# Correlations Between South Facing Slopes and Shifting Life Zones in the San Juan Mountains

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## Abstract

A comparison of vegetation growth on opposing north and south-facing slopes was conducted in the alpine life zone surrounding Silver Lake near Telluride, CO for one day in August 2007. The objective was to compare plant species numbers, blooming stages and total plant counts between a south-facing and (then on a similar) north-facing slope, with the presumption that the south-facing slope could be used as a predictor of how the alpine zone may look in the future with rising global temperatures. It was found that the south-facing slope had a smaller number of plants in later bloom than the north facing slope, yet more plant species. It was concluded that sunlight is the predominant limiting factor for vegetation in this life zone and that eventually the north-facing slope will look like the south-facing slope. Furthermore, plants adapted to dry soil, warm temperature, and harsh sun exposure may eventually invade and take over the alpine life zone.

## Introduction

"The increase in global temperatures is expected to disrupt ecosystems and result in loss of species diversity" (NRDC, 2007). We may or may not see global warming now because it may not appear to affect us daily, the problems will be more apparent once they affect where and how we live. We will see the changes as water availability, temperature, and the precipitation amounts change across the world. For example the recent hurricane Katrina which grew to an enormous size, partially caused by the warmer than average sea temperatures, which evaporated quicker to contribute to the size of the hurricane. But the changes in climate have a much larger affect on smaller areas.

As temperatures get warmer the ecosystems and climates in which plants and animals are adapted to move higher in elevation. The plants and animals are forced to follow their receding habitat to survive, and avoid extinction. Ecosystems at high elevations, such as the alpine life zones, will not have a very large amount of land to move up on. As the ecosystems continue to move to higher elevations they can become isolated on the top of hills or mountains. This idea is known as the global warming extinction hypothesis (Walter, et al. 2005), or the island effect. In the Southwestern United States the alpine environment in the Rocky Mountains is a prime target for habitat loss.

The alpine life zone is sensitive to small changes and a change in an average temperature of two or three degrees would have a huge change on the plant and animal species. The warmer and drier conditions would invite invasive species such as sagebrush to move in. Alpine species are adapted to harsh high elevation environments and conditions. If those conditions which the plants have been prepared for are changed in the slightest, it will have an impact upon the species that have adapted to this climate.

Since a south-facing slope experiences warmer conditions due to longer hours of direct sunlight, such a slope can be used as a predictor for how a similar alpine environment would look and react under warmer and drier conditions. In this study, the prediction was made that an alpine meadow with a south-facing slope will have flowers in later blooming stages than a north-facing slope, due to increased sunlight causing them

to grow faster and bloom sooner. While the north-facing slope is predicted to have a greater diversity of plants as a result of increased moisture in the soil from a later-lying snow pack.

## Site Description

The study was conducted near Telluride, Colorado in the San Juan Mountain range of the Rocky Mountains. Telluride is located in the southwest corner of Colorado. The area of study was near Silver Lake, a glacial cirque, located in a hanging valley above Bridal Veil Basin at 11,800'. Surrounding the lake are several towering peaks ranging in elevation from 12, 200 to 13,200 feet. Steep slopes descending from surrounding peaks line each side of Silver Lake except its eastern edge, where the lake's outlet plummets down a steep slope toward Bridal Veil Basin. The vegetation of the area surrounding the lake is generally made up of small and medium sized plants, as well as grasses, and willows. Silver Lake sits just above tree line with forest coverage below. There was a small amount of gravel and some areas are characterized by talus and larger rocks.

## Methods

### Site Selection

Two study plots were selected near Silver Lake; one on the north facing slope, or the South side of the lake (plot 1a), another on South-facing (north side) of the lake (plot 2a). A similar coverage of vegetation layout and similar slope was taken into consideration for choosing the plots, as well as the north and south-facing aspect and the similar elevation. Once the sites were chosen, a ten by ten meter plot was measured out on each slope. Inside the ten-meter sections, a one-meter by one-meter sub-plot was selected from the farthest southwest corner of the larger plots to add a random factor to site selection.

### Data collection

On each plot, the one-meter section was studied for the number of plant species, the blooming stages, and the individual counts for each species. The first step was to list each species we found growing in the one-meter square plot, and to perform a thorough individual species count. Average species height was calculated for each plot by measuring several samples and finding the mean height. In addition, the blooming stage was noted on a scale of one to five, which is explained below. (See Chart 2 for all data results)

1. The plant had no flower.
2. The plant was just about to flower.
3. The plant was in full bloom.
4. The plant was in the later stages of bloom.
5. The plant had finished flowering.

## Results:

### Plot 1A

Plot 1 showed obviously drier conditions determined by the pattern of plants in later blooming stages and sparse vegetation coverage, calculated by use of a densiometer. Plot 1a (the south-facing slope) had a layout of small flowering plants, grasses, and mosses. The majority of the plants had yellowed and were either finished blooming, or smaller and had not flowered at all, there was also a large portion of gravel and bare ground exposed. Six of the eighteen plant species on this side were in the later blooming stages, with a total of 369 plants counted. The total average height for the plot was 16.6 cm.

### Plot 2A

Plot 2A (north facing slope) had a very dense coverage of vegetation and noticeably more wet conditions, with barely any bare ground and a small amount of gravel. The plot was very lush, green, and blooming with a layout of tall flowering plants, and grasses. Six of the thirteen plant species were in the earlier blooming stages, with a total of 404 plants counted, the average height of the entire plot was 21.8 cm. (See Chart 1)

## Conclusions

The information collected during the study proved the hypothesis to be the very opposite of what was originally supposed. The prediction made that the south-facing slope would have flowers in later blooming stages was proven incorrect, as six of the eighteen species were in the latter or final stages of bloom, 33.3%, whereas the north-facing slope had ten of thirteen species in later bloom, at a percentage of 76.9%. An interesting factor was that the south-facing slope was an average of 5.2 cm. shorter than the north-facing plot. This may prove likely the idea that the plants are growing smaller on the south-facing slope possibly because they are not receiving enough water to grow larger, as well as the growth limiting amount of sunlight.

Another aspect of the hypothesis that proved incorrect was the suggestion that the diversity of species would be greater on the north-facing slope. The north-facing plot had thirteen species, five less than the opposing plot. After studying plot 1a, it seemed as if plot 1a would have less species diversity because of drier conditions.

The south-facing slope's characteristics represented the future looks and circumstances of a drier and warmer area that has undergone a warmer than average temperature change. The information we gathered proved that sunlight is the predominant limiting factor for vegetation in this life zone, as the increased amount of sunlight received by Plot 1A appears to have resulted in higher species diversity. The next conclusion was that eventually the north-facing slope will look like the south-facing slope, under current warming trends. Since the hypothesis is that the south-facing slope will become even more arid and dry in the future, species adapted to drier conditions which can handle the large amount of sun exposure will invade and take over the former species of the area, for example: geraniums, sagebrush, and grasses, plants that can

handle dry soil and warm temperatures, and the harsh sun exposure, may migrate to these locations.

In Gothic, Colorado at the Rocky Mountain Biological laboratory, an alpine meadow was set up with heat lamps strung above it to see what changes could be observed from an average raised temperature of two degrees Fahrenheit. After years of observation sagebrush and other woody shrubs invaded the meadow, beginning to squeeze out native species of the meadow. If the study at hand had been lengthened over a long period of time (decades perhaps) under the current global warming conditions, it is possible we may have seen similar patterns of invasion by species adapted to a drier climate, such as the aforementioned sagebrush, which has proven to be a "King of Hills" (Hilchey 1995). Species on the south-facing slope could have appeared on the north facing slopes, and currently numerous species on the south-facing slope may have decreased in number, or increased in number, while species which had few numbers might have died out completely.

After the study was completed several disused components were found that would have been useful in supporting the hypothesis. Among these include a soil sample to calculate the moisture levels of the ground. This would have confirmed or disproved the presumption of "increased moisture in the soil from later-lying snow pack". The temperature of the ground would have given backup data of increased solar radiation to the south-facing plot.

Another factor, which would have given a better analysis of the species diversity, would have been having more than one plot on each slope. This would have showed a better average (time constraints were the reason this was not carried out this session) of plant species diversity, and a larger average number of individuals per species. To make the entire process of scouting out similar vegetation coverage and sloped hillsides, setting out the plots and the vegetation counts more easily accomplished, more field assistants would have been helpful/necessary.

Additional suggestions for improvement of similar studies would include using long-term temperature loggers at research site locations, one would be able to calculate the average temperature for periods of time, and watch whether the averages are changing. The same general idea of a more accurate analysis of data would be more easily acquired if plots were monitored over longer periods of time. Studying the plots over an extended period of time would possibly allow enough time that you could see the changes in the species diversity happening, or on the other hand, possibly not happening.

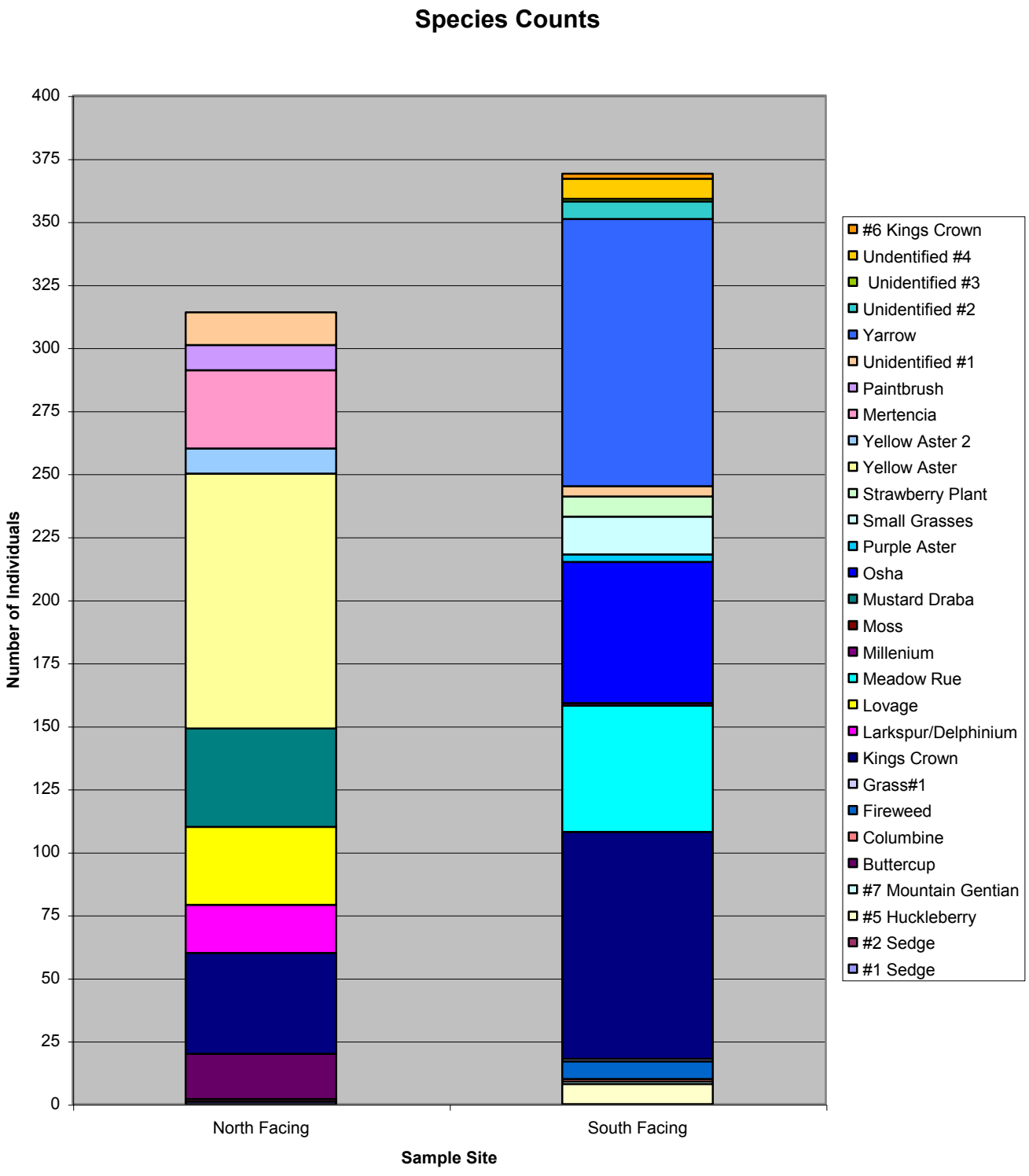
The general need of the entire study was more time. A lot of data collection was done in a short amount of time, and that is the source of a large amount of our conclusions. As a result, the data surely would have been more accurate had a more lengthy analysis been taken.

## References

Walther, G.-R., Beissner, S. and Burga, C.A. 2005. *Trends in the upward shift of alpine plants*. *Journal of Vegetation Science* **16**: 541-548.

Hilchey, Tom, February 1995. *Global Warning Study Shows Sagebrush as King of Hills.*

**Chart 1**




Total Species

Total Species

## Chart 2

| Plot | Date | Time | Plant Species | No. (of individuals) | Total Count (of North Plot) | Blooming stages | Average Height |
|---|---|---|---|---|---|---|---|
| North Facing | 8/9/2007 | 12:30 | Larkspur/Delphinium | 19 | 404 | 3 | 52 cm. |
| North Facing | 8/9/2007 | 12:30 | Mertencia | 31 | 404 | 4 | 30 cm. |
| North Facing | 8/9/2007 | 12:30 | Kings Crown | 40 | 404 | 3 | 32 cm. |
| North Facing | 8/9/2007 | 12:30 | Paint Brush | 10 | 404 | 3 | 33 cm. |
| North Facing | 8/9/2007 | 12:30 | Buttercup | 18 | 404 | 4 | 32 cm. |
| North Facing | 8/9/2007 | 12:30 | Mustard Draba | 39 | 404 | 5 | 10 cm. |
| North Facing | 8/9/2007 | 12:30 | Yellow Aster | 101 | 404 | 4 | 28 cm. |
| North Facing | 8/9/2007 | 12:30 | Yellow Aster 2 | 10 | 404 | 4 | 41 cm. |
| North Facing | 8/9/2007 | 12:30 | Lovage | 31 | 404 | 1 | 22 cm. |
| North Facing | 8/9/2007 | 12:30 | #1 | 13 | 404 | 5 | 25 cm. |
| North Facing | 8/9/2007 | 12:30 | Moss | | 404 | 1 | |
| North Facing | 8/9/2007 | 12:30 | #1 Sedge | 1 | 404 | 3 | 29 cm. |
| North Facing | 8/9/2007 | 12:30 | #2 Sedge | 1 | 404 | 1 | 22 cm. |
| South Facing | 8/9/2007 | 1:30 | Millenium | 1 | 369 | 1 | 32 cm. |
| South Facing | 8/9/2007 | 1:30 | Yaro | 106 | 369 | 1 | 8 cm. |
| South Facing | 8/9/2007 | 1:30 | Grass#1 | 1 | 369 | 5 | 50 cm. |
| South Facing | 8/9/2007 | 1:30 | Osha | 56 | 369 | 1 | 33 cm. |
| South Facing | 8/9/2007 | 1:30 | Fireweed | 7 | 369 | 1 | 18 cm. |
| South Facing | 8/9/2007 | 1:30 | Meadow Rue | 50 | 369 | 1 | 16 cm. |
| South Facing | 8/9/2007 | 1:30 | Kings Crown | 90 | 369 | 5 | 18 cm. |
| South Facing | 8/9/2007 | 1:30 | Columbine | 1 | 369 | 1 | 11 cm. |
| South Facing | 8/9/2007 | 1:30 | Strawberry Plant | 8 | 369 | 1 | 3 cm. |
| South Facing | 8/9/2007 | 1:30 | #1 | 4 | 369 | 5 | 68 cm. |
| South Facing | 8/9/2007 | 1:30 | #2 | 7 | 369 | 5 | 25 cm. |
| South Facing | 8/9/2007 | 1:30 | Purple Aster | 3 | 369 | 4 | 19 cm. |
| South Facing | 8/9/2007 | 1:30 | #3 | 1 | 369 | 4 | |
| South Facing | 8/9/2007 | 1:30 | #4 | 8 | 369 | 1 | 8 cm. |
| South Facing | 8/9/2007 | 1:30 | #5 Huckleberry | 8 | 369 | 1 | 3.5 cm. |
| South Facing | 8/9/2007 | 1:30 | #6 kings crown 2 | 2 | 369 | 1 | 13.5 cm. |
| South Facing | 8/9/2007 | 1:30 | #7 Mountain Gentian | 1 | 369 | 2 | 18 cm. |
| South Facing | 8/9/2007 | 1:30 | Small Grasses | 15 | 369 | 1 | 10 cm. |