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Hollister Hills SVRA

Trail Erosion Surveys

Spring 2014

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Acknowledgements

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Executive Summary

As the number of off-highway vehicle users increases, more demand is placed on trails designated for off-highway vehicle use, and effective conservation efforts are necessary to maintain trail sustainability. Resource managers in Hollister Hills State Vehicular Recreation Area (SVRA), one of California's eight SVRAs where off-road driving is encouraged and managed, are developing a method for prioritizing trails for best management practice treatments. A 2012 report prioritized trail condition and sustainability based upon visual assessment and professional judgment. In collaboration with the park's environmental scientists, a representative subset of those trails was selected for more detailed work aimed at quantifying trail erosion through time serial surveys. This report details the initial topographic surveys of 18 sample sites that were based on trail use type: road, all-terrain vehicle, and single-track; soil type: clay and granitic; and trail sustainability: green, yellow, and red. In 2013 a baseline assessment and digital elevation model was created for each site using ArcGIS. In May of 2014 the sites were revisited and the surveys were completed using the same protocol as the 2013 surveys. Changes in the elevation of sites were compared using ArcGIS and Microsoft Excel.

Rainfall was very light in the region during the year between the surveys, so little erosion occurred beyond the direct impact of tires on the trail. In the context of drought, the three-level erosion hazard index developed by the HHSVRA staff supported by the first year of trail erosion measurements. Also, within the context of low precipitation, there appears to be a difference in erosion rates between the clay and the granitic substrate areas of the park, with granitic soils eroding faster than clayey soils.

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1 Introduction

1.1 Background

Resource managers at the Hollister Hills State Recreational Vehicle Area (HHSVRA) have initiated a trail and road rating system based upon visual assessment. The park staff created a trail erodibility index that ranks trail erosion as green (acceptable), yellow (marginal) and red (action needed) (HHSVRA 2012). The rating system is being evaluated by assessing actual erosion rates on a subset of the rated roads. Erosion rates are assessed using repeat surveys of a subset of rated trails. The first surveys were performed in 2013 (Teaby et al. 2013). The present report presents the results of the second surveys (May 2014), and calculates the erosion rates for the first year of the study. The 18 survey sites are distributed across the HHSVRA and categorized by geologic substrates (Clay and Granitic), off road usage type (Single Track, ATV, and Road), and site condition designation (Green, Yellow, and Red) as determined by park staff through visual inspection (HHSVRA 2012). While soil production can be a function of many factors, the removal of soil (erosion) is largely a function of rainfall volume and rate. The erosion rates calculated in this report are presented in the context of drought conditions that have persisted in the region for the past two to three years.

1.2 Study Area

HHSVRA was established in 1975 and is located in San Benito County, one hour south of San Jose. The park offers outdoor recreation to picnickers, campers and riding enthusiasts within the beautiful Gabilan Mountains (Figure 1). Three areas within the park's 6,640 acres were identified as providing a variety of trail conditions and riding options: Upper Ranch, Lower Ranch, and Renz Property. The Upper Ranch encompasses an 800-acre area with approximately 24 miles of 4-wheel drive (4x4) trails and a fenced motocross track. The Lower Ranch includes a 3,300-acre area with approximately 128 miles of trails and hill climbs for motorcycle and ATV use only. The Lower Ranch area also includes picnic areas, a practice Motocross Track, an ATV track, a Short-Track (dirt race), and a mini-track for the kids. The newest portion added to the park, the Renz Property, includes approximately 23 miles of motorcycle and ATV trails.

1.3 Goals

The long-term goal of the current study is to estimate trail erosion rates in a variety of soils, slopes, and type of trail use in the HHSVRA. This estimate will be based upon the comparison of future surveys with the 2013 baseline surveys at 18 sites (Figure 2). A baseline survey of trails within each erodibility category was completed in spring 2013, and the first resurvey was completed in the spring of 2014. The comparison between the surveys is presented here.

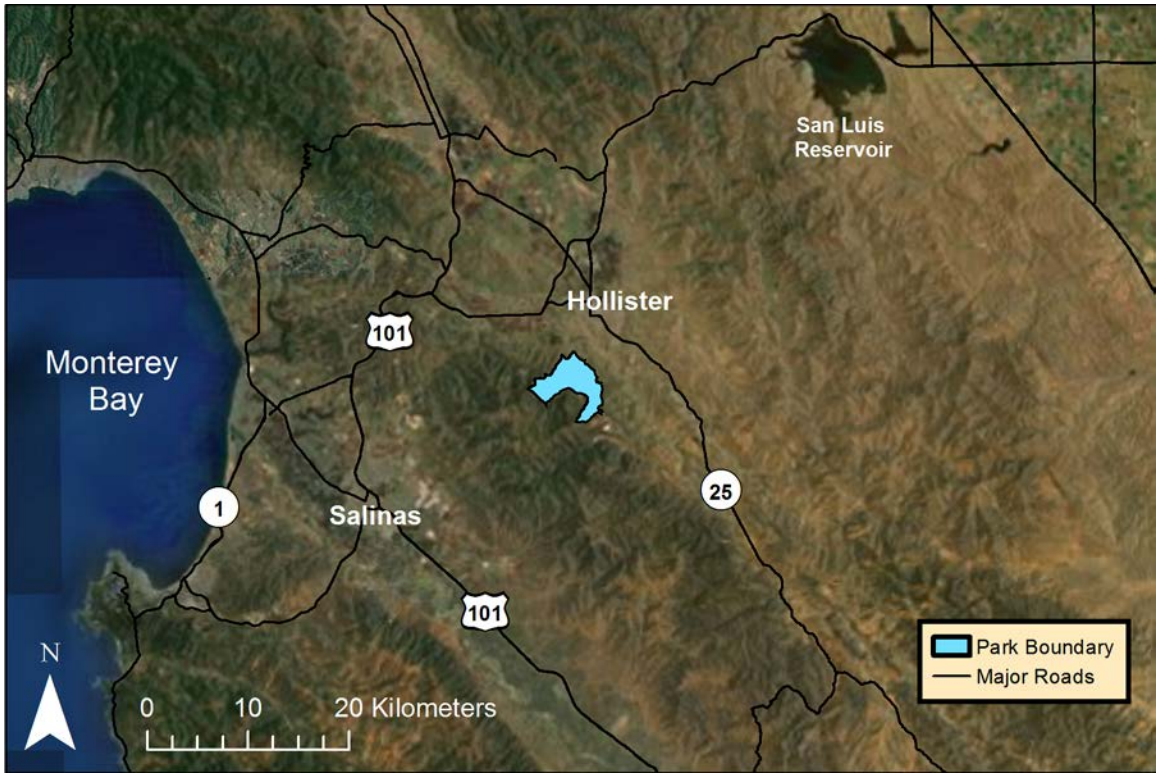


Figure 1. Hollister Hills State Vehicular Recreation Area is found northeast of Salinas.

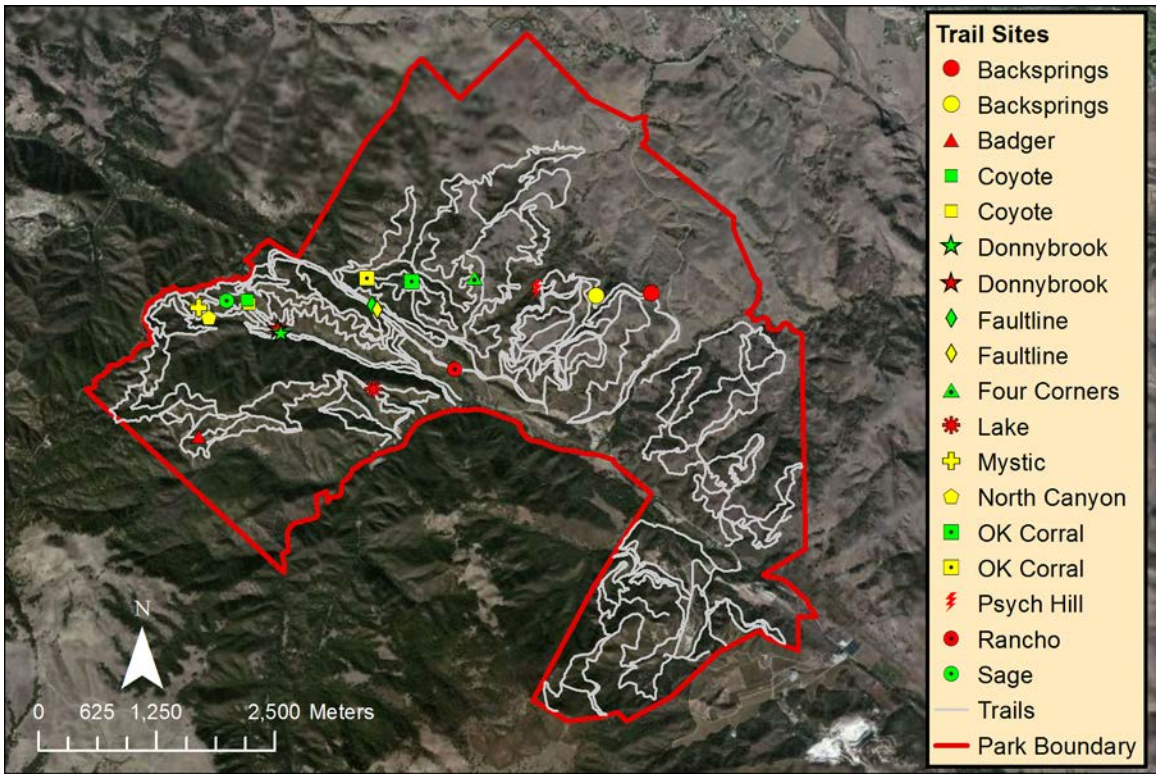


Figure 2. Trail site locations within Hollister Hills State Vehicular Recreation Area.

2 Methods

Each of the 18 sites surveyed in 2013 (Teaby et al 2013) was revisited and surveyed using a robotic total station with surface scanning capability, set up on the site benchmark (BM) with a survey shot to the site backsight (BS) to establish a reproducible three dimensional framework for the survey comparisons framework. The corners of the survey patch were located based on previous placement, and then expanded to capture more of the trail surface for future analysis. Survey data collected from each site were downloaded from the total station as a Comma Separated Values (.csv) file to a computer and the relative position of the 2013 and 2014 survey data was verified in Microsoft Excel. An assumption of the survey is that the locations of the BM and BS at each location are static, so the elevation of the 2014 BS was compared to that of the 2013 BS and the elevation of all survey points was adjusted accordingly where systematic errors were recognized.

For each site, both the 2013 and 2014 survey data were imported into Arc Map (version 10.1) and converted into *Events* using the *Import XY data* function under the File tab. These Events were used to create a Triangular Irregular Network (TIN) for each year's survey using the *Create TIN* tool in the 3D Analyst toolbox. TINs were then converted to Digital Elevation Model (DEM) Rasters using the *TIN to Raster* tool in the 3D Analyst toolbox. The *TIN to Raster* tool was configured to use *Floating* integers and *Natural Neighbor* interpretation to create rasters with a 1cm cell size. A Difference of DEM (DOD) raster was created by subtracting the 2014 DEM from the 2013 DEM using the *Raster Calculator* tool in the Spatial Analyst toolbox. The DOD raster was examined for irregularities and "edge effects", and a polygon shapefile excluding these features was created and used as a template for clips of the 2013 and 2014 DEMs using the *Clip* tool in the Data Management toolbox. These clipped DEMs were then used to create a clipped DOD for each site using the *Raster Calculator* tool in the Spatial Analyst toolbox. This DOD raster was classified with 1cm breaks, and summary statistics (maximum, minimum, mean and standard deviation) were obtained from the raster Properties dialog box.

The *Cut and Fill* tool in the 3D Analyst toolbox was used to determine the volumetric difference between the clipped rasters from 2013 and 2014 by inputting the 2013 raster as the "before" and the 2014 raster as the "after" DEM. The *Cut and Fill* tool counts and then subtracts each 1cm cell of the 2014 raster from the cells of the 2013 raster to calculate the area of the survey patch and the difference in volume of material for each cell between surveys and create a raster showing where material was added and removed. Data form the *Cut and Fill* tool was exported from the layer Attribute Table and analyzed in Microsoft Excel to determine the total volumetric change of the sites between surveys. The 95% confidence intervals of the change in elevation at each site were calculated as $\pm 1.96 \frac{SD}{\sqrt{n}}$. The percent difference between data was calculated by dividing the difference between data by the average of the data.

3 Results

Analysis in both Microsoft Excel and Arc GIS provided information about the change in elevation, the standard deviation of the changes, the area, and the volume of change for each of the survey sites. The results are presented in the context of geologic substrate, usage classification, and hazard index (Table 1, Figures 3 through 6).

Table 1. Locations, soil type, usage, condition, area of sites in square meters, average change in depth of cells within sites, standard deviation of change in depth for cells within a site, and net volume change of sites in cubic meters. Condition is based on the trail erodibility index that ranks trail erosion as green (acceptable), yellow (marginal) and red (action needed). Sites with insufficient data for analysis are designated with "N/A" in some fields.

Location	Soil Type	Usage	Condition	Area (m^2)	Depth (m)	SD	Volume (m^3)
OK_Corral_CSG	Clay	Single Track	Green	3.86	0.007	0.017	0.029
OK_Corral_CSY	Clay	Single Track	Yellow	4.35	0.022	0.031	0.096
Psych_Hill_CSR	Clay	Single Track	Red	N/A	N/A	N/A	N/A
Donnybrook_GSG	Granite	Single Track	Green	4.40	0.045	0.051	0.206
Mystic_GSY	Granite	Single Track	Yellow	2.53	0.002	0.020	0.007
Donnybrook_GSR	Granite	Single Track	Red	3.26	0.038	0.046	0.125
4_Corners_CAG	Clay	ATV	Green	6.19	0.009	0.004	0.057
Backsprings_CAY	Clay	ATV	Yellow	13.47	0.012	0.018	0.171
Backsprings_CAR	Clay	ATV	Red	8.89	0.006	0.026	0.052
Coyote_GAG	Granite	ATV	Green	4.24	0.023	0.010	0.099
Coyote_GAY	Granite	ATV	Yellow	N/A	N/A	N/A	N/A
Badger_GAR	Granite	ATV	Red	6.72	0.038	0.027	0.259
Faultline_CRG	Clay	Road	Green	10.44	0.019	0.007	0.204
Faultline_CRY	Clay	Road	Yellow	5.11	0.041	0.177	0.225
Rancho_CRR	Clay	Road	Red	9.10	0.023	0.029	0.210
Sage_GRG	Granite	Road	Green	8.39	0.008	0.014	0.066
North_Canyon_GRY	Granite	Road	Yellow	7.55	0.060	0.012	0.455
Lake_GRR	Granite	Road	Red	9.28	0.083	0.027	0.772

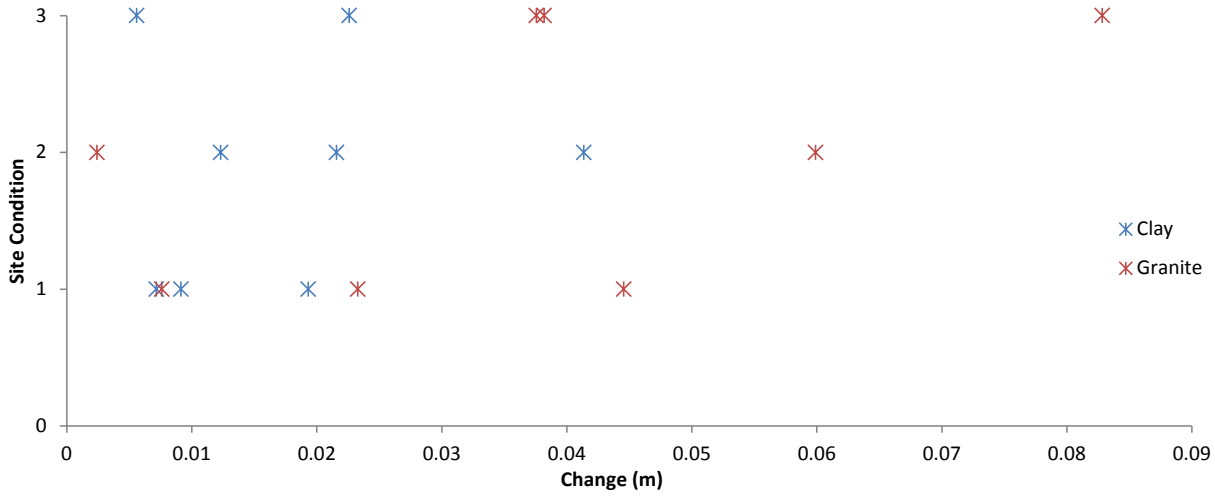


Figure 3. Change in site elevation for all site conditions; Green(1), Yellow (2), and Red (3), and substrate types (Clay and Granitic).

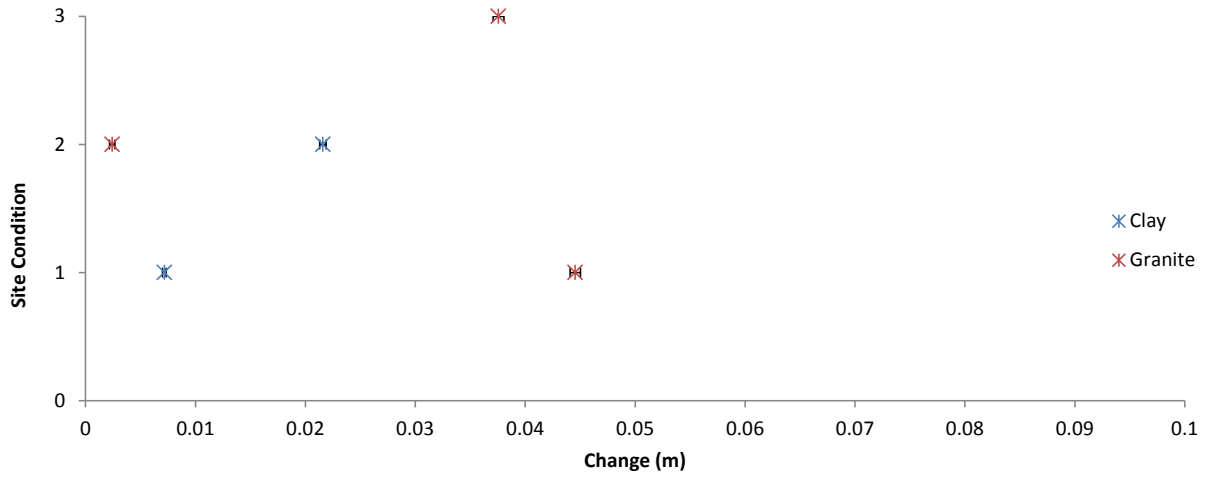


Figure 4. Change in elevation of Single Track sites for Green (1), Yellow (2), and Red (3) site condition designations in both the Clay and Granitic areas of the HHSRVA. The 95% confidence intervals of the averages are shown as horizontal error bars.

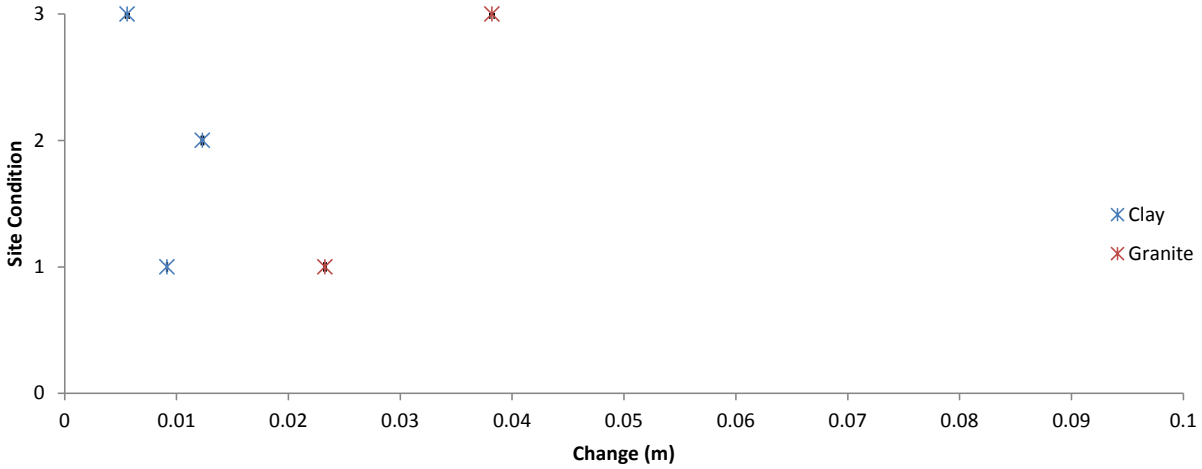


Figure 5. Change in elevation of ATV sites for Green (1), Yellow (2), and Red (3) site condition designations in both the Clay and Granitic areas of the HHSRVA. The 95% confidence interval of the data is shown as horizontal error bars.

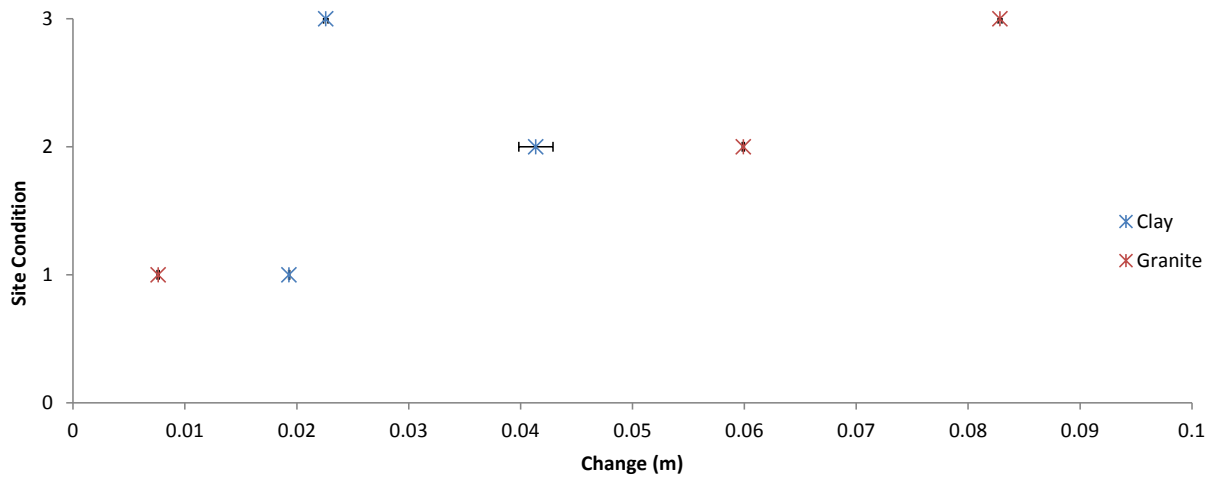


Figure 6. Change in elevation of Road sites for Green (1), Yellow (2), and Red (3) site condition designations in both the Clay and Granitic areas of the HHSRVA. The 95% confidence interval of the data is shown as horizontal error bars.

Within the Clay areas of the HHSRVA, sites with a "Green" designation showed an average change in elevation of 0.012 meters, sites with a "Yellow" designation a change of 0.025 meters, and sites with a "Red" designation a change of 0.028 meters. Within the Granitic areas of the HHSRVA, sites with a "Green" designation showed an average change in elevation of 0.025 meters, sites with a "Yellow" designation a change of 0.031 meters, and sites with a "Red" designation a change of 0.053 meters (Table 2, Figure 7).

Table 2. Change in elevation of survey sites designated as Green, Yellow, and Red in both Clay and Granitic areas of the HHSRVA

Condition	Clay	Granite
Green	0.012	0.025
Yellow	0.025	0.031
Red	0.028	0.053

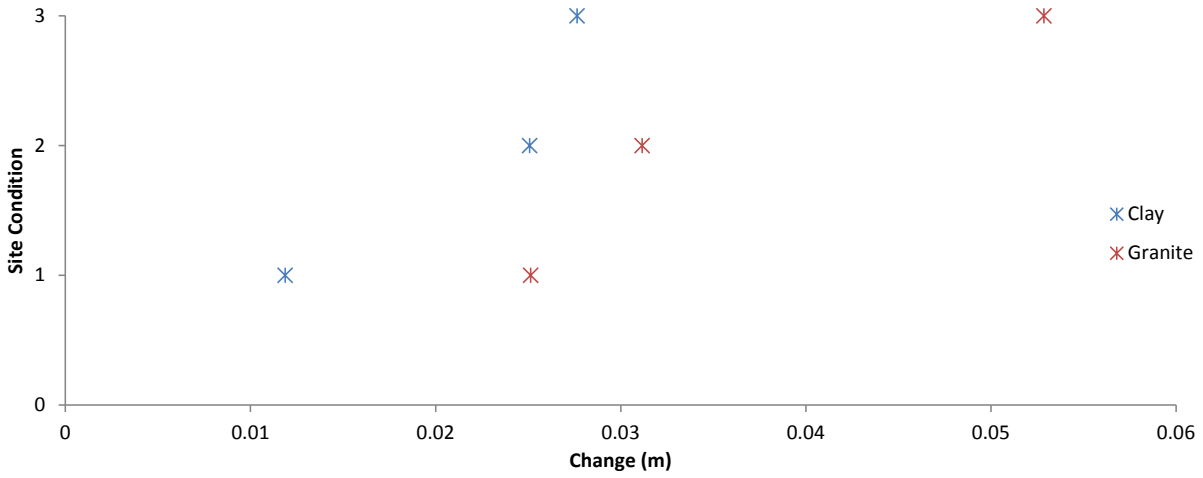


Figure 7. Change in elevation of survey sites versus site condition designations; Green (1), Yellow (2), and Red (3) in both Clay and Granitic areas of the HHSRVA.

Within the Clay areas of the HHSRVA there was a 72% difference in average erosion rate between the Green and the Yellow sites, a 10% difference between the Yellow and the Red sites, and an 80% difference between the Green and the Red sites. Within the Granitic areas of the HHSRVA there was a 21% difference in average erosion rate between the Green and the Yellow sites, a 52% difference between the Yellow and the Red sites, and a 71% difference between the Green and the Red sites (Table 3).

Table 3. Percent difference between Green and Yellow, Yellow and Red, and Green and Red sites located within both Clay and Granitic areas of the HHSRVA.

	Green/Yellow	Yellow/Red	Green/Red
% Difference Clay	72	10	80
% Difference Granite	21	52	71

For sites with a Green designation, there was a 72% difference in erosion rates between Clay and Granitic areas of the HHSRVA, a 22% difference for sites with a Yellow designation, and a 63% difference for sites with a Red designation (Table 4).

Table 4. Change in elevation and percent difference of Green, Yellow, and Red sites located in both the Clay and Granitic areas of the HHSRVA.

Condition	Clay	Granite	% DIFF
Green	0.0119	0.0251	72
Yellow	0.0251	0.0312	22
Red	0.0276	0.0529	63

4 Conclusion

The three-level erosion hazard index developed by the HHSVRA staff is generally supported by the first year of trail erosion measurements (Table 2 and Figure 5). Additionally, Table 2 and Figure 5 suggest that granitic soils erode faster than clay soils in the HHSRVA in the context of low annual precipitation.

5 References

[HHSVRA] Hollister Hills SVRA Natural Resources Staff. 2012. 2012 Trail Assessment Report, Hollister Hills District. 115pp.

Teaby A, Silveus, J, and Smith D. 2013. Hollister Hills SVRA Trail Erosion Surveys: Spring 2013. The Watershed Institute, California State Monterey Bay, Publication No. WI-2013-07, 32 pp.

6 Appendix

The following appendix shows the results of analysis of the surveys with ArcGIS.

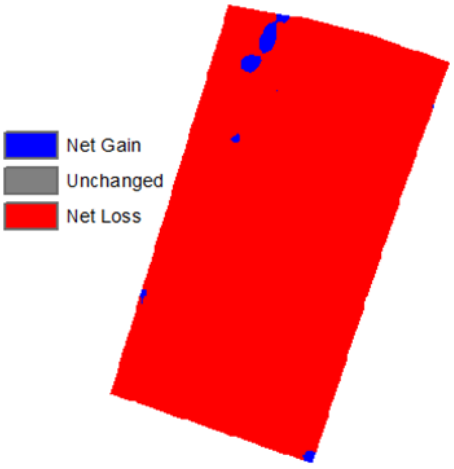
Top Right is a “Cut and Fill” raster; this was created by using the “Cut and Fill” tool and subtracting the altered raster (2014) from the original raster (2013) to obtain volumetric data about the change. “Cut” (Material Removed) is shown in Red and “Fill” (Material Added) is shown in Blue.

Bottom Right is the Attribute Table from the “Cut and Fill” raster; this tool shows “Cut” as Positive Values and “Fill” as Negative Values.

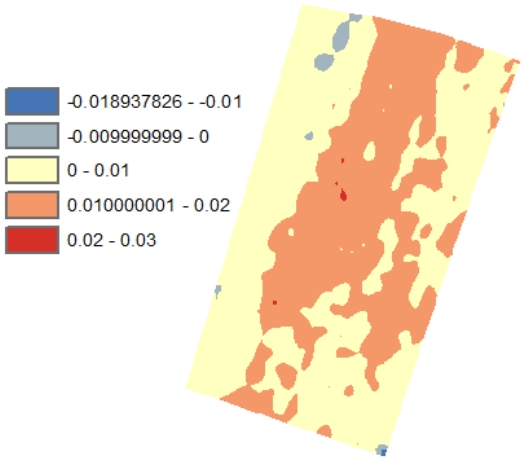
Top Left is a “Difference of DEM” (DOD) raster generated by subtracting the altered raster (2014) from the original raster (2013), so again “Cut” as Positive Values and “Fill” as Negative Values.

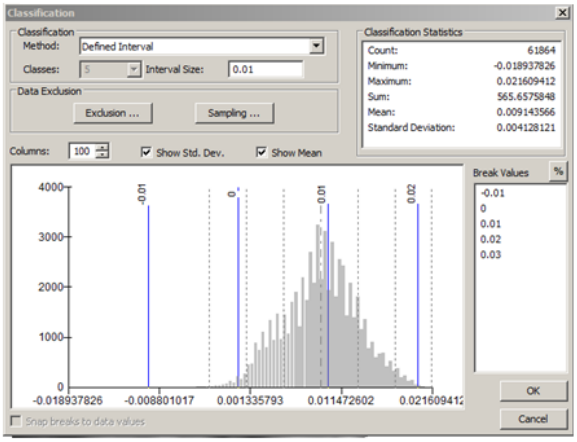
Bottom Left is the Classification Summary for the DOD raster showing summary statistics.

4_Corners_CAG
Net Loss of 0.06m^3

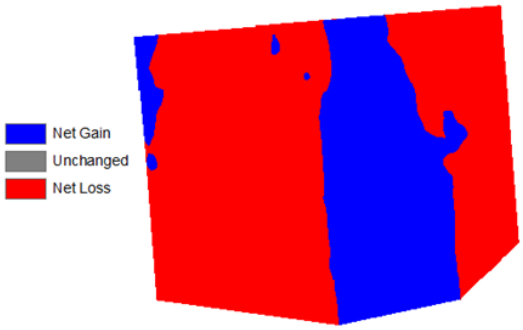


Count	VOLUME	AREA
327	-5.9E-05	0.0327
61190	0.057196	6.119
182	-1.3E-05	0.0182
1	-2.1E-09	0.0001
5	-7.8E-07	0.0005
39	-2E-06	0.0039
35	-1.7E-06	0.0035
85	-5.9E-05	0.0085
61864	0.057061	6.1864



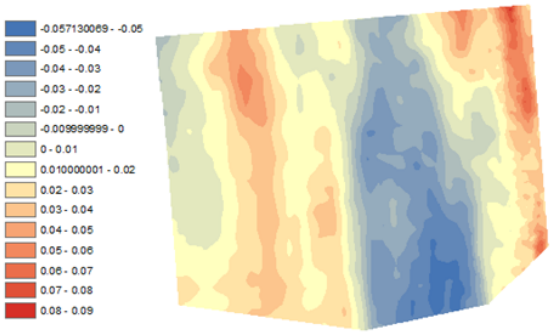


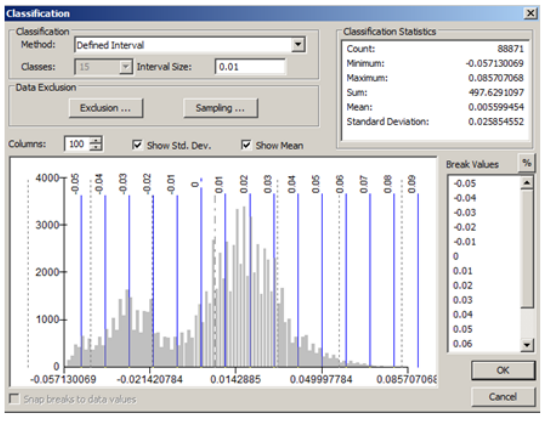
Backsprings_CAR
Net Loss of 0.05m^3



Cut & Fill Table

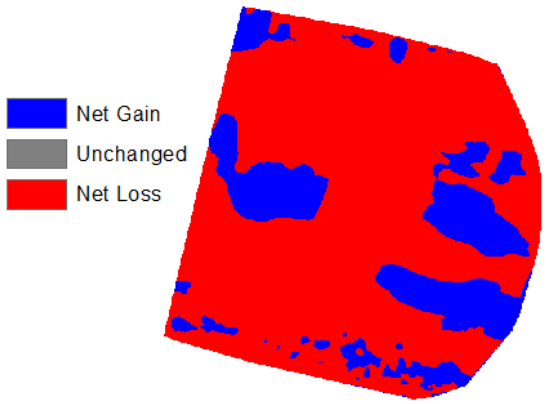
Count	VOLUME (m^3)	AREA (m^2)
17617	0.04412453	1.7617
27388	-0.074212573	2.7388
4	1.99304E-06	0.0004
41922	0.08286886	4.1922
1497	-0.000769731	0.1497
117	-1.14049E-05	0.0117
33	-3.91415E-06	0.0033
125	-1.13226E-05	0.0125
88703	0.051986437	8.8703

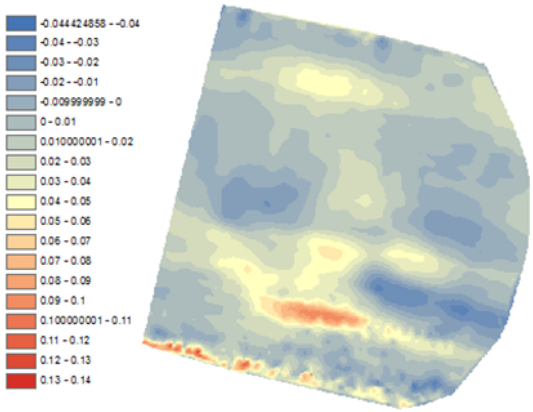




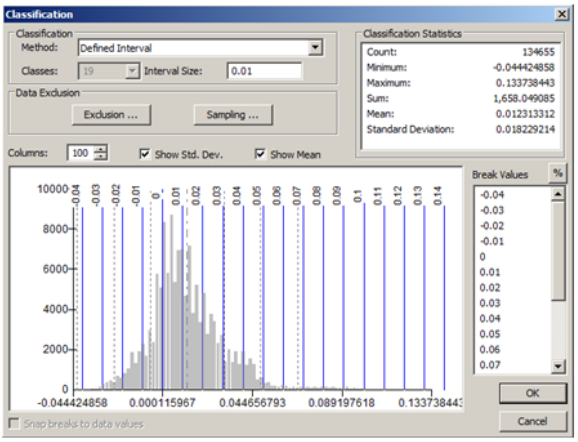
Backsprings_CAY

Net Loss of 0.17m^3



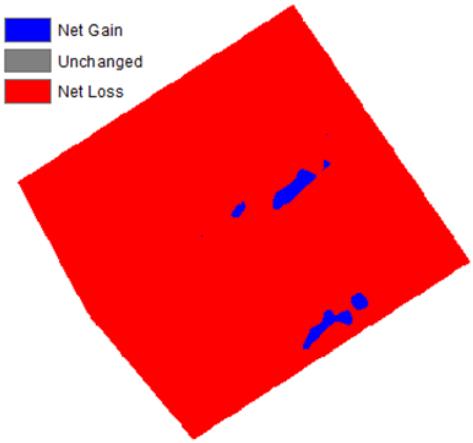


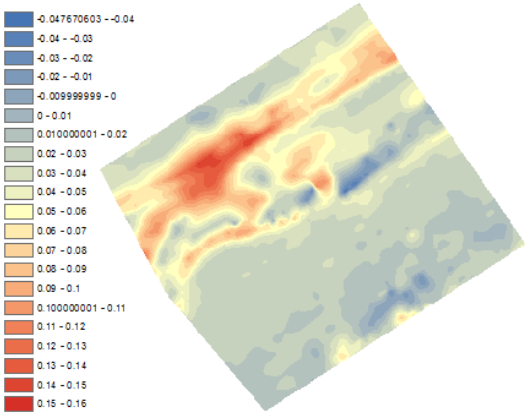
Count	VOLUME	AREA
TRUNCATED TABLE		
2	-4.4E-07	0.0002
1	-5.5E-08	0.0001
44	-4.2E-05	0.0044
2	-3.6E-07	0.0002
1	-2.4E-08	0.0001
10	-4E-06	0.001
134655	0.170514	13.4655



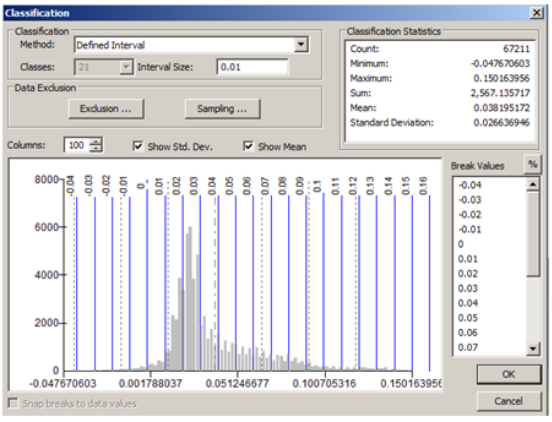
Badger_GAR

Net Loss of 0.26m^3



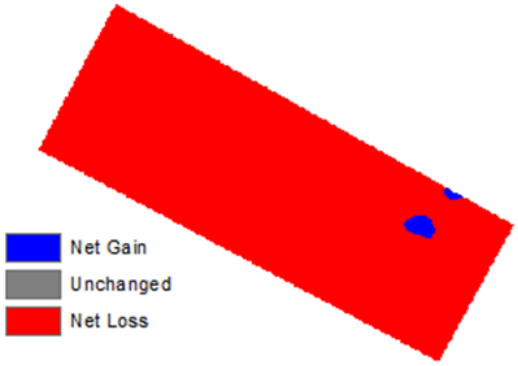


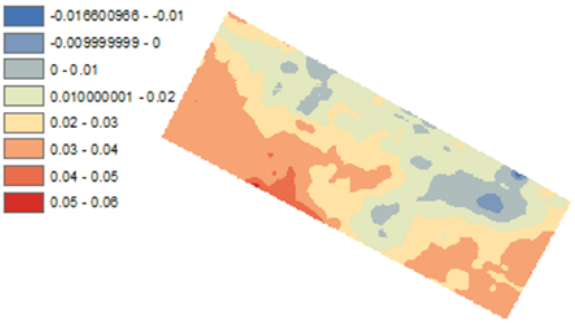
Count	VOLUME	AREA
66109	0.260358	6.6109
1	-4.6E-07	0.0001
24	-2.7E-06	0.0024
451	-0.00064	0.0451
1	-9.1E-09	0.0001
88	-9.5E-05	0.0088
1	-1.1E-07	0.0001
144	-0.0001	0.0144
392	-0.00018	0.0392
67211	0.259336	6.7211



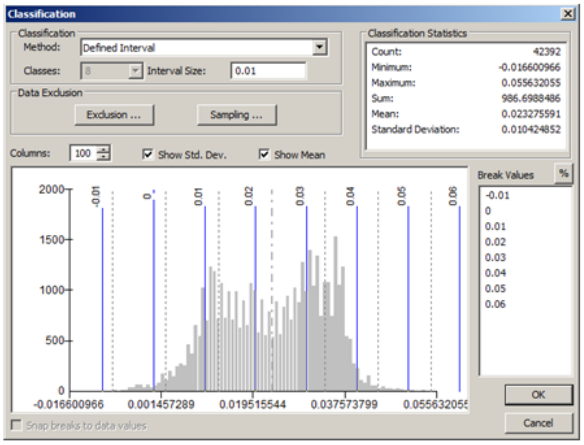
Coyote_GAG

Net Loss of 0.1m^3



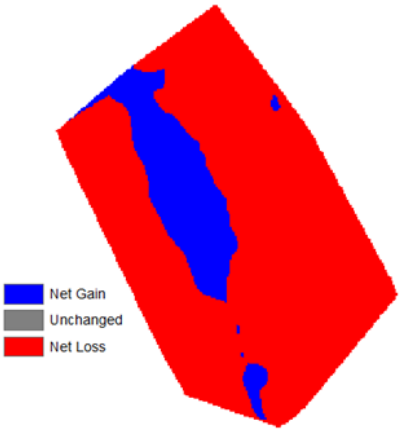


Count	VOLUME	AREA
42009	0.09929	4.2009
73	-4.3E-05	0.0073
1	1.04E-07	0.0001
293	-7.1E-05	0.0293
42376	0.099176	4.2376



Donnybrook_GSR

Net Loss of 0.12m^3



Count	VOLUME	AREA
27135	0.138247	2.7135
5051	-0.01309	0.5051
39	-2.5E-05	0.0039
1	-7.7E-07	0.0001
1	-2.9E-07	0.0001
1	-6.9E-07	0.0001
1	-1.2E-08	0.0001
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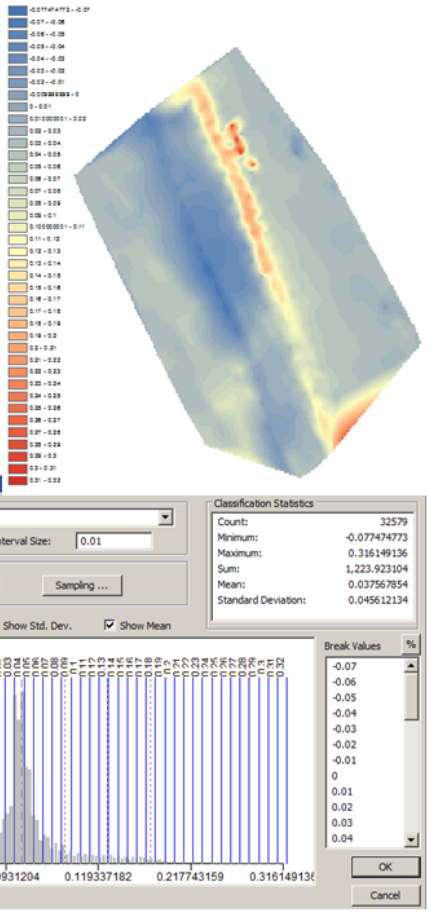
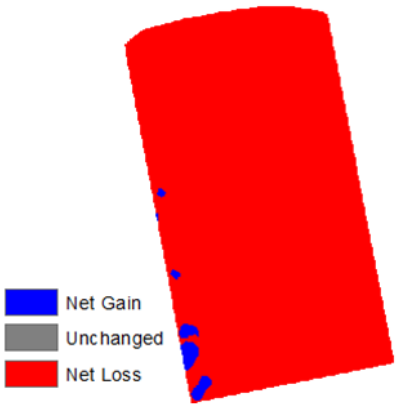
5	-5E-07	0.0005
334	-0.00021	0.0334
32579	0.12491	3.2579

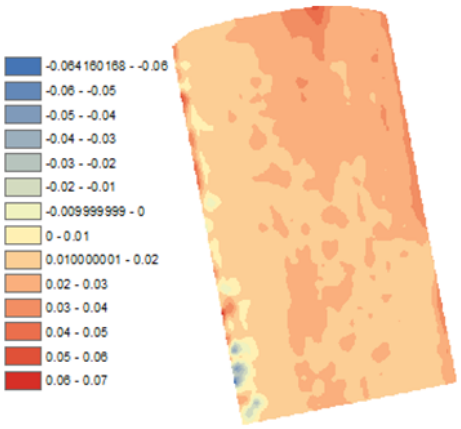


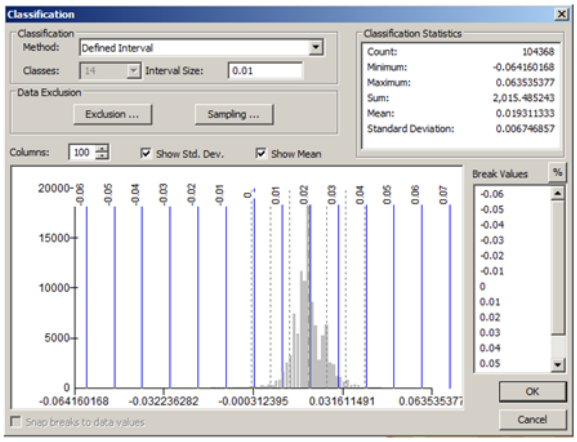
Faultine_CRG

Net Loss of 0.2m^3



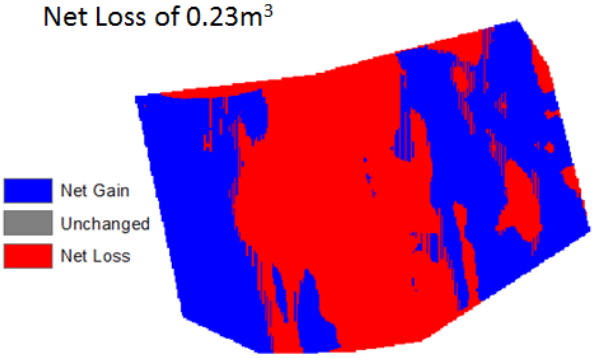
Count	VOLUME	AREA
103052	0.205802	10.3052
1	-3.7E-08	0.0001
72	-2.7E-05	0.0072
2	-1.5E-07	0.0002
17	-4.2E-06	0.0017
84	-2.6E-05	0.0084
273	-0.0003	0.0273
491	-0.00095	0.0491
376	-0.00033	0.0376
104368	0.204159	10.4368



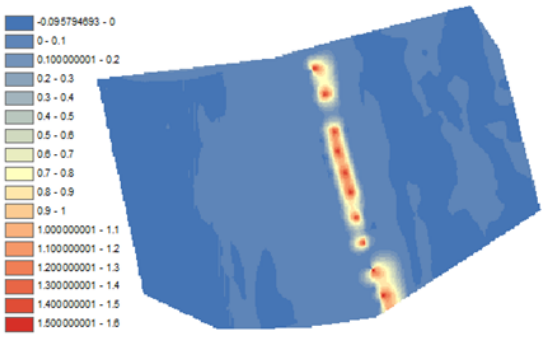


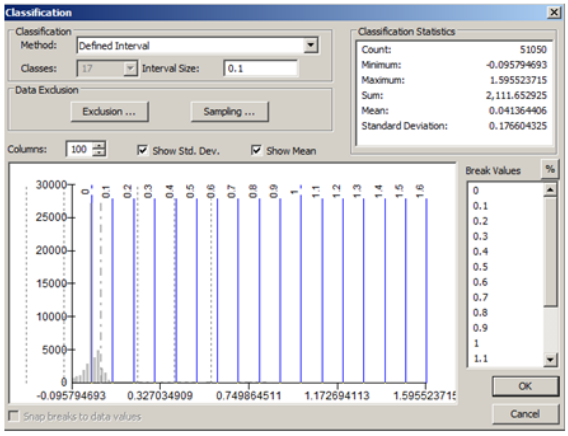
Faultline_CRY

Net Loss of 0.23m^3



Count	VOLUME	AREA
Truncated Table		
13316	-0.00644	1.3316
6	-5.9E-07	0.0006
1	-4.4E-07	0.0001
1	-4.3E-07	0.0001
20	-7E-07	0.002
18	-7.9E-07	0.0018
51004	0.225024	5.1004

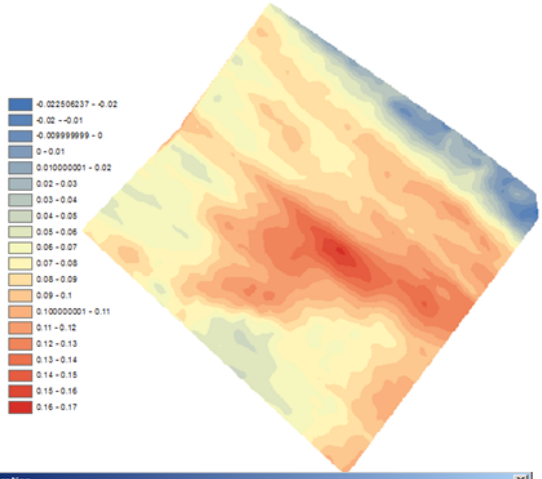


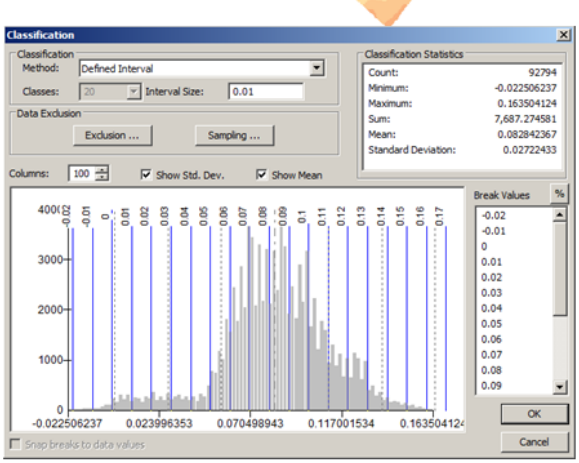


Lake_GRR

Net Loss of 0.77m^3

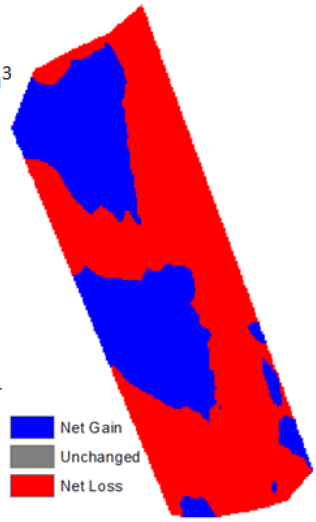
Count	VOLUME	AREA
92253	0.772472	9.2253
46	-5.7E-06	0.0046
34	-1.1E-05	0.0034
59	-9.5E-06	0.0059
5	-2E-07	0.0005
397	-0.00034	0.0397
92794	0.772103	9.2794



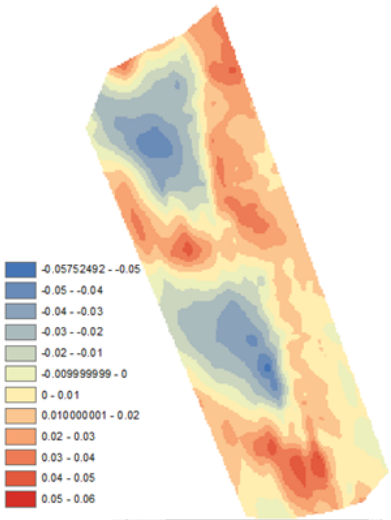


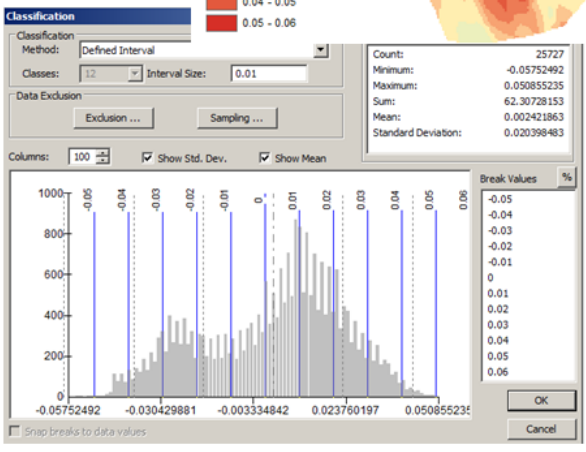
Mystic_GSY

Net Loss of 0.007m^3



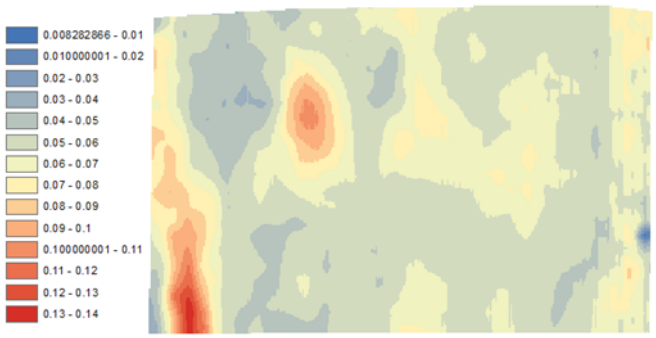
Count	VOLUME	AREA
15853	0.02574	1.5853
4559	-0.00957	0.4559
1	4.6E-08	0.0001
1	1.09E-08	0.0001
4594	-0.00917	0.4594
75	-2.2E-05	0.0075
158	-2.8E-05	0.0158
3	1.95E-07	0.0003
2	1.99E-07	0.0002
3	-1.3E-07	0.0003
265	-8.9E-05	0.0265
1	-1.7E-08	0.0001
1	-3.2E-08	0.0001
1	-7.3E-09	0.0001
18	-2.5E-06	0.0018
192	-7.4E-05	0.0192
25727	0.006778	2.5727



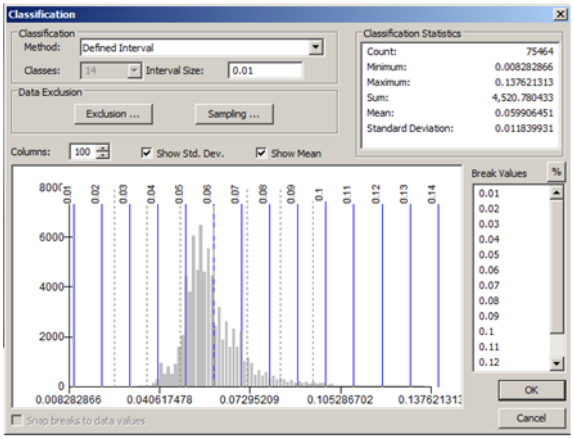


North_Canyon_GRY

Net Loss of 0.46m^3

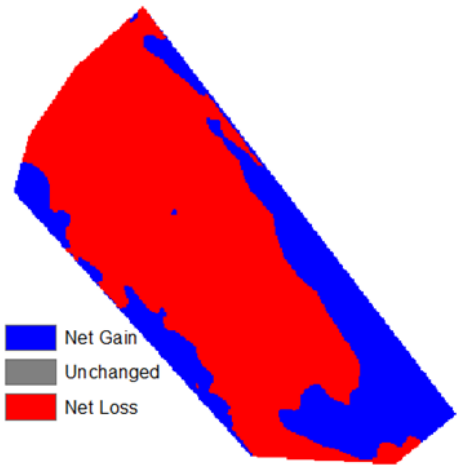


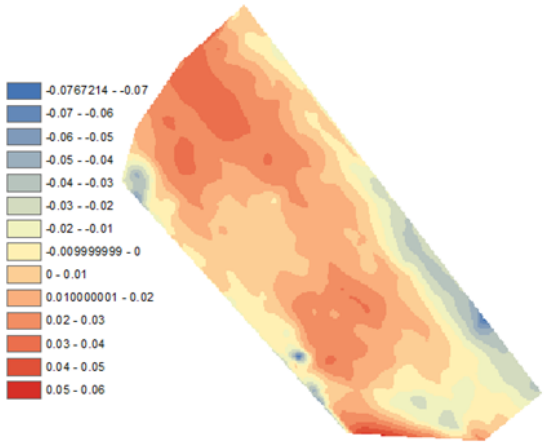
Count	VOLUME	AREA
75465	0.455015	7.5465



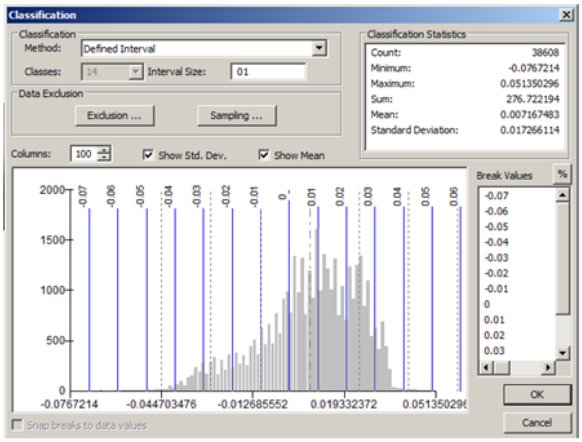
OK_Corral_CSG

Net Loss of 0.029m^3



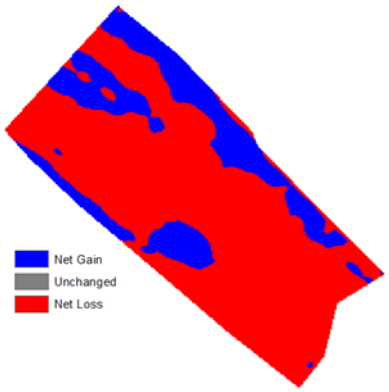


Count	VOLUME	AREA
Truncated Table		
1	-1.5E-07	0.0001
1	-7E-08	0.0001
1	-9.5E-07	0.0001
1	-9.3E-07	0.0001
5	8.34E-07	0.0005
38608	0.028645	3.8608

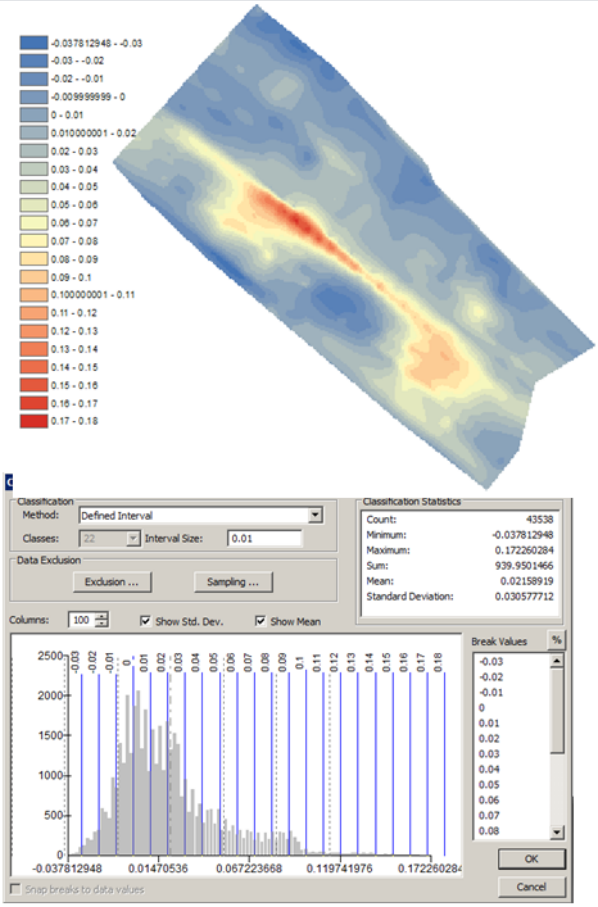


OK_Corral_CSY

Net Loss of 0.1m^3

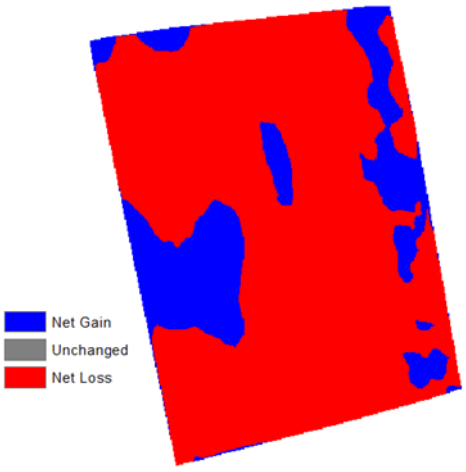


Count	VOLUME	AREA
5379	-0.00521	0.5379
10	2.39E-06	0.001
135	2.07E-05	0.0135
2400	-0.00114	0.24
32625	0.105233	3.2625
92	1.21E-05	0.0092
1	9.33E-08	0.0001
1	2.29E-07	0.0001
158	0.000149	0.0158
2	4.39E-07	0.0002
1	-3.3E-08	0.0001
1	-7.7E-08	0.0001
1	1.59E-07	0.0001
1041	-0.00151	0.1041
23	-2.1E-06	0.0023
1	2.3E-07	0.0001
1512	-0.00175	0.1512
1	6.05E-08	0.0001
1	4.67E-07	0.0001
127	-2E-05	0.0127
5	-1.8E-07	0.0005
1	3.21E-07	0.0001
1	3.45E-07	0.0001
19	-1.6E-06	0.0019
43538	0.095786	4.3538

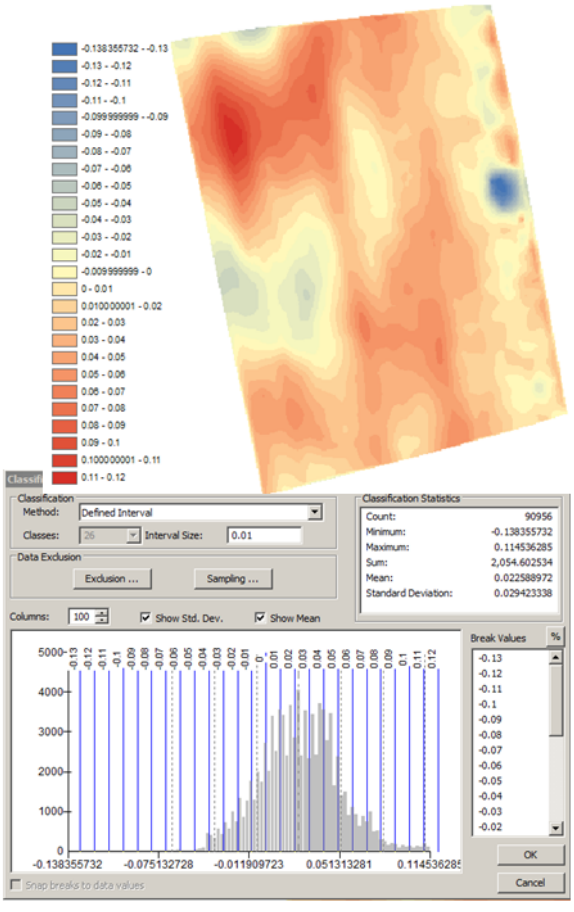


Ranch_CRR

Net Loss of 0.21m^3

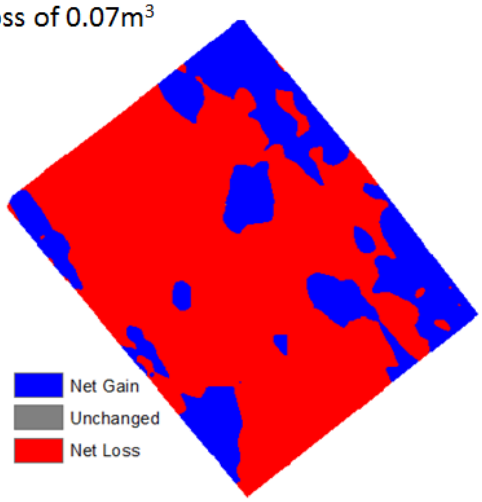


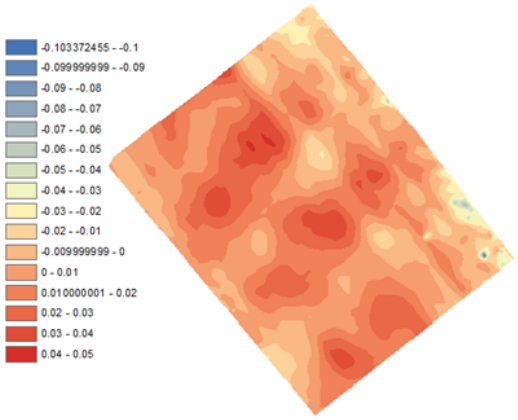
Count	VOLUME	AREA
Truncated Table		
70	-8.4E-05	0.007
22	-6.3E-06	0.0022
4	-2.7E-06	0.0004
3	-2E-06	0.0003
90956	0.209958	9.0956



Sage_GRG

Net Loss of 0.07m^3





Count	VOLUME	AREA
Truncated Table		
667	-0.00015	0.0667
146	-1.6E-05	0.0146
1	-8.6E-09	0.0001
1	-1.7E-09	0.0001
13	-7.4E-07	0.0013
2	-2.1E-08	0.0002
2579	-0.00172	0.2579
83934	0.066233	8.3934