 m above ground and in a "mowing the lawn" pattern to ensure sufficient overlap of images (>70 percent). An additional objective was to capture multiple GCPs in individual photos. Each site's imagery was processed using Pix4D structure-from-motion (SfM) software (<https://www.pix4d.com/>).

2.2 Surface Modeling

For each site, a subset of images was identified that clearly captured the bare trail. Those photos and the associated GCP coordinates were uploaded to Pix4D software. Within the software workflow, the images were aligned and GCPs in each image were manually assigned to optimize the SfM result. A dense point cloud was created to accurately cover the microtopography of the site. The resulting DEM and orthomosaic were exported as layers for each site.

GCP location 3D root mean square error (RMSE) and additional site parameters are presented in Table 2. For most sites, ground surface resolution was between 2 and 4 mm/pixel, which is comparable to the typical total station closing error (<0.01 m). Vertical precision was generally within a few mm (Table 2).

Table 2. Locations, site condition, usage, soil type, 2020 sample area and input parameters (number of photos, number of GCPs), as well as resulting GCP root mean square error (RMSE), GCP vertical (Z) error, and resolution for each site's DEM.

Trail Location	Condition	Usage	Soil Type	Area (m ²)	Photos #	GCPs #	3D RMSE (m)	Z RMSE (m)	Resolution (mm/pix)
OK Corral_1	Green	Single Track	Clay	10	88	9	0.005	0.010	2
Donnybrook_2	Green	Single Track	Granite	11	95	9	0.006	0.005	4
4 Corners	Green	ATV	Clay	65	145	8	0.009	0.009	2
Coyote_1	Green	ATV	Granite	31	102	7	0.004	0.003	3
Faultline_2	Green	Road	Clay	22	86	9	0.009	0.008	2
Sage	Green	Road	Granite	31	69	5	0.008	0.008	4
OK Corral_2	Yellow	Single Track	Clay	9	93	8	0.004	0.003	2
Mystic	Yellow	Single Track	Granite	13	66	6	0.008	0.010	9
Backsprings_2	Yellow	ATV	Clay	53	125	10	0.004	0.003	3
Coyote_2	Yellow	ATV	Granite	44	130	9	0.006	0.005	3
Faultline_1	Yellow	Road	Clay	66	124	8	0.009	0.009	2
North Canyon	Yellow	Road	Granite	98	84	10	0.008	0.009	3
Psych Hill	Red	Single Track	Clay	27	101	11	0.003	0.003	3
Donnybrook_1	Red	Single Track	Granite	14	100	7	0.007	0.005	2
Backsprings_1	Red	ATV	Clay	62	82	9	0.007	0.006	3
Badger	Red	ATV	Granite	46	84	7	0.007	0.008	2
Rancho	Red	Road	Clay	41	43	3	0.002	0.001	2
Lake	Red	Road	Granite	96	100	8	0.012	0.010	4

2.3 Analysis

A difference in DEMs (DoD) was created for each site in ArcMap (v 10.6) with the *Raster Calculator* tool. A mask was created to remove vegetation and DEM imperfections. Due to the differences in trail site area every year of the study, the mask with the smaller area was the limitation for raster subtraction. Using the new mask, the 2019 DEM was subtracted from the 2020 DEM to find the average elevation change. The results were then annually compared to 2019, 2018, 2017, 2016, 2015, 2014, and 2013 and used to quantify cumulative change. Further analysis and plotting were done using R software and the “ggplot2” package (R Core Team 2013).

Sites were analyzed to review the sustainability index's accuracy of potential soil erosion. Sites were categorized and analyzed according to trail use, soil type, and trail maintenance to determine their importance in erosion rates. The correlation between soil type, trail use, and sustainability with managed grading is also analyzed. All analysis was done both annually and cumulatively, including seven years of data collection.

3 Results

Each site's spatially-averaged annual elevation change is shown in Table 3, along with the trail's sustainability category, usage type, and soil type. Positive numbers depict deposition

and negative numbers represent erosion. The overall DoD for each site and a breakdown of annual and cumulative elevation change are illustrated in Appendix A. Between 2019 and 2020, half of the sites were managed and all trail sites categorized as roads were managed (Table 3).

Table 3. Annual elevation change at each site. Site condition is from HHSVRA (2012). Positive numbers indicate deposition and negative numbers indicate erosion. Grey indicates sites that were managed before the annual survey. Blue value is site with imported material—excluded from 2016 analysis.

Trail Location	Condition	Usage	Soil Type	Δ Elev (m)						
				20-19	18-19	17-18	16-17	15-16	14-15	13-14
OK Corral_1	Green	Single Track	Clay	-0.011	0.020	-0.031	0.037	-0.039	0.000	-0.007
Donnybrook_2	Green	Single Track	Granite	-0.010	-0.001	0.022	-0.016	0.007	-0.036	-0.045
Four Corners	Green	ATV	Clay	-0.012	-0.012	-0.092	0.082	0.009	-0.085	-0.009
Coyote_1	Green	ATV	Granite	0.007	-0.016	-0.050	0.033	-0.031	-0.001	-0.023
Faultline_2	Green	Road	Clay	0.020	-0.048	-0.020	0.046	-0.026	-0.044	-0.019
Sage	Green	Road	Granite	0.000	-0.023	-0.007	0.031	-0.026	-0.001	-0.008
OK Corral_2	Yellow	Single Track	Clay	0.002	-0.053	-0.009	-0.009	-0.079	-0.001	-0.022
Mystic	Yellow	Single Track	Granite	0.018	-0.008	-0.023	0.010	-0.021	-0.016	-0.002
Backsprings_2	Yellow	ATV	Clay	-0.019	-0.035	-0.016	-0.014	0.065	-0.005	-0.012
Coyote_2	Yellow	ATV	Granite	0.024	-0.010	0.066	-0.018	0.029	-0.016	-0.016
Faultline_1	Yellow	Road	Clay	-0.030	-0.022	-0.050	0.021	-0.031	-0.052	-0.041
North Canyon	Yellow	Road	Granite	-0.003	-0.027	0.001	0.035	0.079	-0.021	-0.060
Psych Hill	Red	Single Track	Clay	0.012	-0.064	N/A	-0.171	0.040	0.040	0.040
Donnybrook_1	Red	Single Track	Granite	0.002	-0.013	-0.023	0.008	-0.170	-0.055	-0.038
Backsprings_1	Red	ATV	Clay	-0.016	0.022	-0.226	0.191	-0.173	0.000	-0.006
Badger	Red	ATV	Granite	0.019	-0.031	0.011	0.006	-0.170	-0.036	-0.038
Rancho	Red	Road	Clay	0.020	-0.036	-0.013	-0.025	1.286	-0.031	-0.023
Lake	Red	Road	Granite	-0.028	-0.058	0.013	-0.020	0.022	-0.039	-0.083

In the subsequent analyses, we present elevation change values rounded to the centimeter in keeping with data precision estimates. Annual averages parsed out by sustainability index color, trail use, and soil type are presented in Table 4. For each year, those categories are also divided to analyze maintained sites and not maintained sites. In 2020, several trail categories exhibited minor (0.01 m) of elevation change, but the grand average was 0.00 m of change (Table 4).

Table 4: Annual average elevation change summarized by year, sustainability rating, use and grading. Sites with insufficient data are denoted by “N/A.”. Positive numbers indicate deposition and negative numbers indicate erosion.

2013-2014

Averages	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	-0.02	-0.02	-0.03	-0.02	-0.01	-0.03	-0.01	-0.02	-0.04
Managed Sites	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unmanaged Sites	-0.02	-0.02	-0.03	-0.02	-0.01	-0.03	-0.01	-0.02	-0.04

2014-2015

Averages	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	-0.02	-0.02	-0.02	-0.03	-0.02	-0.02	-0.01	-0.02	-0.03
Managed Sites	NA	NA	NA	NA	NA	NA	NA	NA	NA
Unmanaged Sites	-0.02	-0.02	-0.02	-0.03	-0.02	-0.02	-0.01	-0.02	-0.03

2015-2016

Averages	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	-0.03	-0.09	0.01	-0.02	-0.03	-0.03	-0.04	-0.05	0.00
Managed Sites	-0.02	-0.07	0.07	0.01	0.04	-0.07	NA	-0.03	0.02
Unmanaged Sites	-0.03	-0.10	0.00	-0.02	-0.05	-0.02	-0.04	-0.06	0.00

2016-2017

Averages	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	0.01	0.00	0.00	0.04	0.02	0.01	-0.02	0.05	0.01
Managed Sites	0.02	0.04	0.00	0.03	0.04	0.01	-0.01	0.04	0.01
Unmanaged Sites	0.00	-0.08	0.02	0.04	0.00	0.00	-0.03	0.08	0.03

2017-2018

Averages	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	-0.03	-0.05	-0.01	-0.03	-0.06	0.00	-0.01	-0.05	-0.01
Managed Sites	0.00	0.00	0.01	-0.03	-0.02	0.01	-0.02	0.00	0.00
Unmanaged Sites	-0.06	-0.12	-0.04	-0.03	-0.10	-0.01	-0.01	-0.16	-0.04

2018-2019

Averages	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	-0.02	-0.03	-0.03	-0.01	-0.03	-0.02	-0.02	-0.01	-0.04
Managed Sites	-0.03	-0.05	-0.02	-0.02	-0.04	-0.03	NA	-0.01	-0.04
Unmanaged Sites	-0.02	-0.02	-0.03	-0.01	-0.02	-0.02	-0.02	-0.01	-0.03

2019-2020

Averages	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Managed Sites	0.00	0.00	-0.01	0.00	0.00	-0.01	0.00	-0.01	0.00
Unmanaged Sites	0.00	0.00	0.01	0.00	-0.01	0.01	0.01	0.00	N/A

Before 2016, the results did not show much variability. In 2016, park staff began management on selected trails and photogrammetry implementation enlarged the sample sites and created a more detailed result. Annual average elevation change became more variable in 2016, 2017 and 2018, but variability has not been great in 2019 or 2020. A low p-value in a one-way ANOVA with unequal variance ($F=3.4$, $df=6/50.6$, $P=0.007$) indicates that mean elevation change varies through time. The variability does not seem to track rainfall.

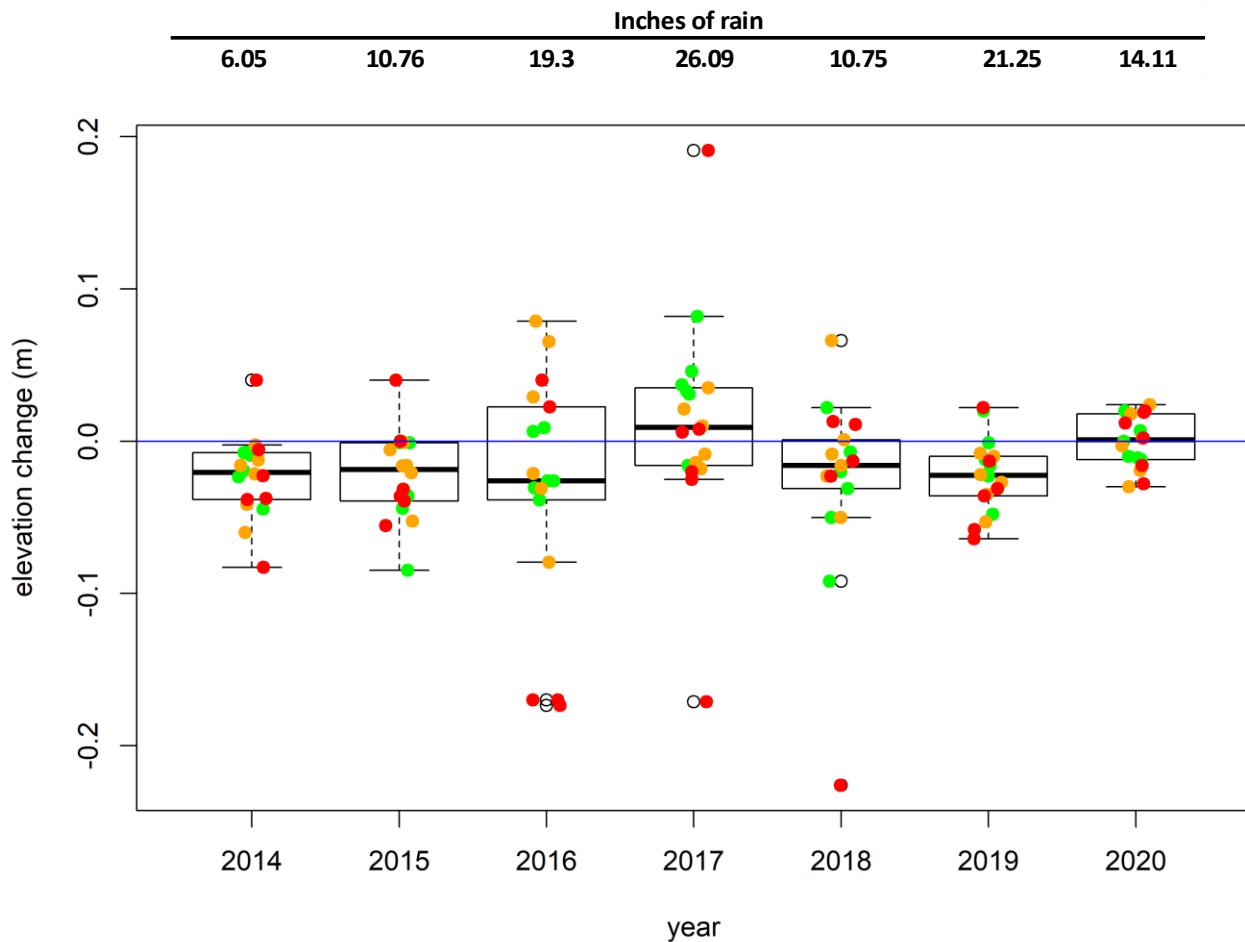


Figure 4. Annual average elevation change for seven years of assessment with corresponding annual precipitation. Dots show individual sites colored by sustainability index (green, yellow, red). ANOVA $P= 0.007$.

Table 5 summarizes the averaged results over the seven years categorized by trail use, soil type, and sustainability index. Each category is further analyzed by managed versus

unmanaged. When all sites are examined together, a one-way ANOVA with unequal variance does not find the annual erosion rates of red, yellow and green rated trails significantly different ($F=1.2$, $df = 2/74.4$, $P=0.3$). When sites are considered by annual average the mean and median across the sustainability index are similar (Table 5; Fig. 5). The standard deviation of red sites (0.07 m/yr) is more than twice that of yellow (0.03 m/yr) and green sites (0.03m/yr). A Levene's test for homogeneity of variance shows that red site's annual variability is significantly higher than annual variability of other color categories ($df=2$, $F=6.03$, $P=0.003$).

When considering cumulative elevation change over the seven-year period, red sites show more erosion than either green or yellow sites (Fig. 5). A one-way ANOVA with unequal variance and subsequent Tukey test indicate that red sites are significantly different from the other sites ($df = 2/8.3$, $F=6.05$, $P=0.02$), with red sites showing more erosion than green and yellow sites by 0.14 m each (Table 5).

Table 5: Summary of seven-year average annual and cumulative elevation changes (m) for all study sites. Notes match those from Table 4.

Averages	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	-0.02	-0.03	-0.01	-0.01	-0.02	-0.01	-0.02	-0.01	-0.01
Managed Sites	-0.01	-0.02	0.01	0.00	0.00	-0.02	-0.01	0.00	0.00
Unmanaged Sites	-0.02	-0.05	-0.01	-0.01	-0.03	-0.01	-0.02	-0.03	-0.02
Cumulative	Overall	red	yellow	green	clay	granite	ST	ATV	Road
All Sites	-0.11	-0.21	-0.07	-0.07	-0.13	-0.10	-0.12	-0.10	-0.10
Managed Sites	-0.03	-0.08	0.05	-0.01	0.02	-0.10	-0.03	-0.01	-0.02
Unmanaged Sites	-0.15	-0.37	-0.09	-0.08	-0.21	-0.09	-0.12	-0.19	-0.10

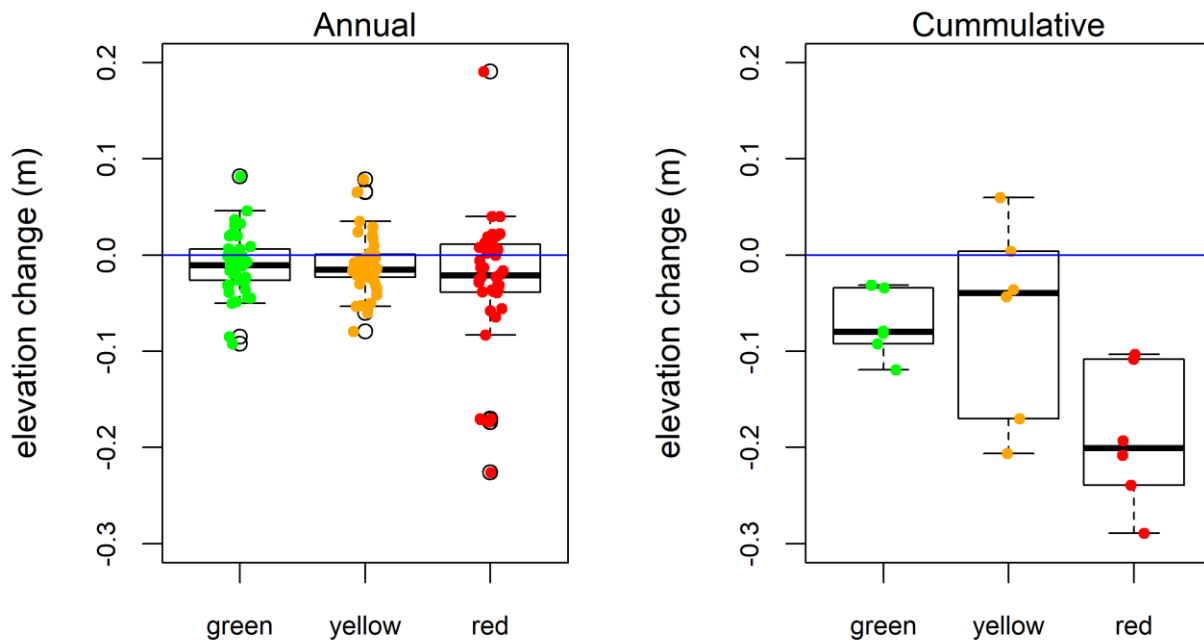


Figure 5. Boxplots of all study sites parsed by sustainability index. (Left) Annual elevation change of all sites (ANOVA $p = 0.3$). (Right) seven-year cumulative elevation change of all sites (ANOVA $p=0.02$).

While managed and unmanaged sites showed no overall change in 2020, the net effect of management has been to reduce erosion in nearly all categories and in both annual and cumulative analyses (Table 5, Fig. 6). Managed sites show 0.12 m less cumulative erosion than unmanaged sites (Table 5). In both managed and unmanaged sites, red sites have much more extreme values (Fig. 6).

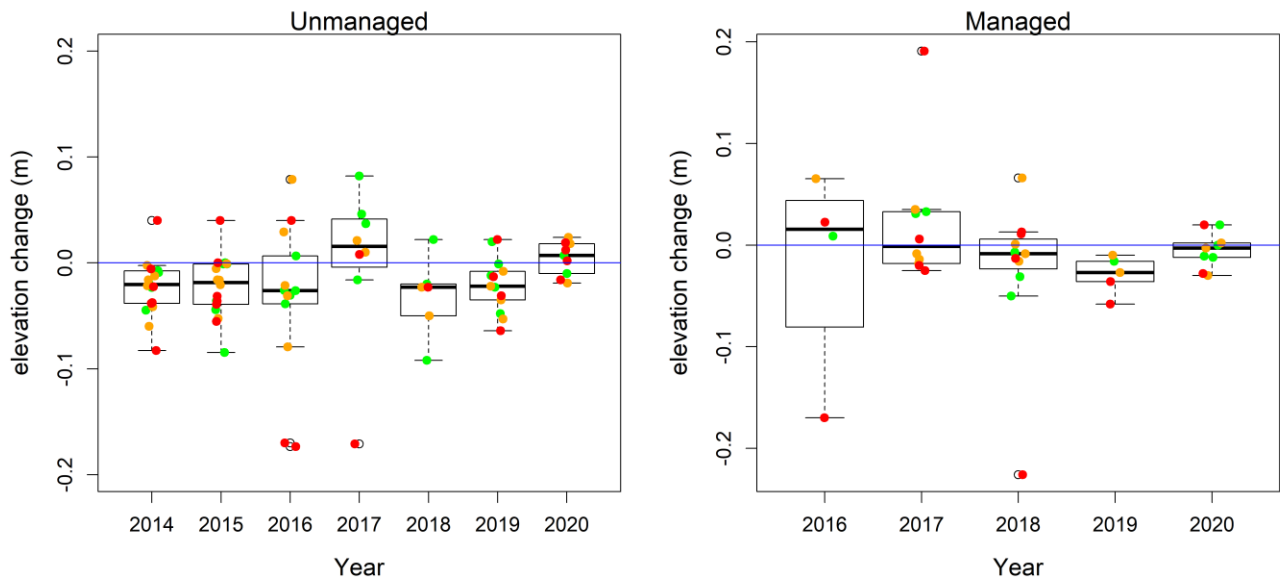


Figure 6: Boxplots of annual elevation change for all sites separated by year and management activity. Dots show individual sites colored by sustainability index (green, yellow, red).

Soil type (clay and granite) did not impact mean erosion rates when analyzed on an annual averaged scale (Fig.7; Table 5). The cumulative erosion of clay is greater than granite (Table 5), but a two-sample t-test, suggests that the differences are not significant when considered annually ($p=0.7$) or cumulatively ($p=0.7$; Fig. 7). Managed clay soil sites had an average annual erosion rate of 0.00 m/yr, whereas unmanaged clay soil sites had 0.03 m/yr of erosion (Table 5). The positive impact of managing clay trails is underscored by the cumulative values, with unmanaged clay sites eroding 0.21 m as compared to 0.02 m of deposition on managed clay sites. The impact of management on granitic trails is less clear (Table 5). Trails with a red sustainability index had more cumulative erosion than trails with green or yellow indices (Fig. 7; Table 5).

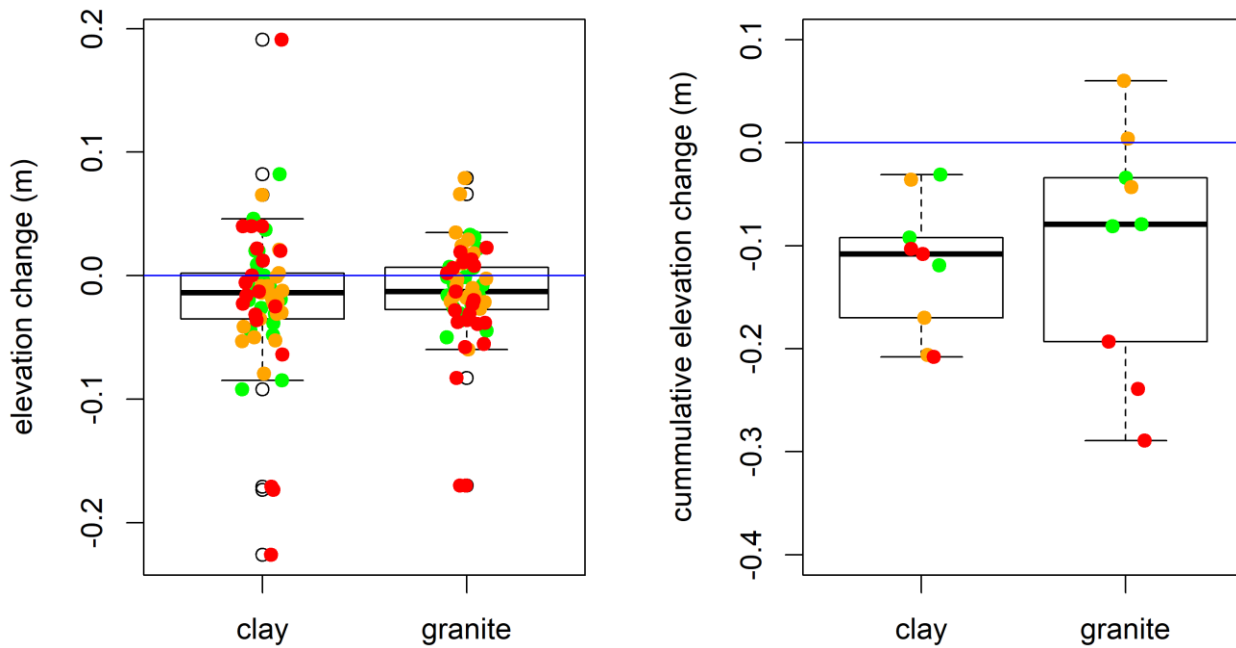


Figure 7. (Left) Annual elevation change of all sites separated by soil type. (Right) Cumulative elevation change of all sites separated by soil type. Dots show individual sites colored by sustainability index (green, yellow, red).

There are no significant differences between the erosion rates when parsed by trail use (Fig. 8; Table 5). There is no significant difference among the trail uses annually or cumulatively ($p=0.97/p=0.96$), but red sites appear to have higher cumulative erosion rates for all trail use types (Fig. 8).

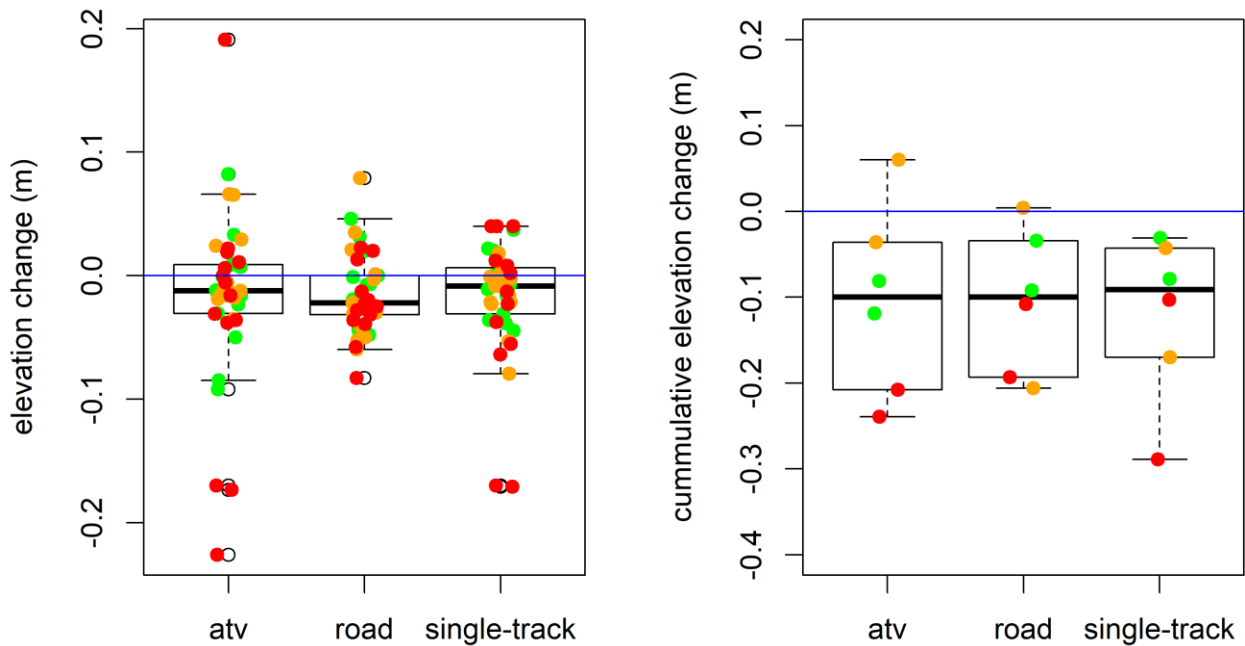


Figure 8. (Left) Annual elevation change of all sites separated by trail use. (Right) Cumulative elevation change of all sites separated by trail use. Dots show individual sites colored by sustainability index (green, yellow, red).

4 Discussion

Seven years of high-resolution surveys of 18 trail sites at Hollister Hills SVRA have produced the following general results.

- 1) We expected the Green, Yellow, Red trail sustainability index to correlate with low, intermediate, and high rates of trail erosion (CDPR 2008; HHSVRA 2012). While no statistical differences between the categories are present at the annual scale, red sites erode significantly more than green or yellow sites when the cumulative effects of seven years are considered ($p < 0.05$; Table 5). Green and yellow sites have similar annual and cumulative erosion rates (Fig. 5).
- 2) The Universal Soil Loss Equation and other soil conservation models normally predict higher soil erosion rates with higher rainfall. Rainfall has varied from 6 inches to 26 inches during the study but the average annual erosion rate was lowest following the highest rain year (2017). There appears to be little correlation between rainfall and erosion rates (Fig. 4; Table 4).

- 3) Clay and granite sites erode at approximately equal rates cumulatively and when averaged over several years (Fig. 7).
- 4) Differences in trail classification did not influence erosion rates cumulatively or annually (Fig. 8; Table 4).
- 5) Trail management that mainly consists of replacing the sidecast berm back into the trail tread is an effective strategy for improving trail sustainability in nearly all trail categories (Table 4; Table 5; Fig. 6).

5 References

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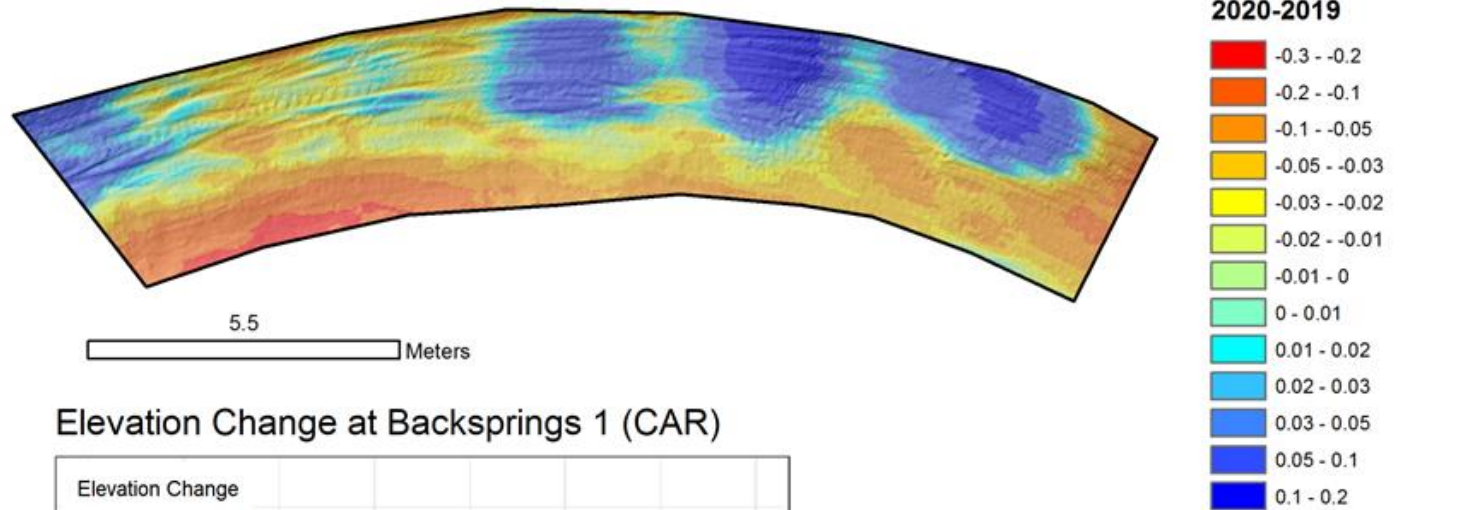
6 Appendix A

The following appendix shows the results of analysis of the surveys with Pix4D Software for all 18 sites.

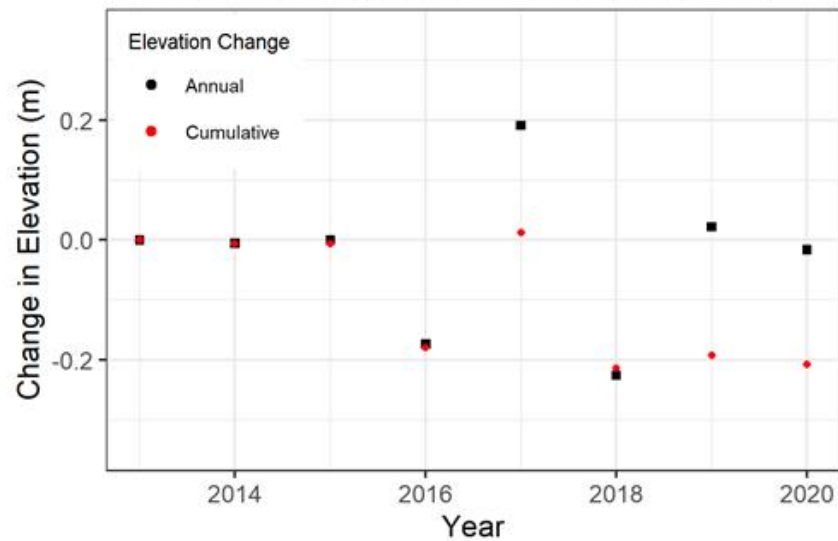
The top image for each site shows 2020 (black polygon) extent overlaid on the orthomosaic photo of the site. The bottom image shows 2020 extent over a “difference of DEM” (DOD) raster generated by subtracting the 2020 raster from the 2019 raster. Positive values indicate sediment deposition and negative values indicate erosion.

Each site has a table describing the overall change in elevation (2013 – 2020) for all years, graded years, and ungraded years, in addition to the 2020 GCP Z error. The graph shows the annual and cumulative elevation change for each site.

Backsprings 1

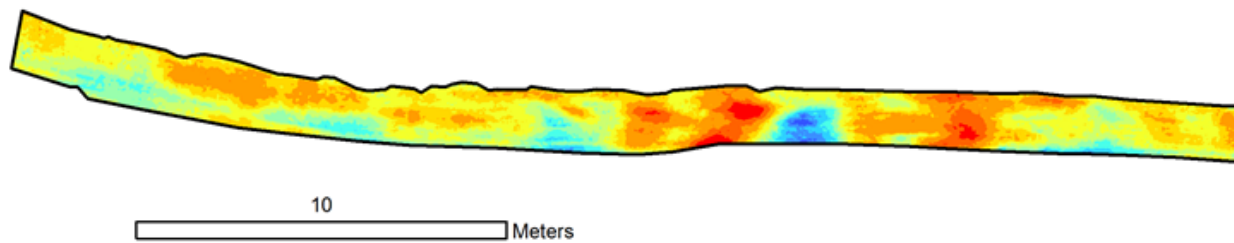


Elevation Change at Backsprings 1 (CAR)

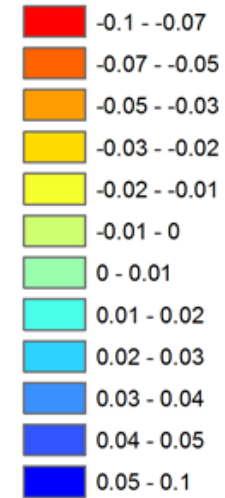


2013-2020 Elevation Change (m)		Backsprings 1 (CAR)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.208	-0.016	0.006

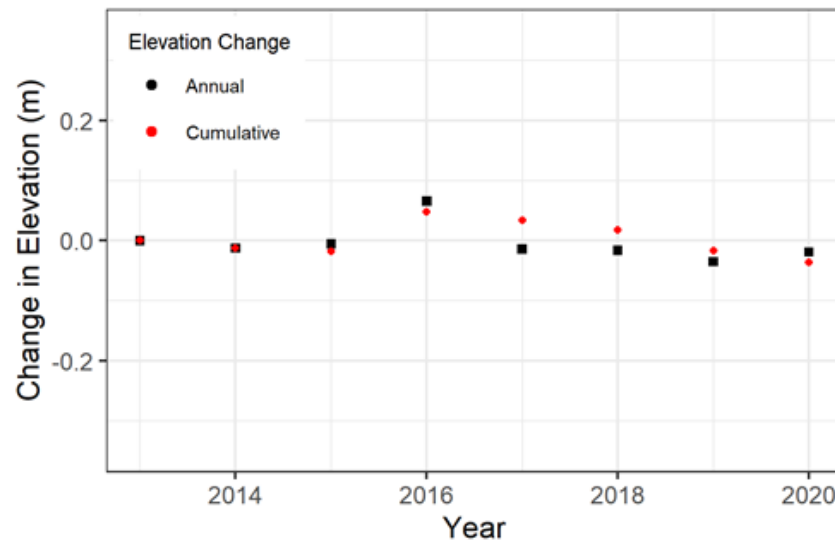
Backsprings 2



Change in Elevation 2020-2019

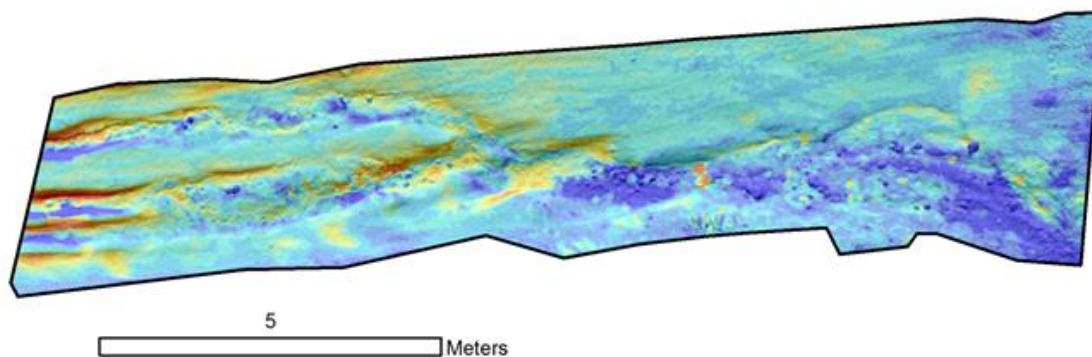


Elevation Change at Backsprings 2 (CAY)

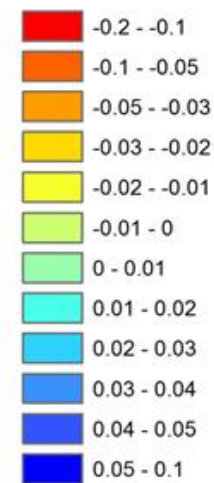


2013-2020 Elevation Change (m)		Backsprings 2 (CAY)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.036	-0.019	0.003

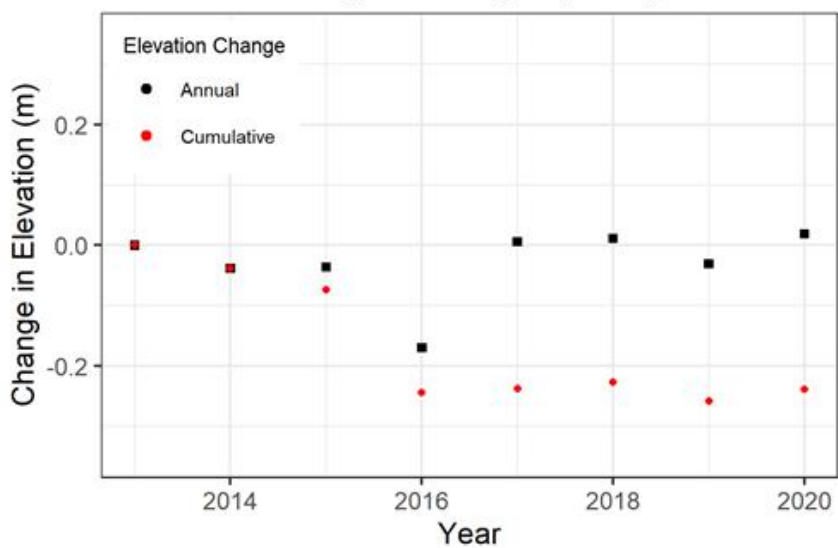
Badger



Change in Elevation 2020-2019

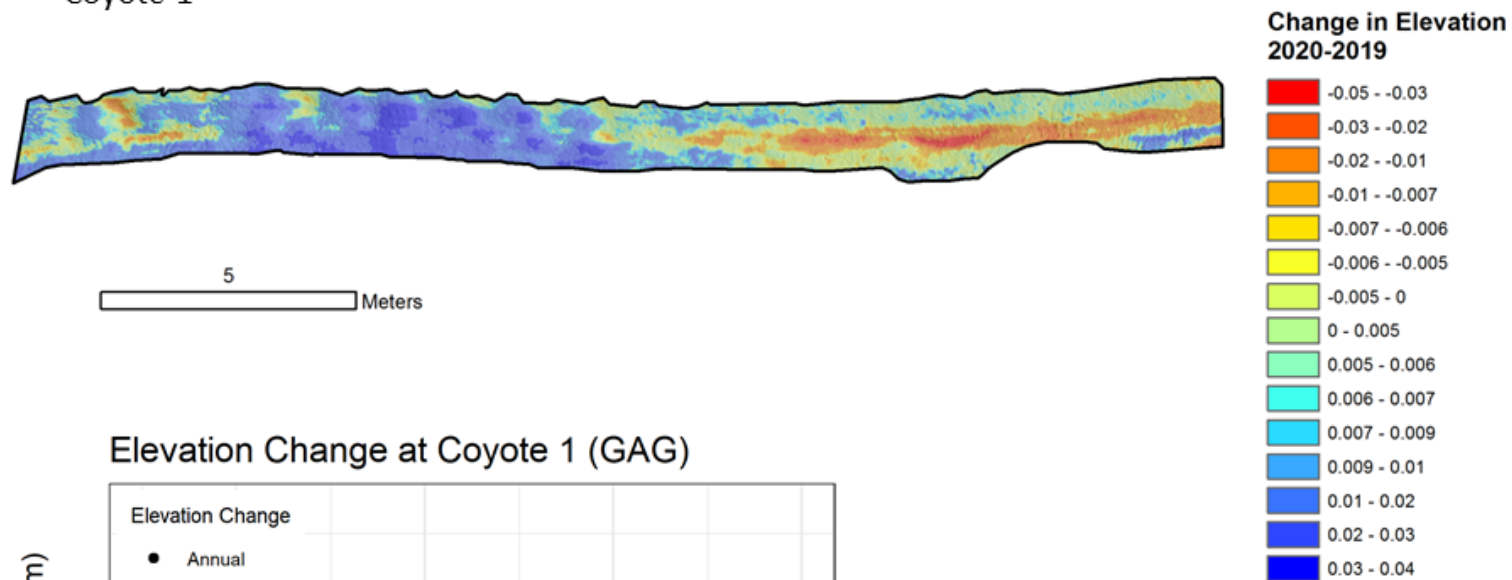


Elevation Change at Badger (GAR)

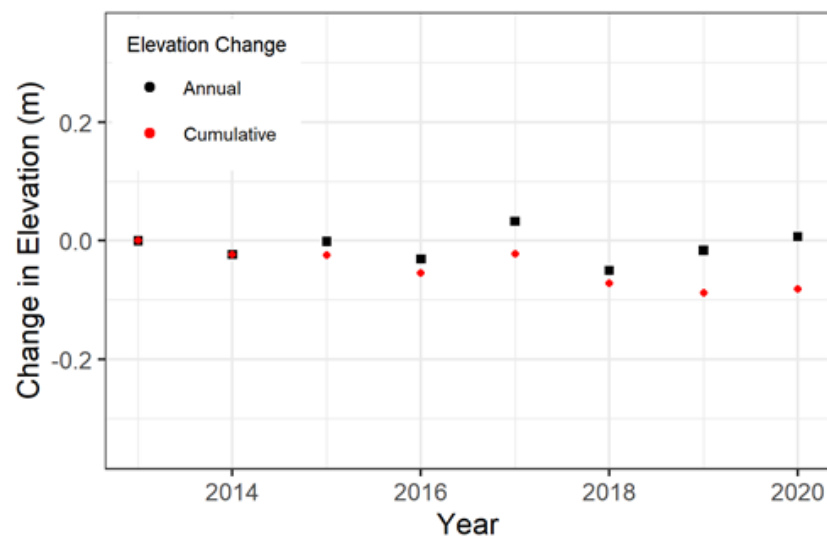


2013-2020 Elevation Change (m)		Badger (GAR)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.239	0.019	0.008

Coyote 1

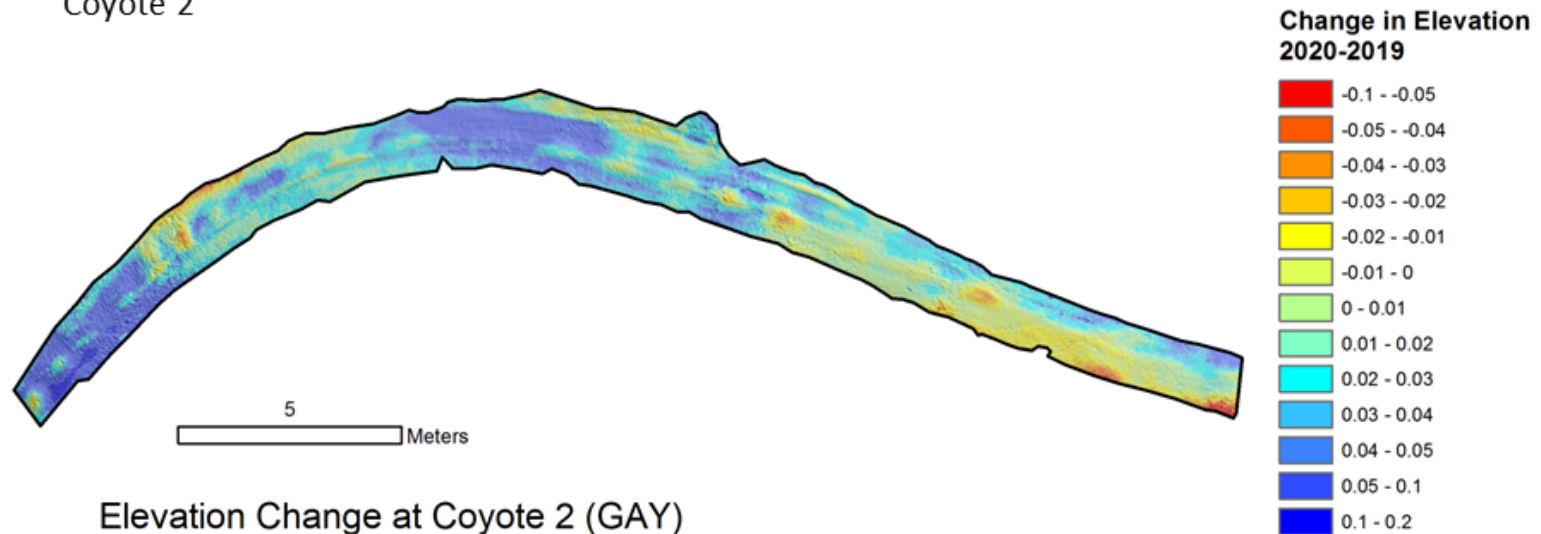


Elevation Change at Coyote 1 (GAG)

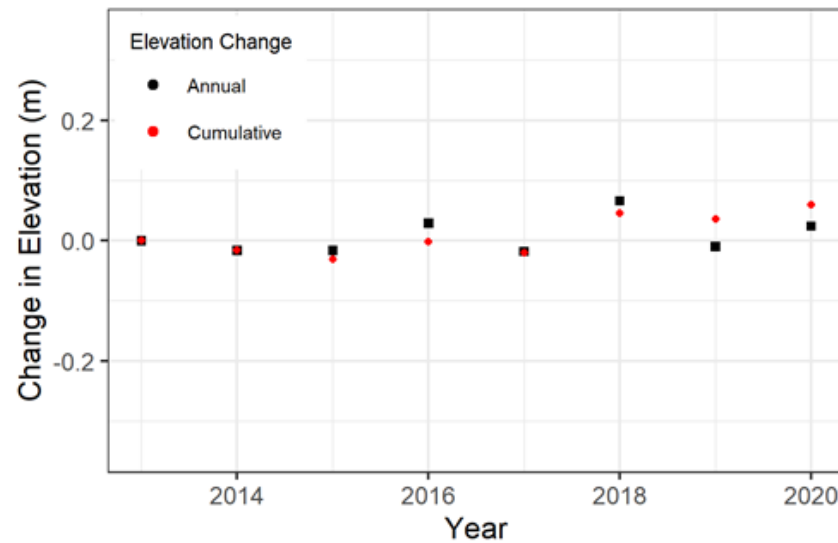


2013-2020 Elevation Change (m)		Coyote 1 (GAG)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.081	0.007	0.003

Coyote 2

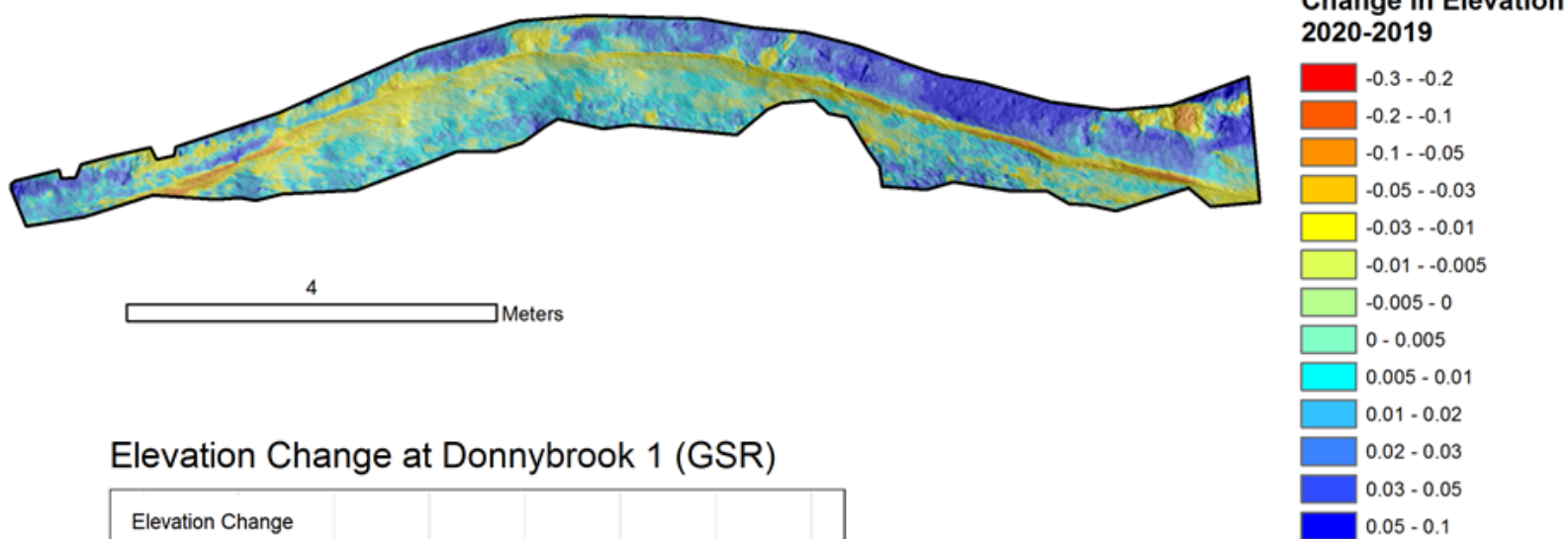


Elevation Change at Coyote 2 (GAY)

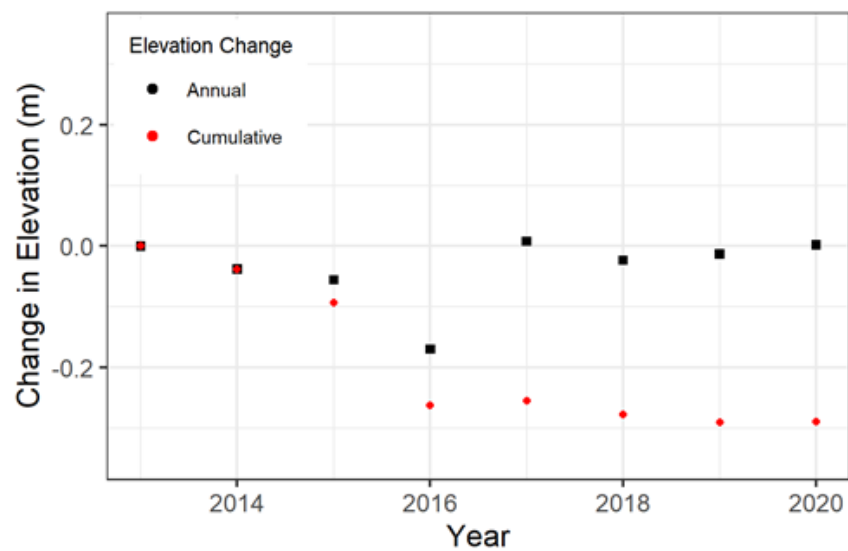


2013-2020 Elevation Change (m)		Coyote 2 (GAY)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
0.06	0.024	0.005

Donnybrook 1

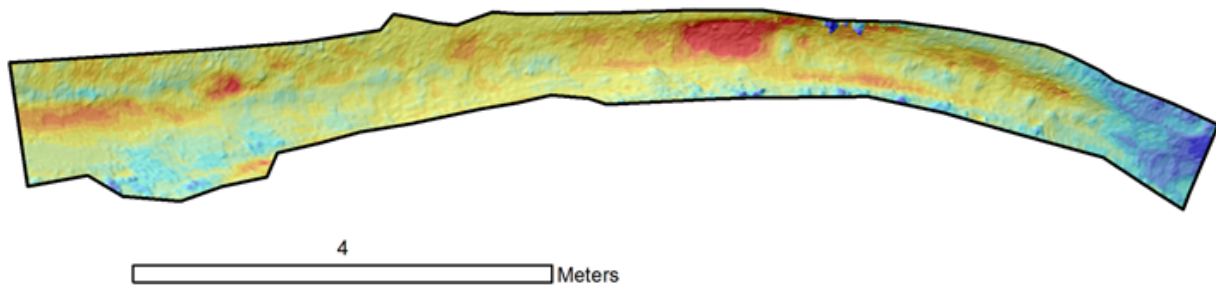


Elevation Change at Donnybrook 1 (GSR)

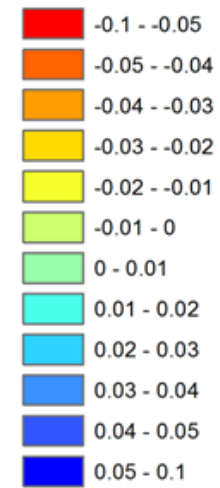


2013-2020 Elevation Change (m)		Donnybrook 1 (GSR)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.289	0.002	0.005

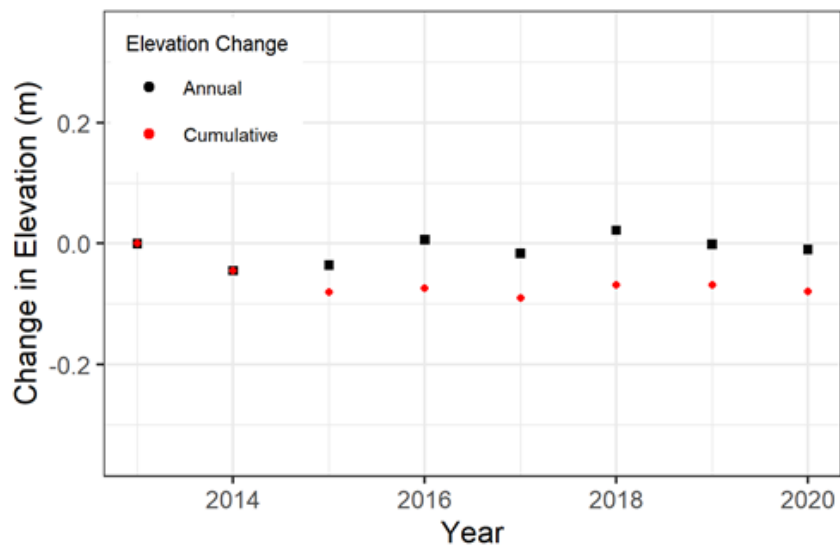
Donnybrook 2



Change in Elevation
2020-2019

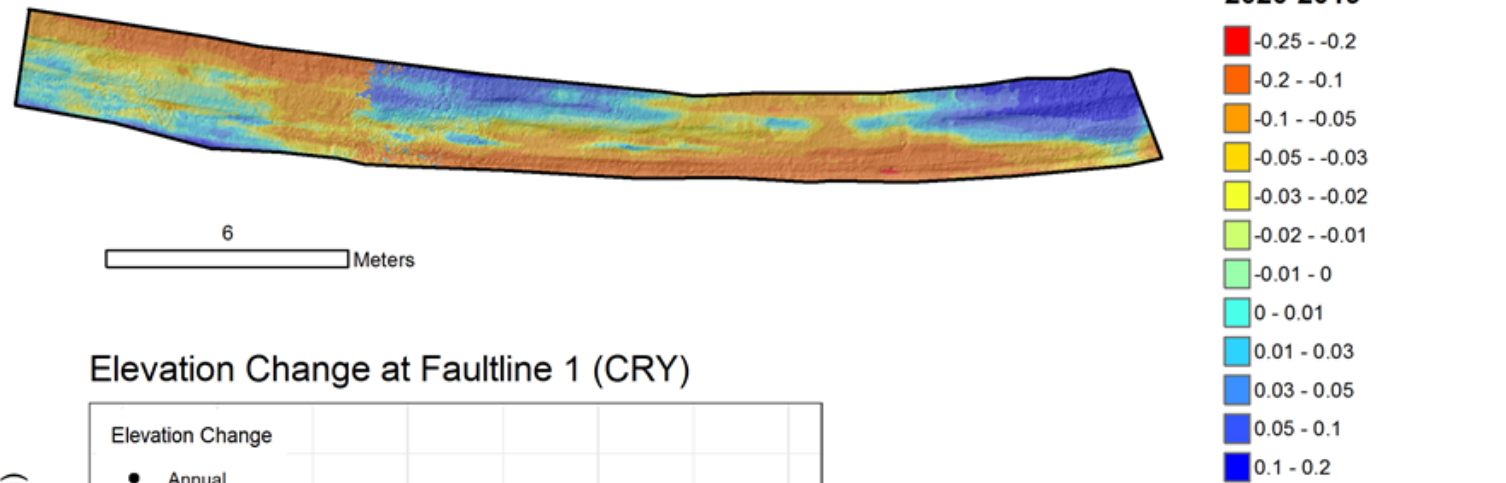


Elevation Change at Donnybrook 2 (GSG)

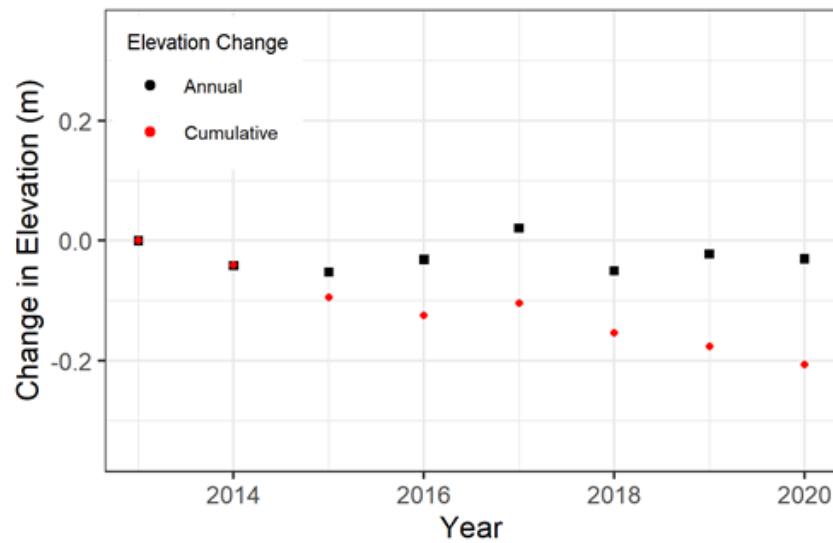


2013-2020 Elevation Change (m)		Donnybrook 2 (GSG)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.079	-0.010	0.005

Faultline 1

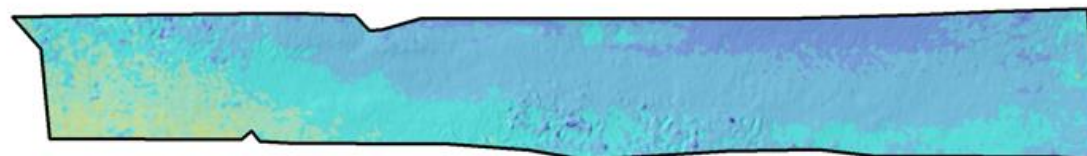


Elevation Change at Faultline 1 (CRY)



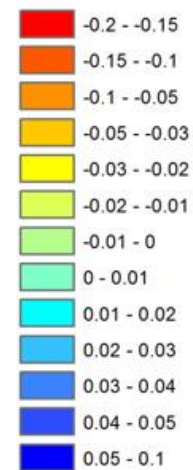
2013-2020 Elevation Change (m)		Faultline 1 (CRY)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.206	-0.030	0.009

Faultline 2

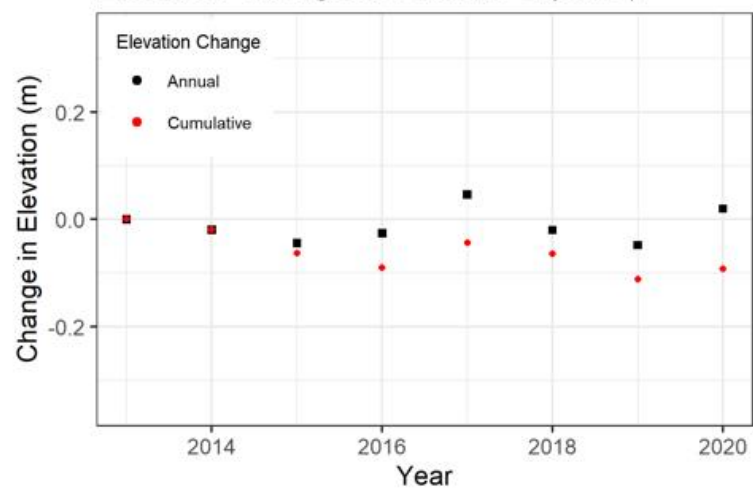


3 Meters

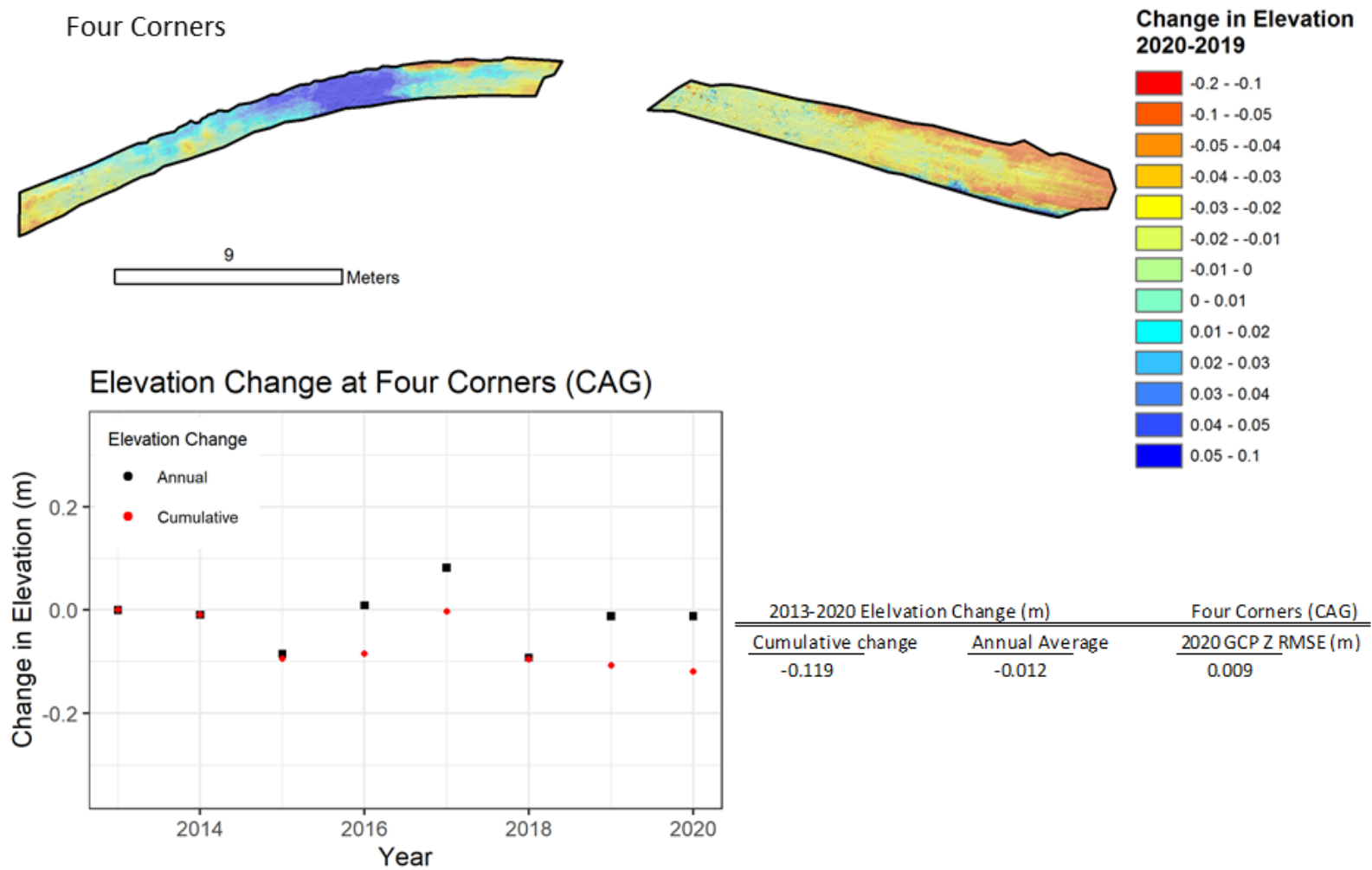
Change in Elevation 2020-2019

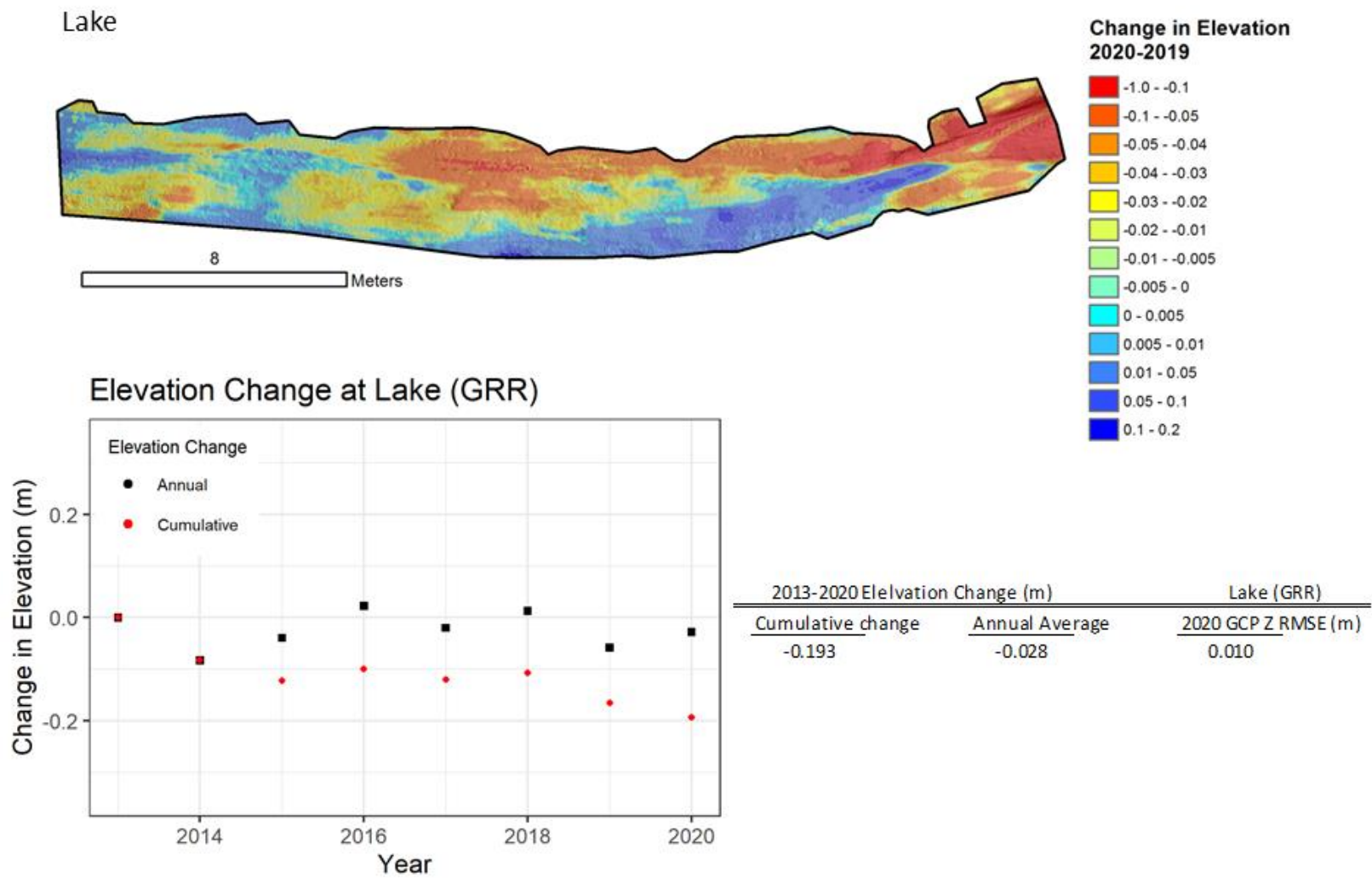


Elevation Change at Faultline 2 (CRG)

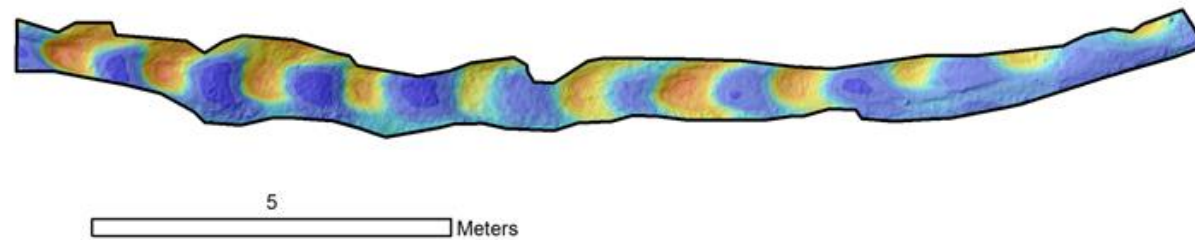


2013-2020 Elevation Change (m)		Faultline 2 (CRG)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.092	0.020	0.008

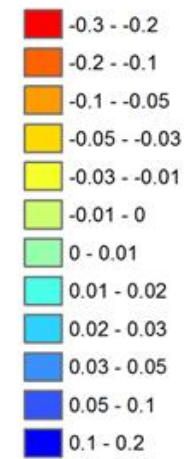




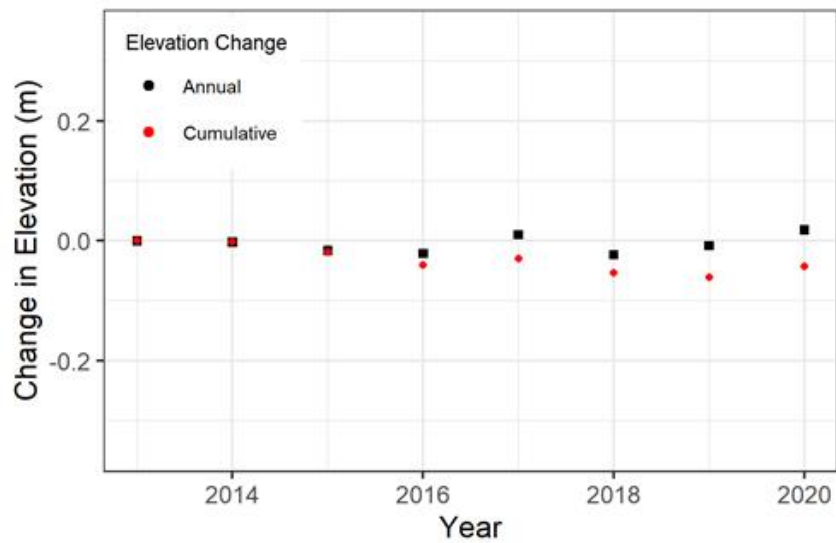
Mystic



**Change in Elevation
2020-2019**

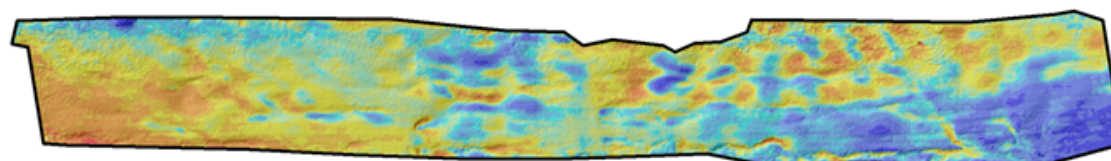


Elevation Change at Mystic (GSY)



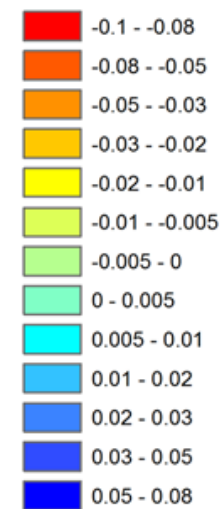
2013-2020 Elevation Change (m)		Mystic (GSY)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.043	0.018	0.010

North Canyon

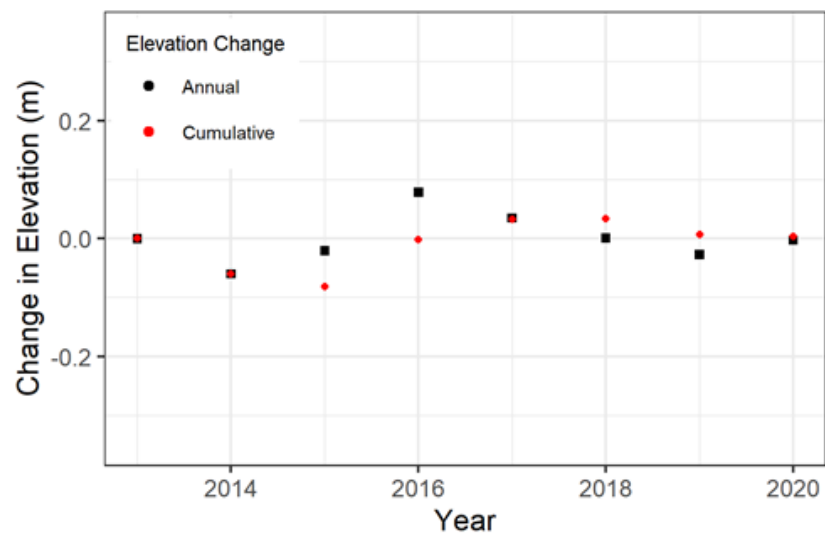


6
Meters

Change in Elevation 2020-2019

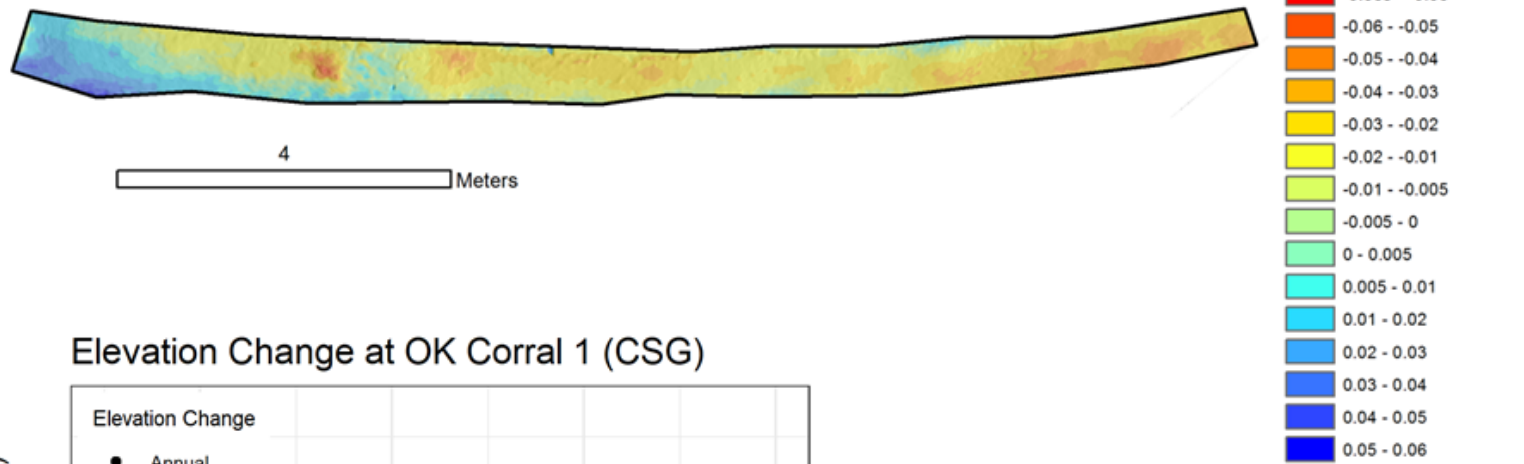


Elevation Change at North Canyon (GRY)

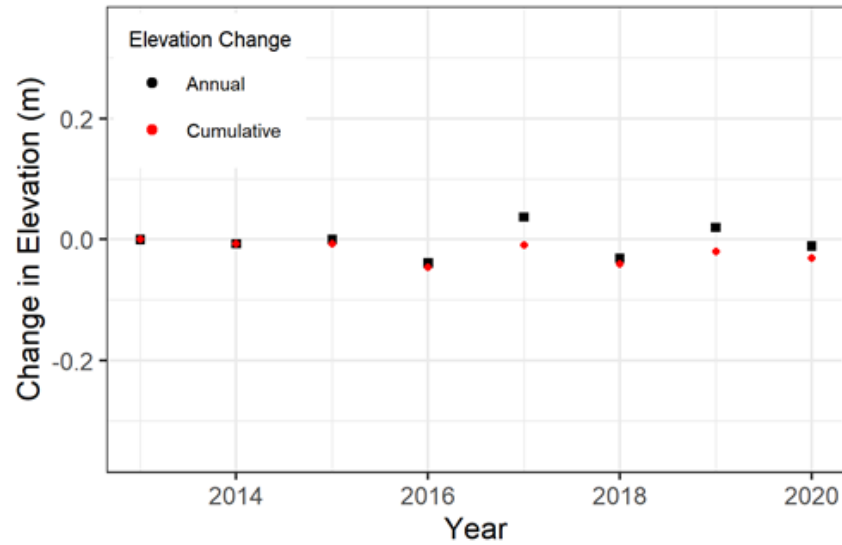


2013-2020 Elevation Change (m)		North Canyon (GRY)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
0.004	-0.003	0.009

OK Corral 1

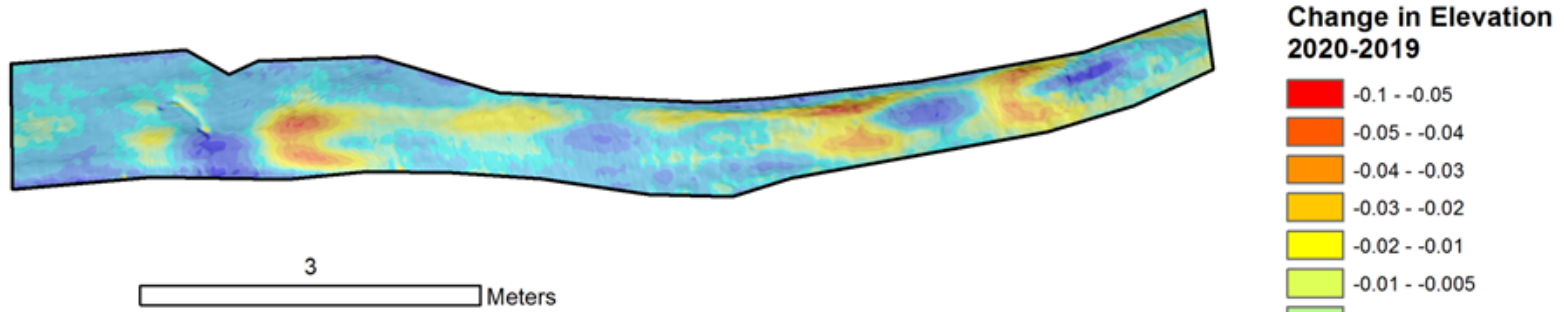


Elevation Change at OK Corral 1 (CSG)

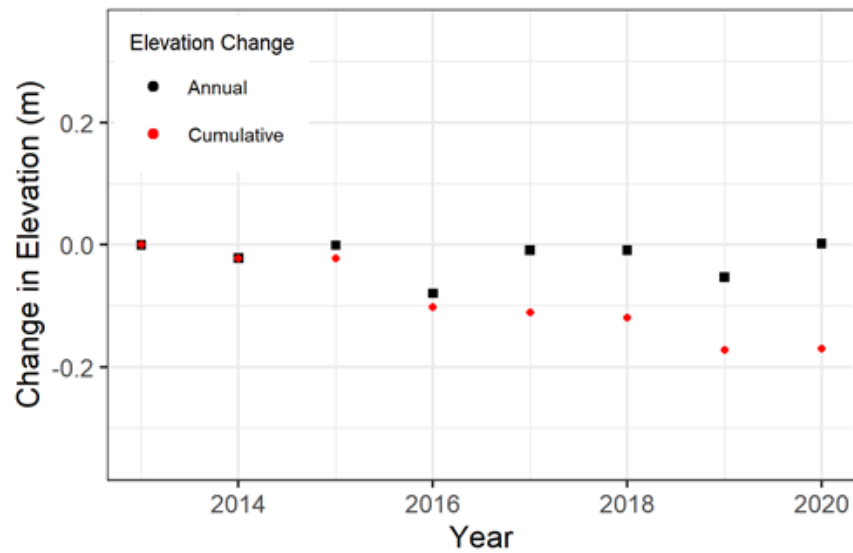


2013-2020 Elevation Change (m)		OK Corral 1 (CSG)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.031	-0.011	0.010

OK Corral 2

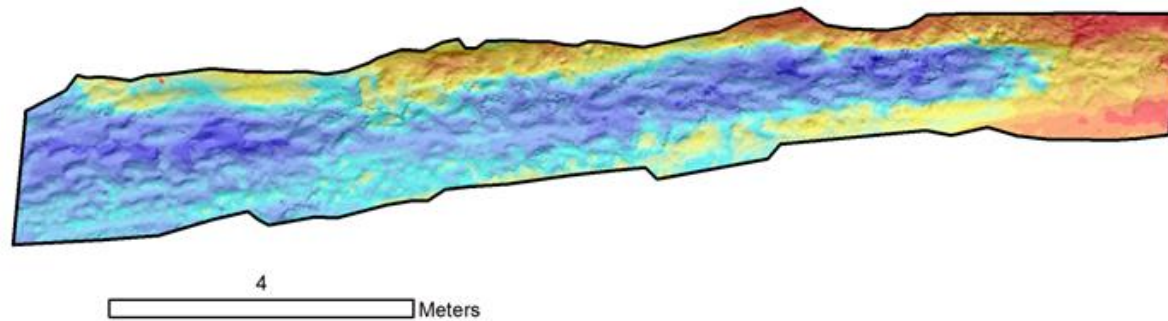


Elevation Change at OK Corral 2 (CSY)

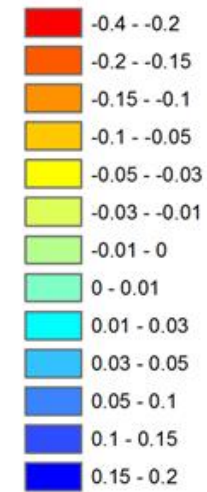


2013-2020 Elevation Change (m)		OK Corral 2 (CSY)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.170	0.002	0.003

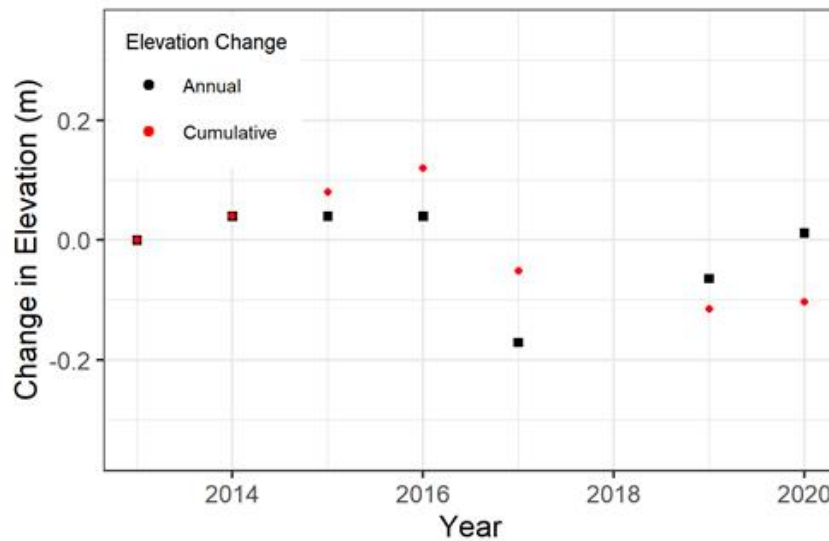
Psych Hill



Change in Elevation 2020-2019

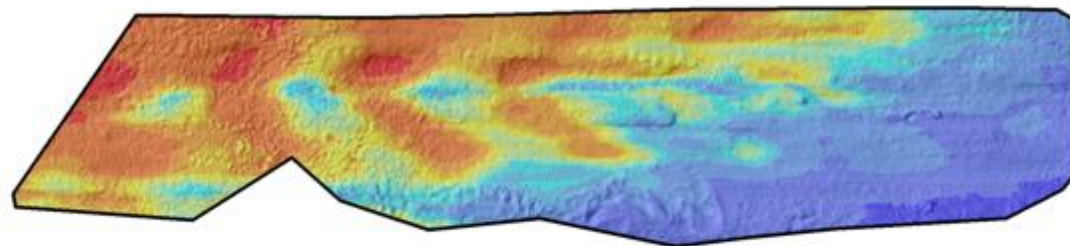


Elevation Change at Psych Hill (CSR)



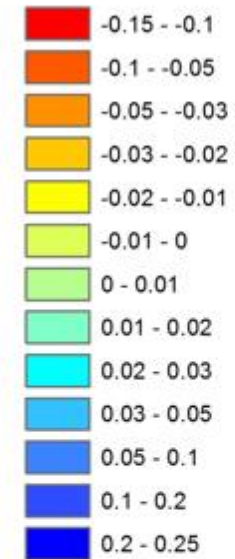
2013-2020 Elevation Change (m)		Psych Hill (CSR)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.103	0.012	0.003

Rancho

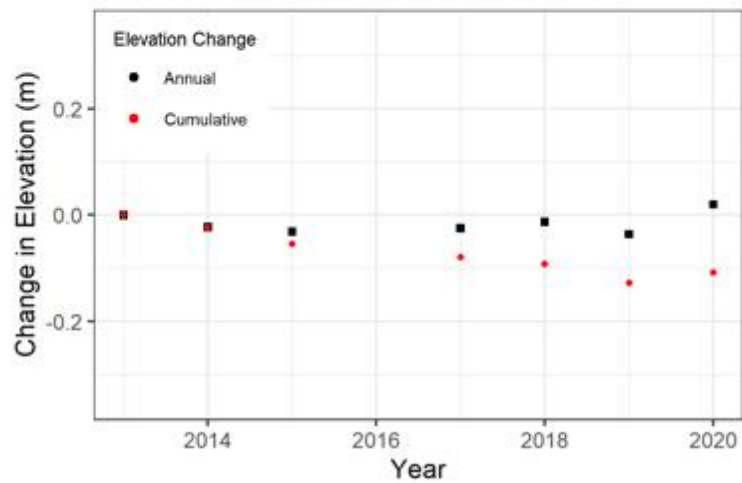


5 Meters

**Change in Elevation
2020-2019**

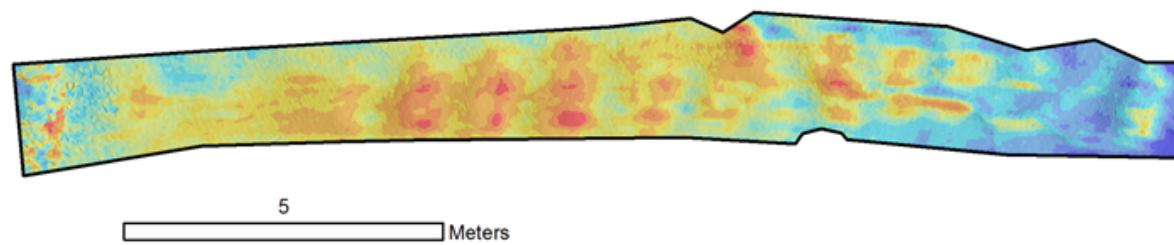


Elevation Change at Rancho (CRR)

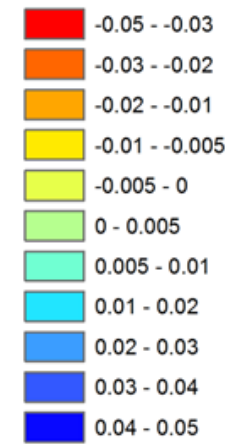


2013-2020 Elevation Change (m)		Rancho (CRR)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.108	0.020	0.001

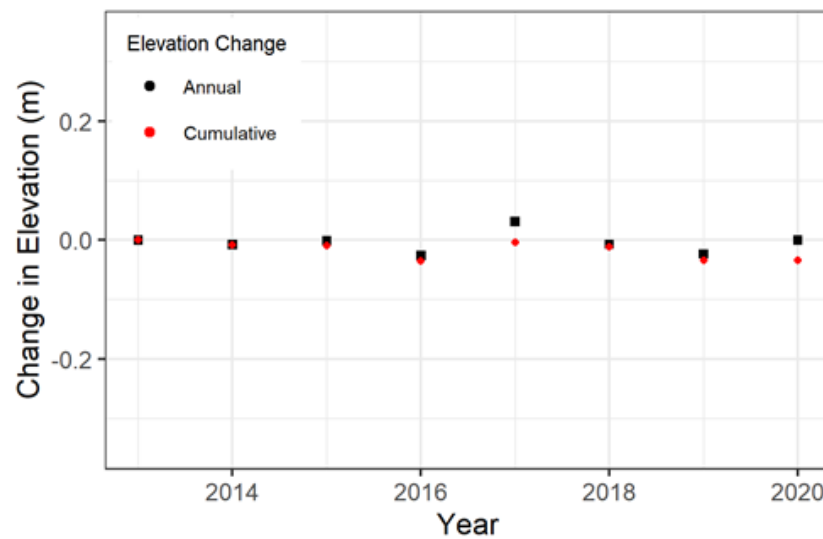
Sage



**Change in Elevation
2020-2019**



Elevation Change at Sage (GRG)



2013-2020 Elevation Change (m)		Sage (GRG)
Cumulative change	Annual Average	2020 GCP Z RMSE (m)
-0.034	0.000	0.008