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Bristlecone, Limber Pine Geology, and Soil Substrates

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Abstract

Bristlecone Pines are among the oldest living trees in the world, and the climate condition under which they thrive is nothing short of extreme in the alpine zone. The experiment takes place in Inyo National Forest, where a hundred Bristlecone and Limber Pines were assessed. The trees were chosen based on a randomized selection that allowed us to analyze trees going upslope. We identified the rock type under the tree canopy, and analyzed the soil by taking the pH using a pH meter. By analyzing the rock and soil under the canopy of Bristlecone and Limber Pines we found that the soil conditions weren’t consistent with the favorable conditions under which the trees grow in. Climate change may play a role in the neutral shift in soil pH due to the increase in the rate of erosion of the rock type which is most prevalent among the pines, dolomite.

Introduction

The harsh climate conditions of a subalpine zone provide livable conditions for few species. Tree species such as the Bristlecone and Limber Pine thrive in these areas as they face little competition with other tree species, crediting their longevity and ability to retain excellent evidence of past climate conditions. However, climate change caused by global warming could pose a serious threat to these species as they try to persevere from the possibility of newfound climate extremes.

Bristlecone Pines can thrive in alkaline soils, with minimal moisture in the soil. These impressively ancient trees favor a 550 million year old rock from the Proterozoic, and Pre-Cambrian Era that is deficient in phosphorus, but rich in calcium and magnesium. Limber Pines are tolerant of alkaline soils, but its preferred substrates include those that are derived from granitic, obsidian, and pumice rocks. However, with climate change occurring at a rapid pace, will harsher climate conditions affect soil erosion? To elaborate on this question, one may ask how this will impact soil erosion by increasing the rate at which rocks are broken down as climate change causes subalpine to become drier and warmer. One of the potential outcomes involves a change in the soil pH towards an unfavorable direction for the pines.

The challenge underfoot in this experiment is the likelihood that climate change will create even more extreme conditions in the high-altitude zones, which will put further stress on the environment by speeding the erosion of the geology in the White Mountain Ranges with gusty winds and reduced precipitation. As rocks erode at a pace faster than they naturally would, this process can affect the pH, and compaction of the soil which will ultimately affect the health of the Bristlecone and Limber Pines. This is where my team and I ran specific soil analysis test, involving the measurement of pH and compaction of the soil, as well as determining the geology under the canopy of the tree.

Bristlecone Pines thrive under a very specific set of conditions, and anything falling outside these conditions can severely stunt the growth of the tree, and possibly even affect their ability to reseed themselves. Bristlecones grow most favorably with dolomite rocks, which is a type of sedimentary rock that has calcium, magnesium, and a small component of limestone. However, as limestone begins to break down in the soil it has the ability to increase the acidity levels of the surrounding soil, this could negatively affect the Bristlecones by changing the pH of the surrounding soil. It's vital that we continue to do further research on these ancient pines, and closely monitor how climate change continues to negatively alter ecosystems around the world.

Methods:

Study Area and Study Species

We conducted this research at White Mountain Research Station, Crooked Creek, California in the Inyo National Forest between October 13 and October 16, 2016.

We studied two species of high elevation pines, the Bristlecone Pine (*Balfourianae*) with short, dark needles bunched in groups of five, and Limber Pine (*Pinus Flexilis*) with longer, and lighter green needles in similar bunches. At an elevation of over 10, 150 ft. the subalpine conditions were extremely windy, with gusts of over 60 mph, and dry. Vegetation was minimal, as majority of the landscape was covered in cushion plants, and dried Big Sagebrush. Mammals in the area were small burrow dwelling species ranging from pikas, to the hibernating marmot. Subalpine, and alpine zones are among the areas that are highly impacted by climate change.

Experimental Design

The research that was conducted on over 100 trees involved several methods of data collection. To begin the process of surveying the Bristlecone and Limber pine trees randomly we began by choosing ridges with groves on Google maps. To do this, a pin was dropped on areas within five miles of the White Mountain Research Center, and without prior knowledge of the trees of each grove, team members chose four sites that were relatively separated. Once we arrived to the grove, we assessed the first tree we walked up to at the bottom of the ridge, and wrote down whether the tree was a Bristlecone Pine or Limber Pine. Then, in order to randomize the choice of trees surveyed we drew a paper out of a bag that has three directions, one of which will dictate where you will head to the next tree. The direction papers had “left”, “right”, and “up” written on them as options for where you will head next. If the paper drawn out of the bag is “left”, then you will head towards the first upslope pine that is on your left-hand side, and the same process is repeated for the other directions.

Rock Identification

Rock identification is an aspect that we didn’t overlook as we surveyed trees upslope, and we completed several steps to determine the types of rocks that we encountered. First, we checked for any rocks under that canopy of the tree such as the dolomite in Figure 1.

Figure.1 Bristlecone Pine growing from dolomite.

Next, we took notes on the size of the rocks and whether they were small and fragmented, of medium size, or large boulders. To determine the type of rock present we analyzed the color, and texture of the rock. For example, we took note of whether the rock had a red hue, or it the rock felt gritty. We also took notes of any patterns occurring in the rock, such as cross bedding or crystallized specs within it as seen in Figure 2.

Figure.2 Cross bedding in shale and sandstone rocks

By analyzing these specific areas on rocks, we could identify whether the rock was of metamorphic or sedimentary origin, and by doing so we narrowed it further and stated if the rock was granite, dolomite, or other.

Soil Analysis

The last area of our study involved a series of soil analysis ranging from measuring soil pH, to the compaction of the soil. We measured the pH of the soil with a pH meter that we inserted into the ground approximately one pace from the tree canopy as displayed in Figure 3.

Figure. 3 pH meter inserted into soil

After a minute, we recorded the pH that the meter displayed. In the same area where the pH was measured we collected soil samples by digging past the duff layer with a trowel, and collecting a standardized amount of soil for each tree. Furthermore, soil compaction was determined by dropping a post digger 65 inches off the ground one meter away from the western point of the tree. The post digger was then removed immediately, and the indentation on the ground was measured in centimeters with a ruler, this process was repeated for the north, south, and west direction of the tree. However, if a boulder disrupted access to the vicinity around the tree then the data point was not recorded.

Results

The data we collected and graphed showed a significant trend in which kind of rock types that Bristlecone Pines preferred to grow in. In Graphs 1A, 1B, and 1C in the Appendix, we found that Bristlecones primarily grew on ridges where a majority of the rocks that were present were dolomite. Since Bristlecone Pines continued to favor dolomite, and rarely grew on other types of rock, this could pose a threat to the tree species in the future if the dolomite rocks were to erode and cause a shift in the soil pH. This shift may have been proven as we took the pH of the soil for each tree, and noticed that sites with dolomite present had a lower pH than site 4 shown in Graph 1D, which was occupied by shale and sandstone. The Graphs 2A, 2B, and 2C had Bristlecone growing in soils that were within a neutral range, likely due to an acidic shift away from the favorable alkaline levels. This may have been brought on by the dolomite eroding and leaching limestone into the soil. The dolomite at site 1, 2, and 3 gave off a sandstone feel by being very gritty which may have been a characteristic of the rock being broken down by the constant gusty winds in the higher alpine areas. Site 4 was the only site where we observed Bristlecones that weren’t growing from dolomite; this allowed the soil to maintain a healthy alkaline pH between 11 and 12.

While dolomite may be eroding at an increased rate under windier and drier weather conditions, the soil in the vicinity of the pines is becoming neutral and venturing away from alkaline levels, which is what Bristlecones favorably grow in. In future studies, we should focus on how climate change is impacting Bristlecone Pines in the subalpine regions by altering the very constrained conditions in which they can grow. While Limber Pines may grow in a wider range of pH levels, and rock types, this isn’t the case for Bristlecone Pines and the slightest change in environmental conditions may ultimately affect their growth rate, and ability to reseed themselves.

Discussion

Climate change is a driving force in altering the environmental conditions towards negative gradients of temperature and precipitation scales. In a study done by researchers in

White Mountains, Ca., they found that the change in climate was impacting the plant community by decreasing the populations of cushion plants in an area (Cleland and Kopp 2014). While cushion plants may be a much smaller plant species in comparison to the Bristlecone Pine, the evidence of man-made global warming having an effect on climate in alpine regions is evident and alarming.

Furthermore, research done by scientists surveying the impact of climate change on coniferous trees in Japan found that the climate conditions were shifting at subalpine regions which resulted in the cool, wet summers becoming warmer (Tsuyama, et al. 2015). This increase in temperature in the trees' range may have adverse effects on the keystone subalpine conifers, *Tsuga diversifolia* and *Abies veitchii,* by making it difficult for them to grow, and ultimately complete their life cycle (Tsuyama, et al. 2015).

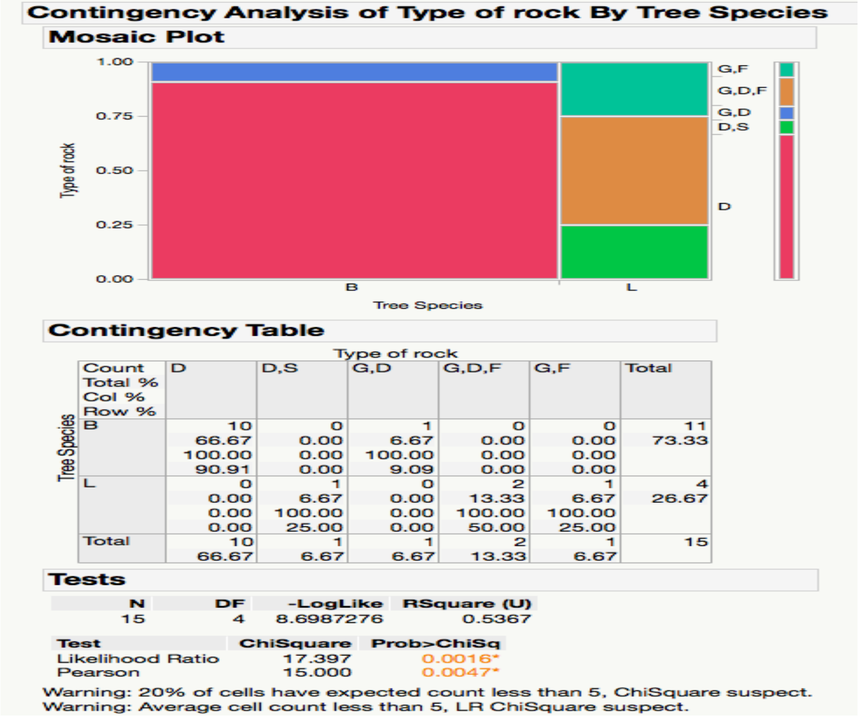
The ability to observe the affects that anthropogenic climate change has in alpine, and subalpine areas serves as evidence of the rate at which human activity is becoming an issue for some of our oldest forests, such as those in the White Mountains. Prior to the shift in climate, Bristlecone Pines grew exceptionally well in areas with dolomite. The whiteness of dolomite rocks reflected sunlight off of the ridges where Bristlecones grew, allowing them to retain moisture in the soil for longer periods of time and aiding the growth of the trees (Mooney, et al. 1962). However, now the rock may be actually hurting the tree by drawing the soil towards more neutral levels on the pH scale. As environmental conditions fluctuate within the Bristlecones' subalpine ecosystem, the ancient tree may not be able to keep up and withstand the shift in pH that will come with the change in climate.

Appendix

LEGEND: B = Bristlecone Pine, L =Limber Pine, D = Dolomite, G = Granite,

S = Sandstone, F = Feldspar

(1A) Site 1



Contingency Analysis of Type of rock By Tree Species

Mosaic Plot

Contingency Table

Count Total % Col % Row %	Type of rock D	D,S	G,D	G,D,F	G,F	Total
B	10 66.67 100.00 90.91	0 0.00 0.00 0.00	1 6.67 100.00 9.09	0 0.00 0.00 0.00	0 0.00 0.00 0.00	11 73.33
L	0 0.00 0.00 0.00	1 6.67 100.00 25.00	0 0.00 0.00 0.00	2 13.33 100.00 50.00	1 6.67 100.00 25.00	4 26.67
Total	10 66.67	1 6.67	1 6.67	2 13.33	1 6.67	15

Tree Species

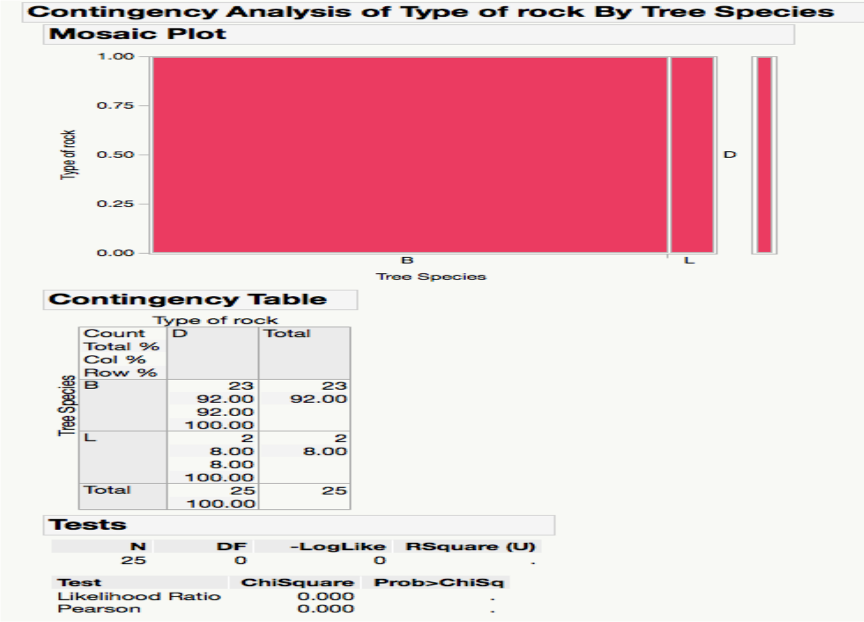
Tests

N	DF	-LogLike	RSquare (U)
15	4	8.6987276	0.5367

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	17.397	0.0016*
Pearson	15.000	0.0047*

Warning: 20% of cells have expected count less than 5, ChiSquare suspect.
Warning: Average cell count less than 5, LR ChiSquare suspect.

(1B) Site 2



Contingency Analysis of Type of rock By Tree Species

Mosaic Plot

Contingency Table

Type of rock

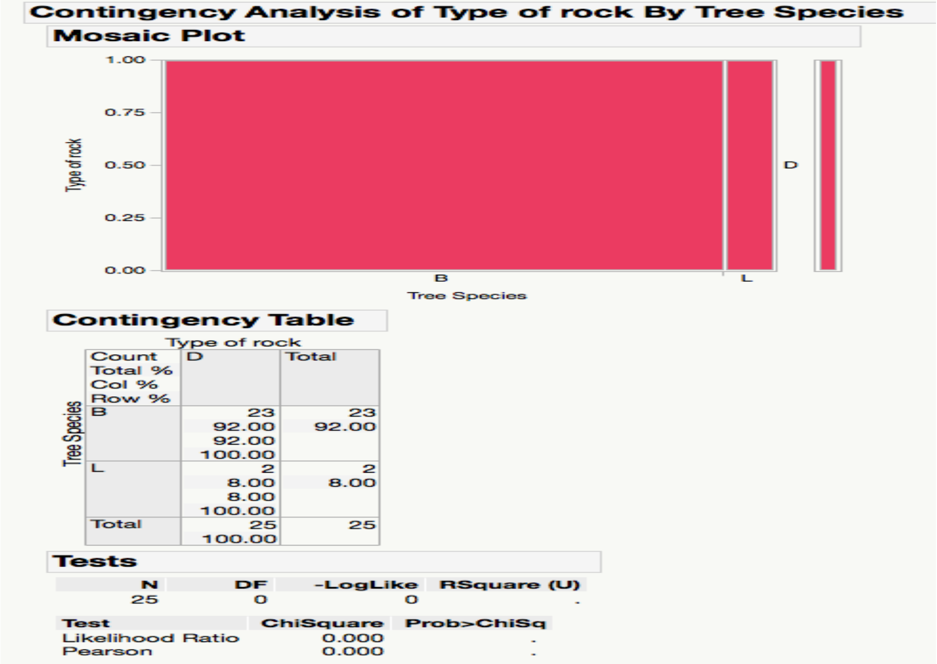
Tree Species	Count Total % Col % Row %	D	Total
	B	23 92.00 92.00 100.00	23 92.00
	L	2 8.00 8.00 100.00	2 8.00
	Total	25 100.00	25

Tests

N	DF	-LogLike	RSquare (U)
25	0	0	.

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	0.000	.
Pearson	0.000	.

(1C) Site 3



Contingency Analysis of Type of rock By Tree Species

Mosaic Plot

Contingency Table

Type of rock

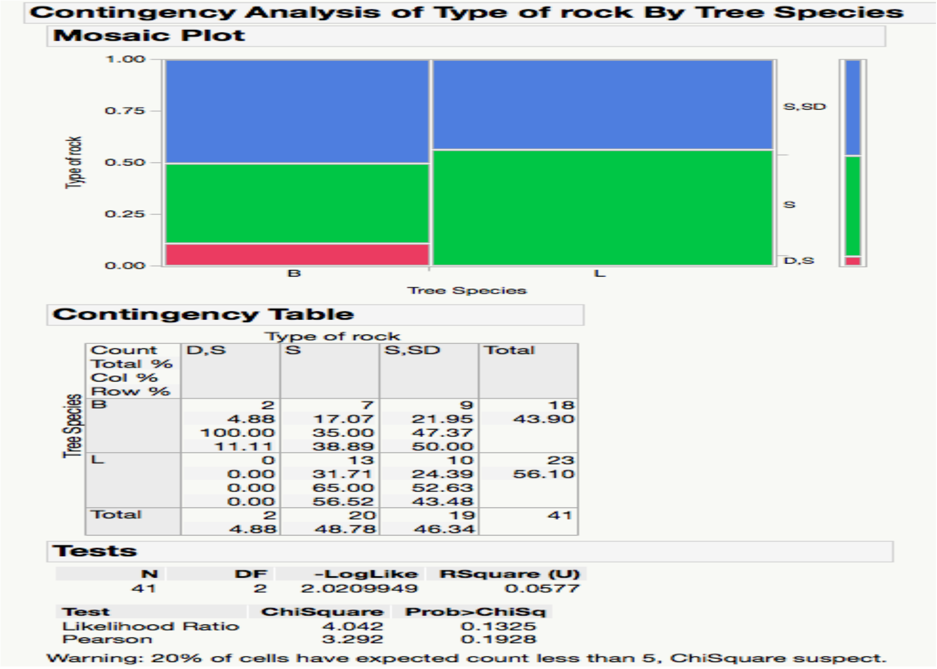
Tree Species	Count Total % Col % Row %	D	Total
	B	23 92.00 92.00 100.00	23 92.00
	L	2 8.00 8.00 100.00	2 8.00
	Total	25 100.00	25

Tests

N	DF	-LogLike	RSquare (U)
25	0	0	.

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	0.000	.
Pearson	0.000	.

(1D) Site 4



Contingency Analysis of Type of rock By Tree Species

Mosaic Plot

Contingency Table

Type of rock

Tree Species	Count Total % Col % Row %	D,S	S	S,SD	Total
	B	2 4.88 100.00 11.11	7 17.07 35.00 38.89	9 21.95 47.37 50.00	18 43.90
	L	0 0.00 0.00 0.00	13 31.71 65.00 56.52	10 24.39 52.63 43.48	23 56.10
	Total	2 4.88	20 48.78	19 46.34	41

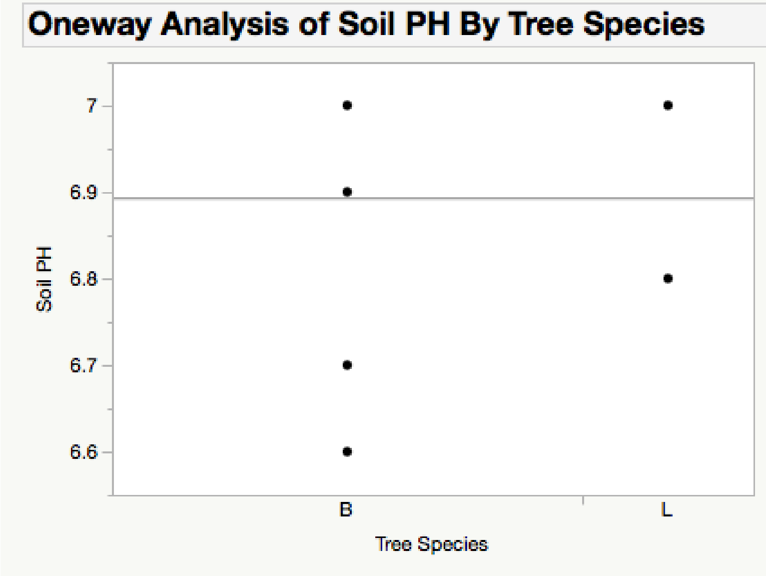
Tests

N	DF	-LogLike	RSquare (U)
41	2	2.0209949	0.0577

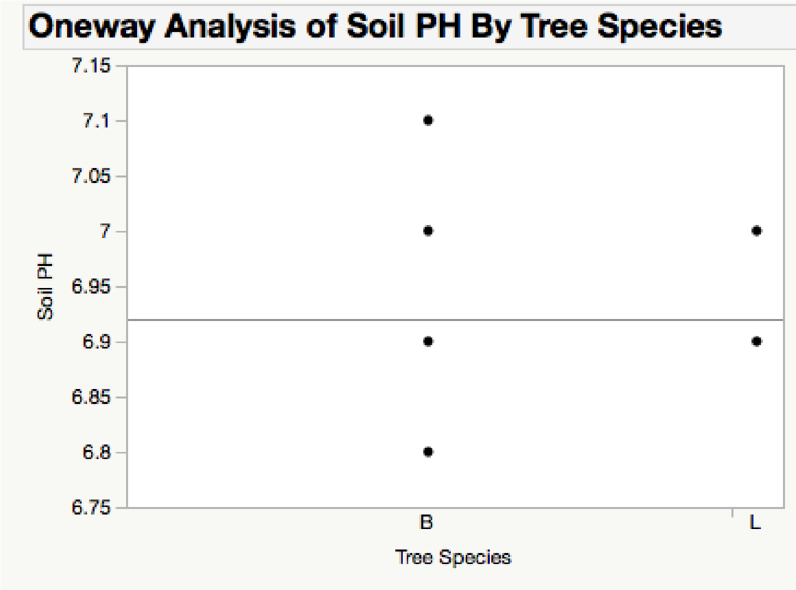
Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	4.042	0.1325
Pearson	3.292	0.1928

Warning: 20% of cells have expected count less than 5, ChiSquare suspect.

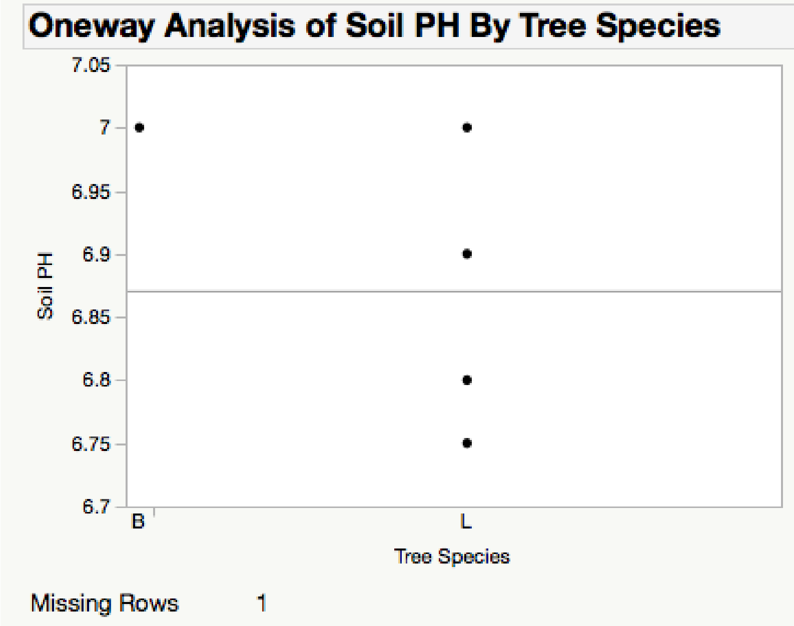
(2A) Site 1



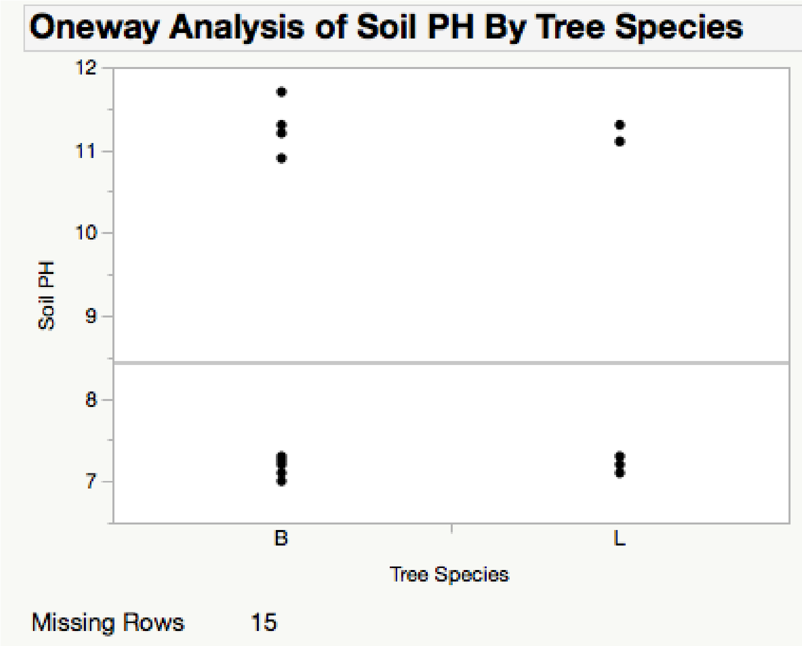
(2B) Site 2



(2C) Site 3



(2D) Site 4


Oneway Analysis of Soil PH By Tree Species
12
11
10
9
8
7
Soil PH
B
L
Tree Species
Missing Rows 15

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