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# Fire Edge Effect on Water Potential and Stomatal Conductance in Salvia leucophylla

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## Abstract

While most plants caught in the middle of wildfires are completely incinerated, many in the edges survive despite suffering partial incineration and/or heat-induced damage. We hypothesized that heat damaged *Salvia leucophylla* will display a decrease in both stomatal conductance and water potential. We suspected that applying excess heat would lower the plant's water levels and damage functional components necessary for photosynthesis, so the stomata would close to conserve water. *S. leucophylla* was chosen to study due to the likelihood of this widespread coastal sage to be found in the edges of wildfires in the Santa Monica Mountains. Using a heat gun, we applied sufficient heat to induce cellular death in six treatment groups, and measured their stomatal conductance, fluorescence, and water potential to compare to the six control groups. Contrary to our expected outcome, we found no difference in water potential ($P > 0.05$) and a significant increase in stomatal conductance ($P < 0.05$) in the healthy leaves that survived the applied heat. We believe the fourfold increase in stomatal conductance is a result of increased water availability per leaf and of increased demand for energy supply per leaf.

## Introduction

The edge effect is the effect of the transitions and interactions between two different adjoining ecosystems. In fire prone communities, plants living on the edge of their ecosystem and in this intermediate zone are often spared from being fully burned by these fires. *Salvia leucophylla*, or purple sage, is known for being a hardy and drought tolerant perennial herb. As a part of the widespread coastal sage scrub and chaparral communities, *S. leucophylla* is likely to be a species common in the edges of forest fire. A study on photosynthesis of desert plants in high temperatures had shown that "the temperature at which [chlorophyll] fluorescence begins to rise rapidly with increasing temperature coincides with the onset of damage to the capacity for photosynthetic $CO_2$ fixation by intact leaves." (Seeman et. al, 1986) If $CO_2$ fixation is decreased with extreme heat then stomatal conductance may decrease to prevent excess gas exchange. It is possible that heat can also deplete water available, in which case photosynthetic activity would decrease because photosynthetic activity is directly correlated to stomatal conductance. We decided to test whether this statement by Seeman et. al. applies to intact leaves on adjacent branches to heat killed leaves . We looked at stomatal conductance, or the amount of carbon dioxide exiting the stomatal openings, and stem water potential, the negative pressure inside the stem of a plant.

## Hypothesis

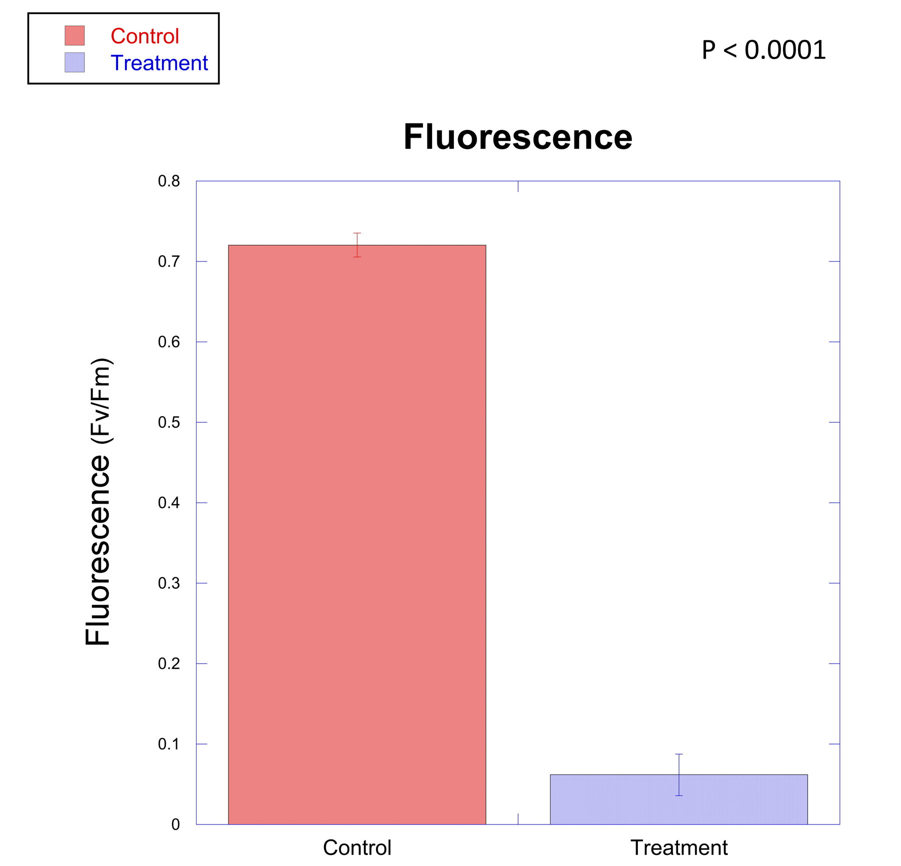
Heat damaged *S. leucophylla* will display a decrease in both stomatal conductance and water potential.

## Conclusion

Our hypothesis did not correlate with the data that we collected. Water potential remained the same, but the stomatal conductance increased significantly. This may be because the amount of water available to the plant remained the same, but there were fewer leaves to use it. The sudden decrease in leaf area may have led the living leaves to compensate for the lost plant leaves by increasing photosynthetic activity (gs ↑).

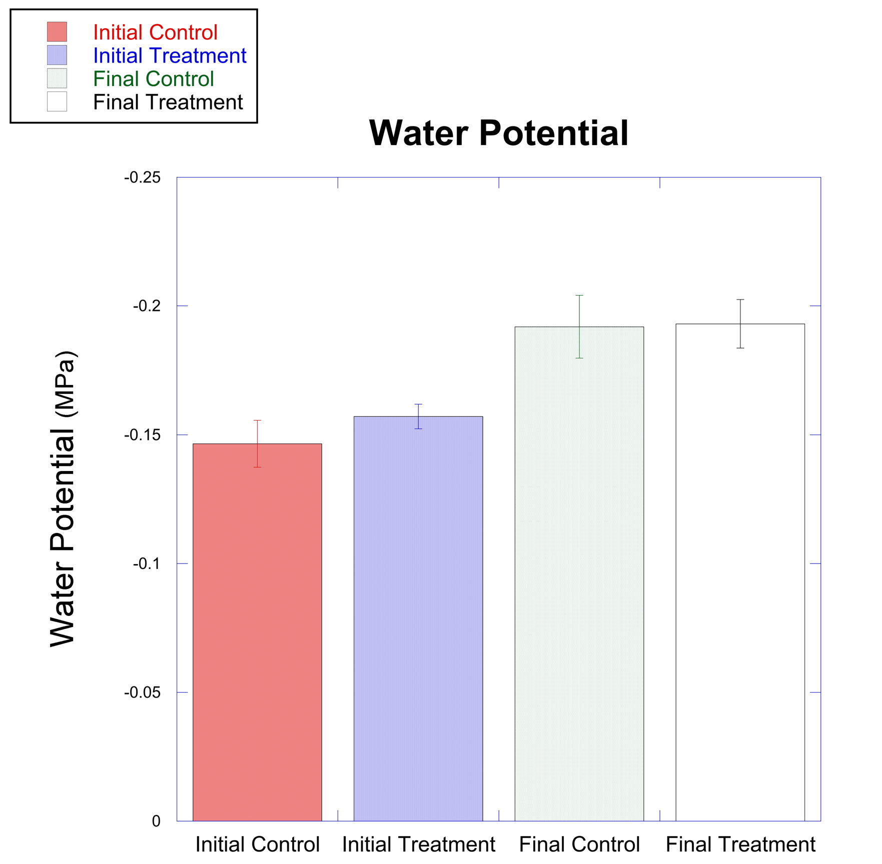
(Left to right): Laura Miranda, Paul Chung, Dr. Davis, Brigid Bergin.

## Results




**Graph 1:** Fluorescence (Fv/Fm) measurements of the control (0.728) and treated leaves (0.062). Measurements ranging from 0.7 to 0.8 show that the leaf is healthy, while those below 0.1 indicate that the leaf is dead.

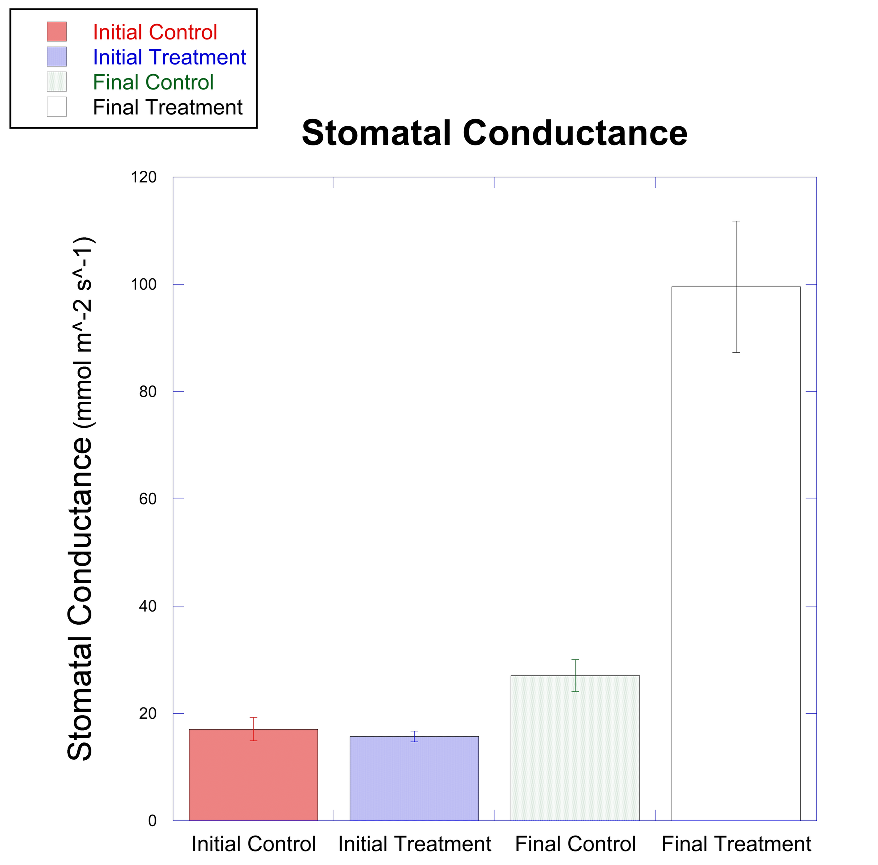
**Image 1:** An example of a branch of a control group (Center leaf: Fv/Fm = 0.745; gs = 28.4 mmol m^-2 s^-1).




**Graph 2:** Initial and final water potential for the control and heat treated plants. There was no significant difference in water potential between the control and the treatment for both initial (before treatment) and final (1 week after treatment) measurements (paired t-test, $P > 0.05$).

**Image 2:** An example of a heated branch of a treatment group, pictured immediately after heating (Cemter leaf: Fv/Fm = 0.212; gs = 42.8 mmol m^-2 s^-1).

**Average Leaf Temperature:**
- Initial: 15.7°C
- Final: 29.4°C




**Graph 3:** Stomatal conductance (gs) comparison of control and heated plants. The final measurements of the treated plants show that stomatal conductance is statistically significant, being almost fourfold larger than the final control plants.

**Image 3:** An example of a treatment branch with both heat-damaged and unaffected leaves (Damaged leaf: Fv/Fm = 0.009; gs = 0.00 mmol m^-2 s^-1; Green leaf: Fv/Fm = 0.761; gs = 134.4 mmol m^-2 s^-1).

## Methods

**Image 4:** Study site and tagged plants on the side of the mountain behind Keck Science Center at Pepperdine University.

The plant we used for our experiment was *Salvia leucophylla*, a coastal sage scrub growing on the hillside behind the greenhouse at Pepperdine University. We chose plants that were in roughly the same area and were about the same size. We tagged and numbered a total of twelve plants with colored ties, six control and six treated. We first found the average leaf temperature using an IR thermometer and the average stomatal conductance using a porometer. We took several readings from different parts of each plant and averaged them. We also measured the stem water potential of the terminal buds of each plant using the Scholander-Hammel Pressure Chamber. After taking all of these measurements, we used a heat gun to burn about half of the leaves from the six treated plants over the course of three days. The leaves were heated well past 55°C, the threshold for plant cellular survival (Downton et. Al, 1983), until cell death was evident (discoloration, Fv/Fm < 0.1). After treating the leaves with heat, we measured the leaves with a fluorometer to ensure that they were no longer photosynthetically active and therefore dead. Seven days after we started treating the leaves with heat, we took the same measurements again.

**Image 5:** Our group demonstrating the equipment used: porometer, IR thermometer, and heat gun.

**Image 6:** Healthy *S. leucophylla* (control).

**Image 7:** *S. leucophylla* after heat treatment.

## Discussion

Contrary to the expected decrease in both water potential and stomatal conductance, water potential of the treated group (-0.192 MPa) remained equivalent to that of the control (-0.193 MPa); stomatal conductance increased fourfold in leaves that survived the heat within the treated group (control : 27.1 mmol m^-2 s^-1, treatment: 95.5 mmol m^-2 s^-1; $P < 0.05$). This may be because the leaves that survived had more water available per leaf for photosynthesis. The treatment group lost a significant amount of leaves to heat, but water potential remained equivalent between the treatment and the control groups. In addition to the increase in water availability per leaf, the demand for energy production per leaf also increased. In order to meet this increased workload, each of the leaves that survived the heat must increase their stomatal activity, resulting in the increased stomatal conductance measured. Such is the proposed recovery mechanism for plants found in the edges of wildfires.

A long term study should reveal whether or not this maximized stomatal activity of the surviving leaves is beneficial by causing the heat damaged *S. leucophylla* to successfully recover and remain healthy. We suspect that , despite the upward spike in stomatal activity, damage from heat would ultimately be detrimental to the individual plant. The demand for energy may outweigh the photosynthetic capacity of the survived portions of the plant, which in addition to the effects of plant hormonal response may result in plant death. We believe that plant hormone regulation is what differentiates leaf area loss due to heat-induced damage from manual removal of the leaves.

Due to the hazardous nature of wildfire simulation, we were limited to observing individual plant response to heat guns. We damaged the leaves of the plants we studied , but we did not alter the plants in the surrounding area. Our results may have changed if we studied an area before and after it was devastated by fire, since there are many factors beyond heat-induced damage to the leaves that impact the ecosystem's ability to recover from wildfires. Although frequent fires would damage the plants and be detrimental to the ecosystem, we believe there are possible advantages from occasional wildfires: 1) the fire clears away weeds and revitalizes the soil 2) certain types of seeds (i.e., *Ceanothus megacarpus*) germinate ideally under post-fire conditions 3) fire alleviates stress from high population density and promotes diversity among newly sprouting plants 4) occasional intermediate fires prevent fuel build up for bigger, lethal fires. Recent studies attribute the upward trend in fire potential and frequency to climate change (Liu et. al, 2010). As scientists, we must further explore the effects of wildfires on the ecosystems around us to understand and prepare for the consequences of global warming.

## Acknowledgement

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## Work Cited

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