High Alpine Revegetation

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Abstract

This study measures the revegetation process, via species diversity and plant coverage, of 3 sections of 20-inch diameter above-ground water pipeline at various elevations between approximately 12,000 feet and 11,000 feet in a high alpine basin above Telluride, CO. The region in question recently had 2,000 feet of new pipeline installed, leaving large sections of barren ground. The Town of Telluride implemented a revegetation program in the hopes of reviving this area by harvesting seeds in proximity and raking them into the disturbed ground. This study monitors 3 sections of this historic pipeline: one last disturbed in 1938, one in the 1990's, and the recently disturbed ground of 2006. Neither of the older sites received any revegetation efforts. Vegetation samples were taken at the 3 study sites on August 12, 2009. At each site, 2 sample sets were taken: A **Control Transect** and a **Disturbed Transect.** Each **Control** is as similar in terms of slope, aspect and location as possible to its corresponding site, but existed entirely off the disturbed area. 4 Daubenmire frames were taken along each transect; vegetation species in each frame were identified and given a value from 1-6 (Table 1) based on percent coverage. The 2006 pipeline yielded the largest amount of bare ground, lowest vegetation percent coverage, and highest species diversity. The 1990's pipeline showed similar results as the 2006 disturbance but with less bare ground and lower diversity. The 1938 site was the most revegetated. It was shown that the 2006 site is most ideal for plant re-growth, being significantly lower in elevation, and milder in temperament than the two previous sites. It is furthermore evident that the most recently disturbed section of pipeline is the least recovered.

Introduction

It is, perhaps, fitting that the most visually stunning, staggering, and breath-taking landscape is also the most fragile. The zone of high alpine plants is balanced precariously on a precipice of external conditions. The equilibrium of these high altitude plants are exceptionally adapted to their harsh alpine conditions, i.e. increased solar radiation, intense, unrelenting winds, extreme precipitation and drastic temperature changes. This unique combination "…exerts an enormous influence on the vegetation." (Blair, 167). It would seem that the harsh conditions would prohibit multitudes of species from thriving in these locations; however, it actually provides a high diversity of plants which are all highly adapted to their finicky growing conditions. A plethora of exquisite and interesting vegetation in the high alpine region relies on a relatively undisturbed and stable environment.

The shocking situations in which these plants thrive, along with their striking beauty, however, create a lively interest among the populace to observe and recreate in these sensitive areas. This base desire to somehow be a part of this beauty has led to much controversy and tragic abuse. Certain auxiliary circumstances sometimes require these areas to be disturbed and uprooted. Such circumstances include ski

areas, highways, hiking trails, and access roads to various mine claims, which often pervade mountainous regions.

The region in question in this study, in the Southwest corner of Colorado, high in the San Juan Mountains, has conditions that perfectly comply with the definition of a fragile, high alpine zone. Bridal Veil Basin is a picturesque example of such a region that depends on a delicate set of circumstances to thrive. "Scientists who study the alpine believe that this ecosystem is particularly vulnerable, but is also important for learning how human impacts affect natural processes." (Gellhorn, 197) This historically complex basin has a municipal water pipeline running from Blue Lake to the historic Bridal Veil Power Station. Historically, the installation of said pipeline has, because of primitive technology, had negligible impacts on the surrounding vegetation. However, in 2006, 2000 ft of new pipeline was installed using our "modern" heavy machinery. The devastation that ensued in proximity to the pipeline left sections of barren disturbed ground. In lieu of this destruction, the Town of Telluride implemented a revegetation program in the hopes of reviving this area. (Jacobson)

This study examines the progress of these efforts and species diversity on 3 sections of disturbed ground in Bridal Veil Basin. Two of the sections had had ample time to fully recover (1938, 1990) and also never received revegetation efforts. This study predicts lower species diversity and overall reduced plant health on the most recently upturned surfaces.

Site Description

This study site is located high in the San Juan range of the Rocky Mountains, in the Southwest corner of Colorado. It lies above the town of Telluride in Bridal Veil Basin. The hanging valley above Bridal Veil Falls also has 5 glacial valleys lying above it. It is from one of these high alpine cirques, Blue Lake, that the water which flows through the pipeline in question, is drawn.

The first and highest sample site, a section of pipeline installed in 1990, lies just below the lake at 12,100 ft. This transect is in proximity to steep, jagged slopes comprised of San Juan Breccia volcanic ash deposits. The soil here is shallow and sparse; the plants here are hardy and small. Groves of willow dot the nearby landscape, in drastic contrast to the daunting, volcanic peaks in the background.

The second location along the pipeline, set in 1938, is notably the most lush. This transect is situated through a willow clump and up a mildly steep slope full of thick vegetation. It is lower in elevation than the first, and is markedly more moist than the first, as it runs parallel to the run-off of another high alpine hanging cirque, Mud Lake. Here the plants grow much taller and vivacious, as there is more water, and the soil here is much richer and deeper. The slopes above and below are distinctly

more green than the higher site, which resembled flora beaten repeatedly by the elements.

The third and final site is the most recently disturbed ground and has the lowest elevation. This sample falls on a steep avalanche slope and lies just on the cusp of the Engelmann Spruce and Sub-alpine Fir forest that blankets the lower slopes of this region. The slope here is much harsher, providing a much shallower base of soil. The area where the pipeline was ripped up and re-installed is almost completely barren, resembling a gravel road. A few unusual, weed-like plants dot the disturbed ground and on the other side, the slope falls away quickly into thickets of more willow.

All of these sites have a west-facing aspect and cross the various sections of pipeline near it. Based on their surroundings and locations, they receive relatively the same sunlight and bare the brunt of the same elemental forces, with the top site being more exposed to the harsh wind and greater snow-loads. The extreme conditions under which these types of vegetation thrive and survive provide a dramatic setting, complimented by the spire-like, majestic mountains that engulf these valleys.

Methods

Vegetation samples were taken at each of the three study sites on the Blue Lake pipeline on August 12, 2009. At each site, two sample sets were taken: A **Control Transect** and a **Disturbed Transect.** Each **Control** is as similar in terms of slope, aspect and location as possible to its corresponding site, but existed entirely off the disturbed area. The **Disturbed Transects** were chosen on subjective basis by estimating which section of pipeline best represented the majority of the land surrounding it. 15 meters of measuring tape was laid perpendicular to the pipeline, crossing it at 7.5m. Then a Daubenmire Frame was placed at .5 m with the tape running directly through the middle of the frame. The Daubenmire was used as a tool to estimate the percent ground cover of a given plant or substance by giving each species identified a value between 1 and 6, with "Trace" indicating the presence, but not prevalence, of a species. Taking it frame by frame, after accounting for bare ground, rock, lichen and moss, and litter, each species was identified and assigned a value. After each species in the frame had been identified and quantified, the next frame was placed at 4.5m and the procedure was repeated. This was done four times along each transect following the **Disturbed Transect** at the highest site, the **Control Transect** was laid and the process was repeated. Then the middle section of pipeline was sampled and this entire process was again repeated. It was repeated once more for the last section of pipeline

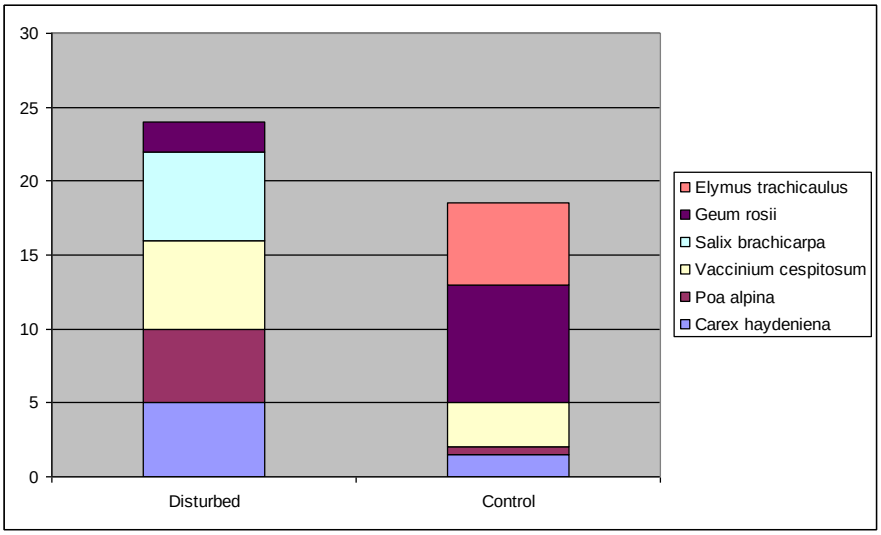
Methods, Part 2: Data

4 Daubenmire samples were taken at each transect, with 2 transects at each sampling location (the Control & the Disturbed) for a grand total of 24 Daubenmire frames. Within each frame, percent coverage for each plant species was estimated using the value system illustrated in Table 1. Each transect had up to 35 species, which yielded approximately 280 data points per section of pipeline. For simplification of the subsequent data charts, the values for all 4 Daubenmire frames along each transect were added together for each species. This new value was used to compare the sites. For example, if 'Species X' obtained values of 0, 2, 1, and 3 for each Daubenmire on 1 transect, 'Species X' was given a total value of 6. This process was repeated for each species on each transect. Species that obtained a summation greater than 5 were used in the charts and graphs below. Species diversity was still taken into account and duly noted in the results.

Results

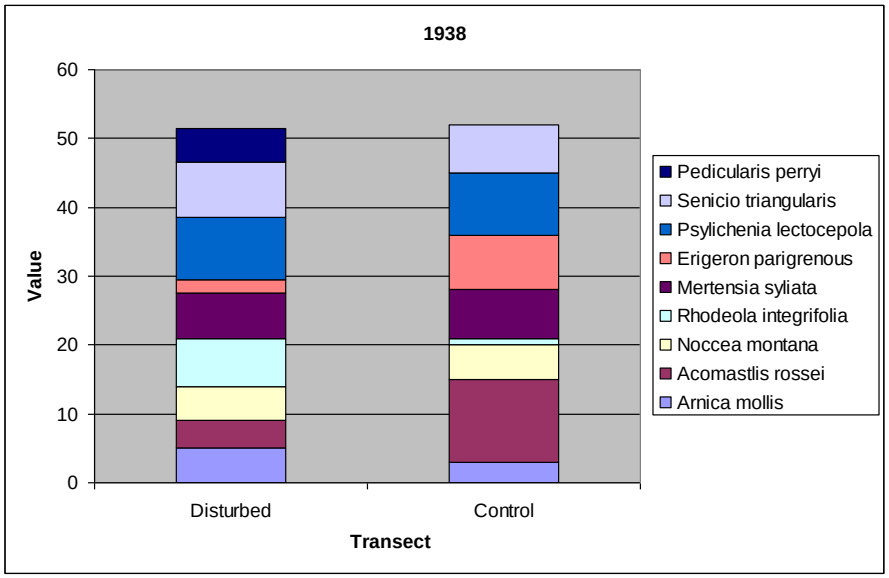
The highest study site, containing the pipeline disturbed in the 1990's, contained the lowest number of species, 28. This number is the combined number of species found on the Disturbed & the Control transects. The Control had 13 species of plants that did not exist on the Disturbed. The Disturbed had 5 species that were not found off the pipeline. The species diversity of the Control transect is 23. The species diversity of Disturbed transects is 15. Six species at this site scored a cumulative percent coverage value of 5 or more.

1990's Pipeline Sample

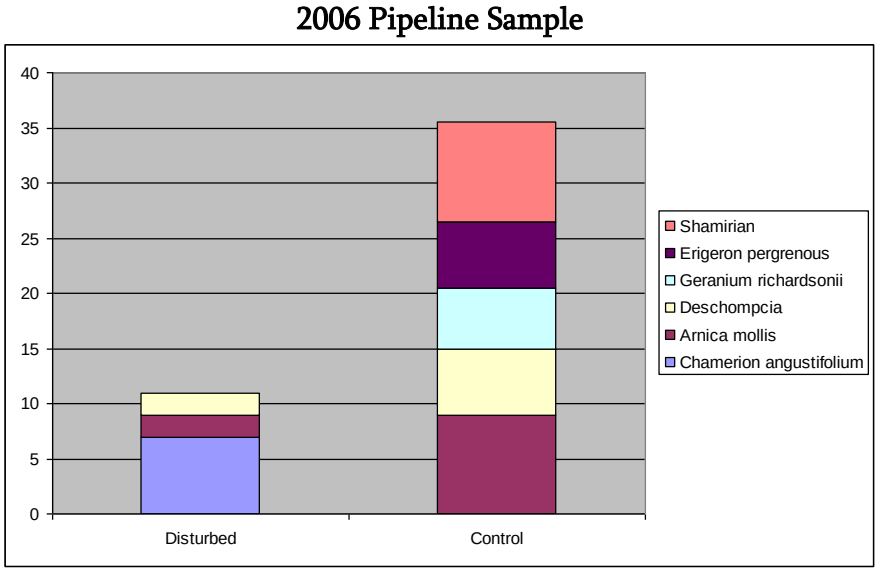


The middle (1938) study site had a higher number of species, 31. It can be assumed because this section was disturbed so long ago, there would be much less difference between the Control and the Disturbed plant counts. This is demonstrated by the fact that the Control had only 6 species that the Disturbed did not. Interestingly, the Disturbed transect also had 6 species that were not found along the Control transect. The species diversity of the Control is 24, and the species diversity of the Disturbed is 25. Nine species at this study site scored a cumulative percent coverage value of 5 or more.

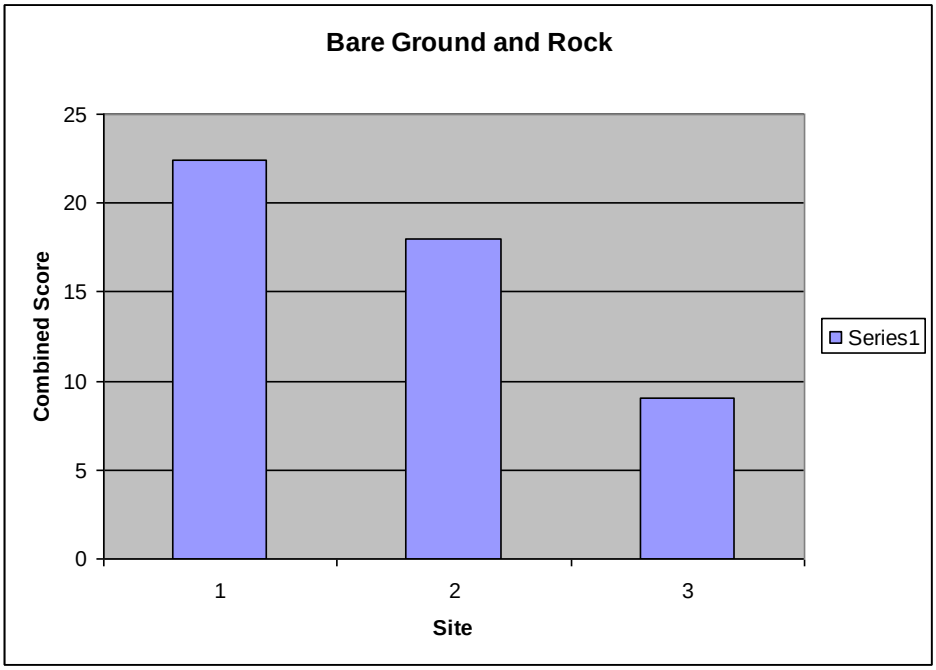
1938 Pipeline Sample



The lowest and most recently disturbed section of pipeline (2006) had, at least visually, the most drastic change between the area near the pipeline and the Control. This site had a total of 36 different species. There were 8 plant species that existed on the Disturbed transect but not on the Control, and there were an astounding 20 Species on the Control that were not on the Disturbed. Species diversity of the Disturbed transect is 15. The species diversity of the Control transect is 23. Six species at this study site scored a cumulative percent coverage value of 5 or more.



In order to compose a better picture of the revegetation process, bare ground and rock were also given a value on the scoring chart (Table 1) for each Daubenmire. Because bare ground is essential to understanding the results, here follows a graph comparing the cumulative scores for each Disturbed transect at the 3 sites, with Site 1= 2006, Site 2=1990's and Site 3=1938.



Discussion

This study predicts a lower species diversity and overall reduced plant health on the most recently upturned surfaces. The compiled results do not show a decreasing species diversity that correlates with the age of the pipeline. The two more recently disturbed pipelines had the exact same species diversity both on and off the pipeline, with 23 being the Control and 15 on the Disturbed section. But the oldest pipeline did have, per Control and Disturbed sections, the highest species diversity, 24 and 25 respectively. However, because of the efforts made in the name of compatibility and ease in terms of the data analysis, these results may not be truly representative of the situation. It then should be mentioned, that with closer investigation, it becomes apparent that the revegetation efforts have drastic differences between each study site, and even drastic differences along the transect. This follows the avenues of logic, because, as can be seen in the attached photos, the transect on the 2006 pipeline stretches up the hill, beyond the actual disturbed area in direct proximity to the pipeline. This all becomes clearer when looking at the graph of Rock and Bare Ground, showing clearly that the 2006 Disturbed Transect has copious amounts of ground where no vegetation is growing at all.

After breaking down the data and analyzing the results, it becomes apparent that, as was predicted, the middle (oldest) pipeline is the most revegetated. It has the highest number of species, as well as the lowest difference between the Control and Disturbed transects. It can be assumed that this is because this section of pipeline was installed by tram, which is much more low-impact than bulldozers. This section of pipeline has also had 71 years to recover its previous state of vegetation. In terms of location, this section of pipeline was blessed with good water, a more mild elevation, and decent shelter from the harsh high alpine wind.

It follows logically then, that the highest study site, installed in the 1990's has mediocre revegetation. This site is the highest, and most exposed. The plants at this site are much more fragile and delicate to drastic environmental disturbances, such as the installation of a new pipeline, and have very slow growth rates. The vegetation here has had insufficient time to return to its former prosperity, as plants in the alpine take much longer to recover, because conditions there are so harsh and inhospitable. It also didn't help that this pipeline was installed with heavy machinery, which tear up the ground almost beyond recovery. However, the Disturbed transect still shows improvement from the 2006 study site.

Because the 2006 transect crossed from never disturbed ground, to greatly and recently torn ground, it showed, in the results, that this study site had the widest variety and prevalence of various vegetation, however, with pictures as an aid, it is clear that little to no recovery has been made in close proximity to the pipeline. But, the location of this section of pipeline is most ideal for vivacious plant life, being

significantly lower in elevation, and milder in temperament than the two previous sites; this could account for the higher species diversity calculated. This area was also manually re-seeded, as part of the Town of Telluride's revegetation program, which should provide an extra boost to the recovery process. It should be noted, as well, that this section of pipeline contained the greatest amount of rock and bare ground, indicating little to no revegetation in these specific locations. So, while 'species diversity' may be a misleading term to make conclusions around, it is evident that the most recently disturbed section of pipeline is the least recovered.

To improve the results, conclusions and cohesiveness of this study, I would recommend placing Daubenmires directly parallel to each section of pipeline at some set interval, as well as placing Daubenmires along a transect parallel, but removed from the disturbed ground. This would provide clear information with which one could compare the growth of the vegetation on the disturbed ground to the vegetation in similar situations on undisturbed ground. This would also eliminate the variable, where the Disturbed transect crosses not only the barren, disturbed ground, but also ground above or below the pipeline, which represents a healthy plant population. It would also be scientifically methodical to enact long-term vegetation monitoring, so as to eliminate the confounding effects of the passage of time on plant re-growth. To paint a more accurate and representative picture of the revegetation developments, the methods of this study should be fine-tuned, and enacted over long periods of time.

Works Cited

Blair, Rob, et al. *The Western San Juan Mountains*. 1st. Niwot, CO: University Press of Colorado, 1996. Print.

Gellhorn, Joyce. *Song of the Alpine*. 1st. Boulder, CO: Johnson Books, 2002. Print.

Jacobson, Alessandra. Personal Interview. 8 July. 2009

Table 1

Value	Percent Coverage
T	<1%
1	1-5%
2	2-25%
3	25-50%
4	50-75%
5	76 – 95%
6	96% +