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An Investigation to Remotely Sense Mineral Leeching Through Soils

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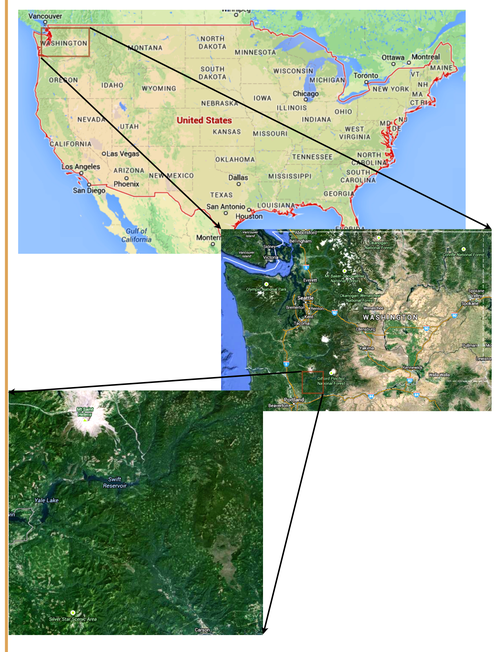
Abstract:

Satellite data of the Earth's surface provide a wealth of information on landscape conditions. I use Landsat data to determine an important geologic process that influences the composition of the soils. My project focusses on the experimental hypothesis that we can use plant vigor as a proxy to document mineral washing downslopes through soils. I constructed a Normalized Difference Vegetation Index (NDVI) composite image from Landsat data to help assess vegetation heath in my target location - a national park south of Mount St. Helens. This location was selected because of its steep inclines, dense undisturbed vegetation, and fertile soils. It is my hypothesis that as water trickles down through the soil it picks up and moves the dissolvable minerals downslope, therefore providing more minerals that aid vegetation growth and vigor at the bottom of the slopes. The NDVI analysis presented here provides data that can be used in a more detailed analysis of the same.

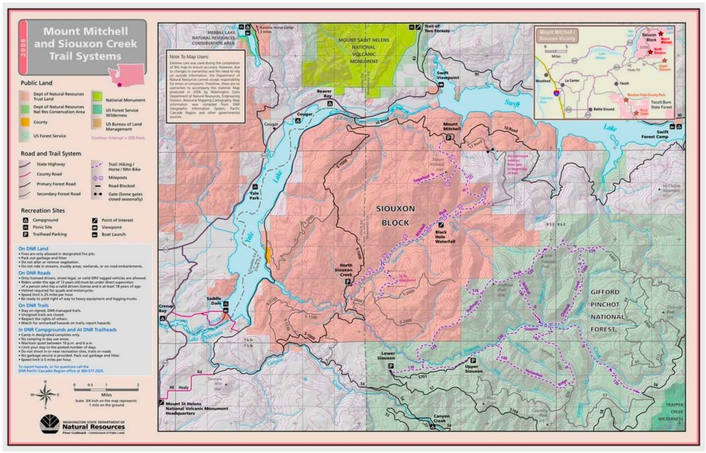
Intro:

In the past the method to observe mineral washing is through a test pit with a bucket to collect the water. Once the water is collected in the bucket the water must be transported to a lab and analyzed. This is a painstaking process which may work in easily accessible locations but in places without roads or other utilities this may be nearly impossible to accomplish. My goal is to find a link between vegetation vigor and mineral washing so that in the future we can test for mineral washing using satellite imagery from the "comfort" of an office desk.



Tools:

The data I used in this project was collected by Landsat 8 on August 7th 2014. This data was post-processed to extract imperfections in the image caused by weather in the local area. Because of this cut and paste style of corrected areas I used caution not to mix areas of slope where the image changed dates. The programs I used to produce all maps mentioned in this project were Beam and Nest. These programs used in conjunction allowed me to make a stack of usable bands and then preform an NDVI to check on vegetation health in the area of interest.



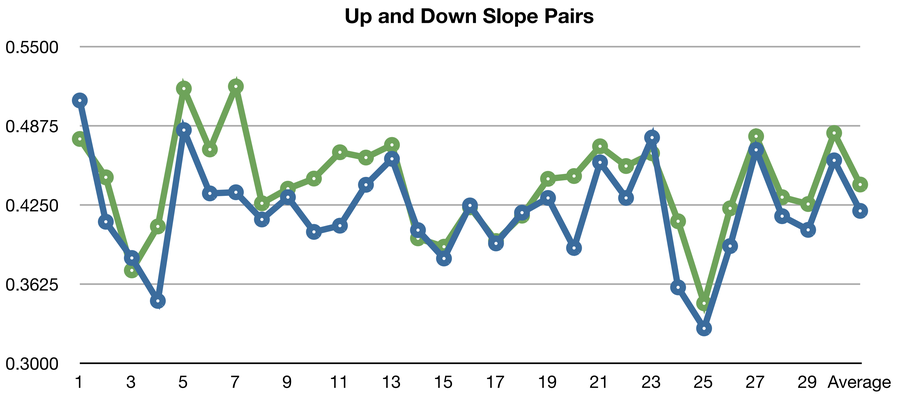
Land Use Currently:

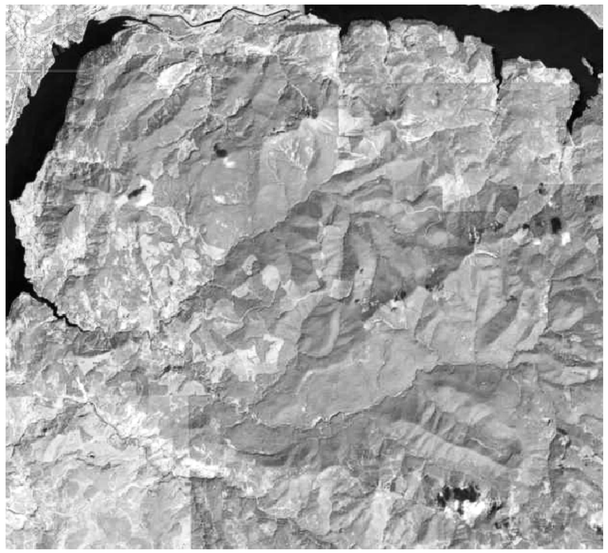
Above is a map I found using an application called Maplets for mobile devices. This searches the wed for you to find trail maps of certain locations and then you can download them or use them as overlays with GPS technologies to help you find your nearest trail if you get lost in the woods. I was finding it hard to get a good topographic overlay onto the environment I was studying but I found this map witch also shows how the land is being used, or not used in this area which may help explain any artifacts in the data. The contour lines are at 200 foot intervals. This shows us that the mountains are indeed very steep and not very weathered. The fact that these mountains are so steep is probably the biggest reason for this location not being developed.

Data Table:

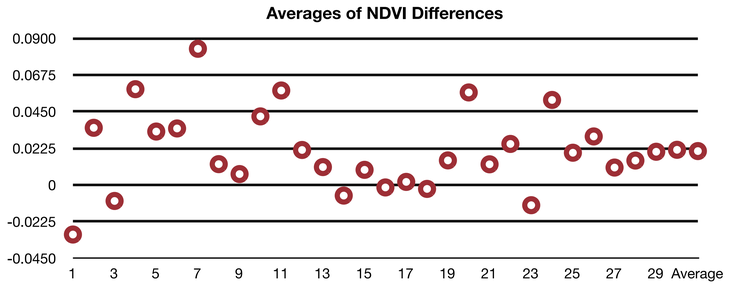
To the right is the data table where I took the NDVI numbers from the pixel values directly. I took 60 points for 30 up slope and down slope pairs. I then had the program give me the differences for each pair but I did not graph this because it was more difficult to find a pattern in the graph than in the numerical data. At the bottom of the data table I incorporated a the averages of both columns at the bottom. This shows that the average difference of .02 in the NDVI values which is an observable difference. As you may see if there are negative values from the differences often they are very close to zero.

Sample #	Up Slope	Down Slope	Difference
1	0.5076	0.4772	-0.0304
2	0.4118	0.4469	0.0351
3	0.3832	0.3734	-0.0098
4	0.3493	0.4081	0.0588
5	0.4842	0.517	0.0328
6	0.4342	0.4689	0.0347
7	0.4351	0.5187	0.0836
8	0.4136	0.4264	0.0128
9	0.4312	0.4379	0.0067
10	0.4038	0.4459	0.0421
11	0.4087	0.4667	0.058
12	0.441	0.4625	0.0215
13	0.4615	0.4725	0.011
14	0.4052	0.3987	-0.0065
15	0.3828	0.3921	0.0093
16	0.4247	0.4232	-0.0015
17	0.3947	0.3966	0.0019
18	0.419	0.4166	-0.0023
19	0.4306	0.4457	0.0151
20	0.3911	0.4479	0.0568
21	0.4587	0.4714	0.0127
22	0.4306	0.4558	0.0252
23	0.4783	0.4659	-0.0124
24	0.36	0.4122	0.0522
25	0.3276	0.3474	0.0198
26	0.3926	0.4224	0.0298
27	0.4686	0.4793	0.0107
28	0.4162	0.4312	0.015
29	0.4054	0.4258	0.0204
30	0.4603	0.4819	0.0216
Average	0.4203	0.4412	0.0208





Above is the output map of the NDVI tool in Beam. This image is a gray scale image representing the number values of each pixel from -1 to 1. Pixel IDs with the number close to -1 represents water. This is shown in the map as black areas. Bare soils have an ID closer to 0. As this area is well vegetated and quite lush there are very few locations where we will find 0s. There are some locations with bare soil where landslides have occurred. While collecting data points I made sure to avoid these locations so that the did not screw my data. As you may see there are some distinct shading differences between certain hills. Because of this I will be using slope sets, one point upslope and one point downslope to be able to compare them. By comparing the upslope and downslope pairs I should be able to get cleaner

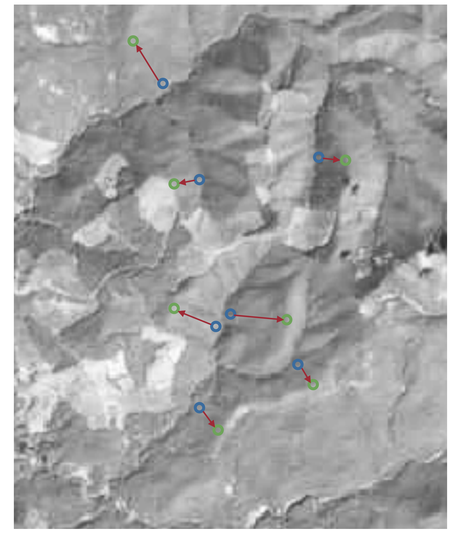


Above is graph of the NDVI difference values. These are not associated with each other but instead uses the difference between the down slope and the upslope to show the value above zero. Any values above zero shows an increase in plant vigor as you look down the slope. This graph shows the majority of the points above zero, hence showing my hypothesis is correct and may be able to be used in a larger scale in the future.

Graph of test locations:

To the left is a graph of the up slope and downslope NDVI numerical pixel values. Even though these values are not connected between point numbers I have kept the lines to show how much space between these test points may have been positive showing where the upper slope vegetation was less healthy than the lower slope. As you may notice there are only a few locations where the green line dips underneath the blue. This shows us that even when the lower slope has less healthy vegetation it's only slightly less to the point where it may be a shadow or artifact in the image. This is why I took 30 test locations to try and remove issues in the output data.

A Few Test Points:



Conclusion:

In conclusion I found that there was a correlation in the slope and the vegetation health. This seems to support my original hypothesis that the vegetation would be more healthy at the bottom of the slopes. This may be contrary to logical thoughts since the ones at the top would get more sun for longer parts of the day. This mineral washing is still a point of interest in a lot of research and may want to be used in soil studies over larger areas of land. This could dramatically decrease the cost of these studies. By using remote sensing on data already obtained we may be able to study old soil structures and their mineral washing features as well.

Future Examination:

I would like to test this new process in an area which has been tested using the traditional method. If I was able to preform this in a location such as this we may be bale to check its accuracy. Also I would like to obtain soil maps of locations to maybe use to study more. I am interested if certain soils would show the change in mineral washing more or less depending on their compositions and permeabilities. As this is a new process and never been used in the field I would like to continue doing many more tests and in all types of locations changing the variables such as soil type, slope severity, vegetation species, yearly rainfall, and resolutions of imagery.

References:

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