Air Quality Indicators at Lake Merritt, Oakland, California

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Introduction

Lake Merritt is significant in its role as both a recreational center for humans, as well as a refuge for migratory wild birds. It is, however, closely surrounded by streets and highways, and even sees a large amount of water traffic by motor-driven boats and pontoons. These two factors contribute to what we suspect is a generally high level of emissions in the atmosphere surrounding the lake.

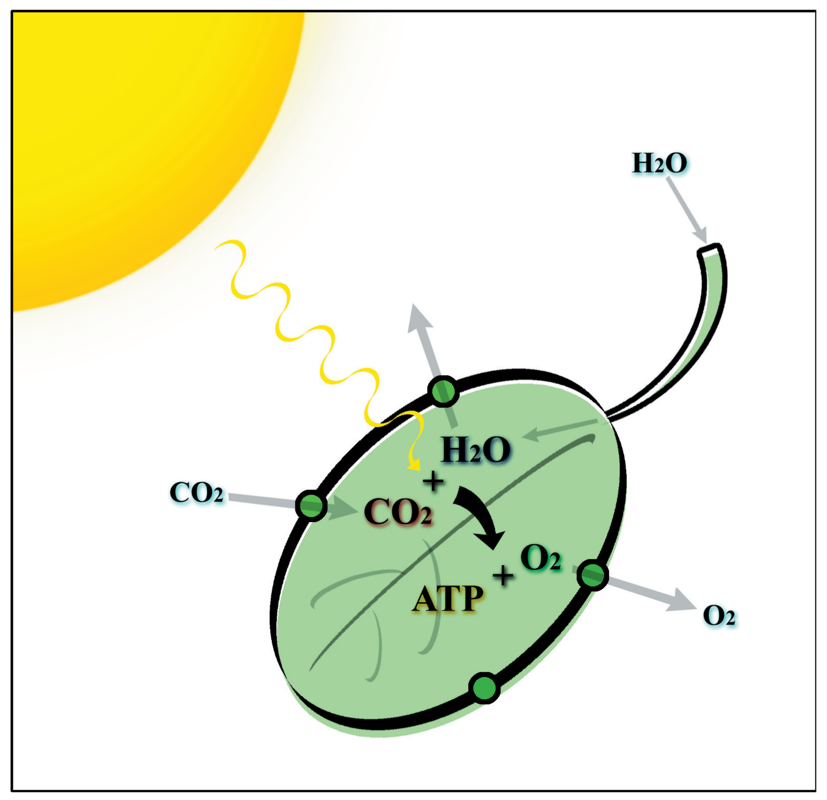


FIGURE 1.
Interactions between the leaf and the environment

We believe that the relative levels of stomata may reflect properties of the local environment, whether it is in the air or in the soil. This is because we expect that over time, new generations of leaves or plant life would possess characteristic better suited to their surroundings. Furthermore, there are certain relationships we would expect to see: an environment with consistently low levels of carbon dioxide would yield leaves with high numbers of stomata -- since more are needed to keep pace with the energy demands of the leaf. On the other hand, extremely arid environments or dry soil would yield low numbers of stomata -- preventing the escape of water from the plant. Oxygen levels should only have a minor impact on the number of stomata; their escape is sufficient but not necessary for plant survival. Extreme levels of oxygen, however, may cause cellular damage to the plant.

At Lake Merritt, the main contributing factor to the relative levels of carbon dioxide in the environment is vehicular emissions. Moisture levels, by comparison, would be influenced by factors such as air temperature and wind speed -- increased levels of either would contribute to high evaporation rates. Thus, we determined that the parameters we would measure in this study are carbon dioxide levels, temperature, and wind speed. We also measured oxygen to confirm that it has no distinguishable effect on the number of stomata observed.

Methods

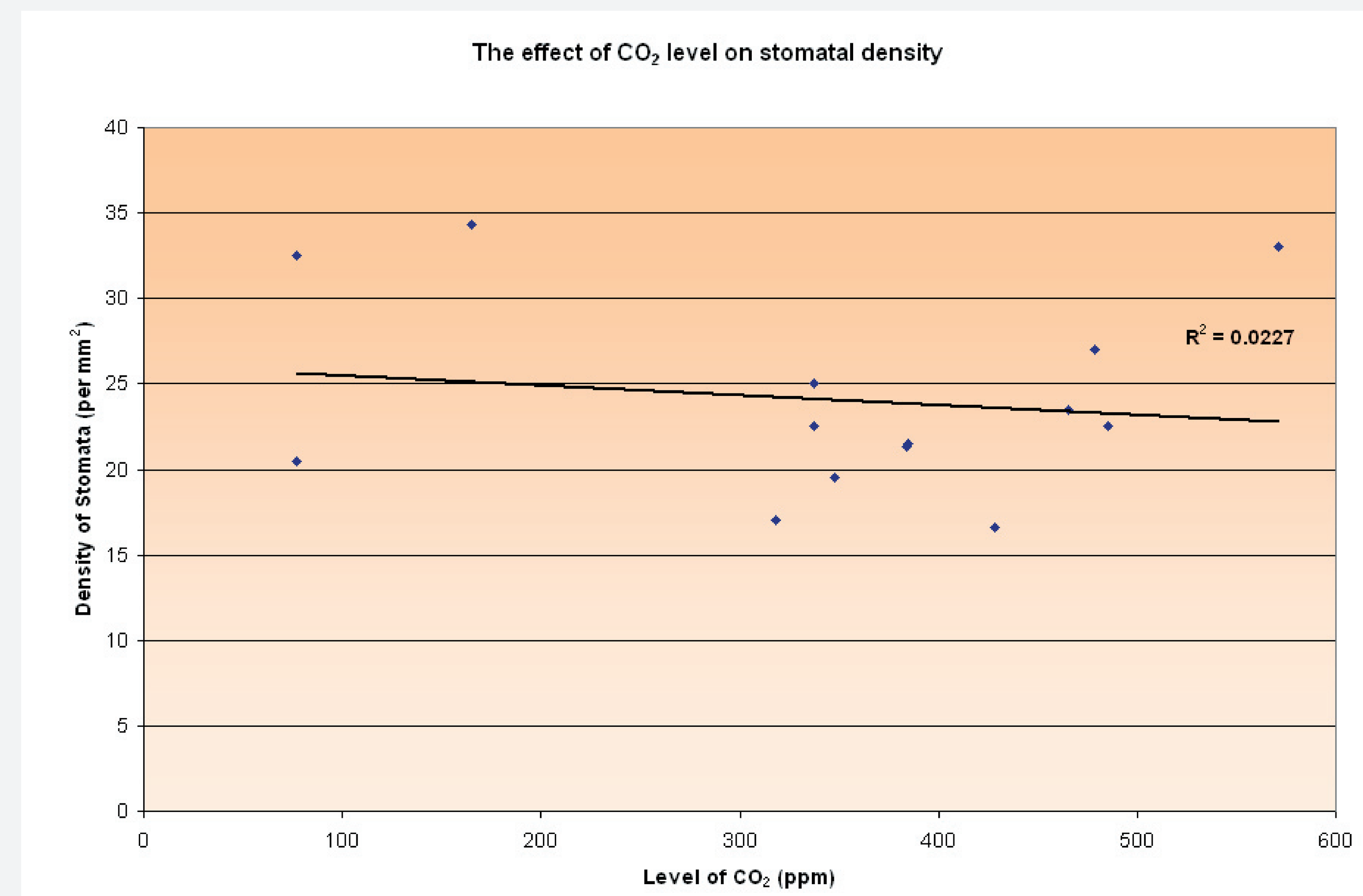
We retrieved an overhead satellite image of Lake Merritt in order to pick ten different sites around its perimeter. We selected the sites to get the greatest cross-section of population density, tree density, and urban elements such as cars or buildings. From each site, we chose two representative trees and marked their locations. We picked one low-hanging leaf from each tree on every day of data collection. We made measurements of carbon dioxide and oxygen levels with our Xplorer GLXes, and took windpseed data with an anemometer. We sampled data this way every weekday for a period of one month from June to July.

Each leaf sample was placed in a Ziploc bag so that we would be able to identify our specimens. We analyzed the percentage damage on them by performing an image analysis on digital photographs of each leaf using Global Systems Software.

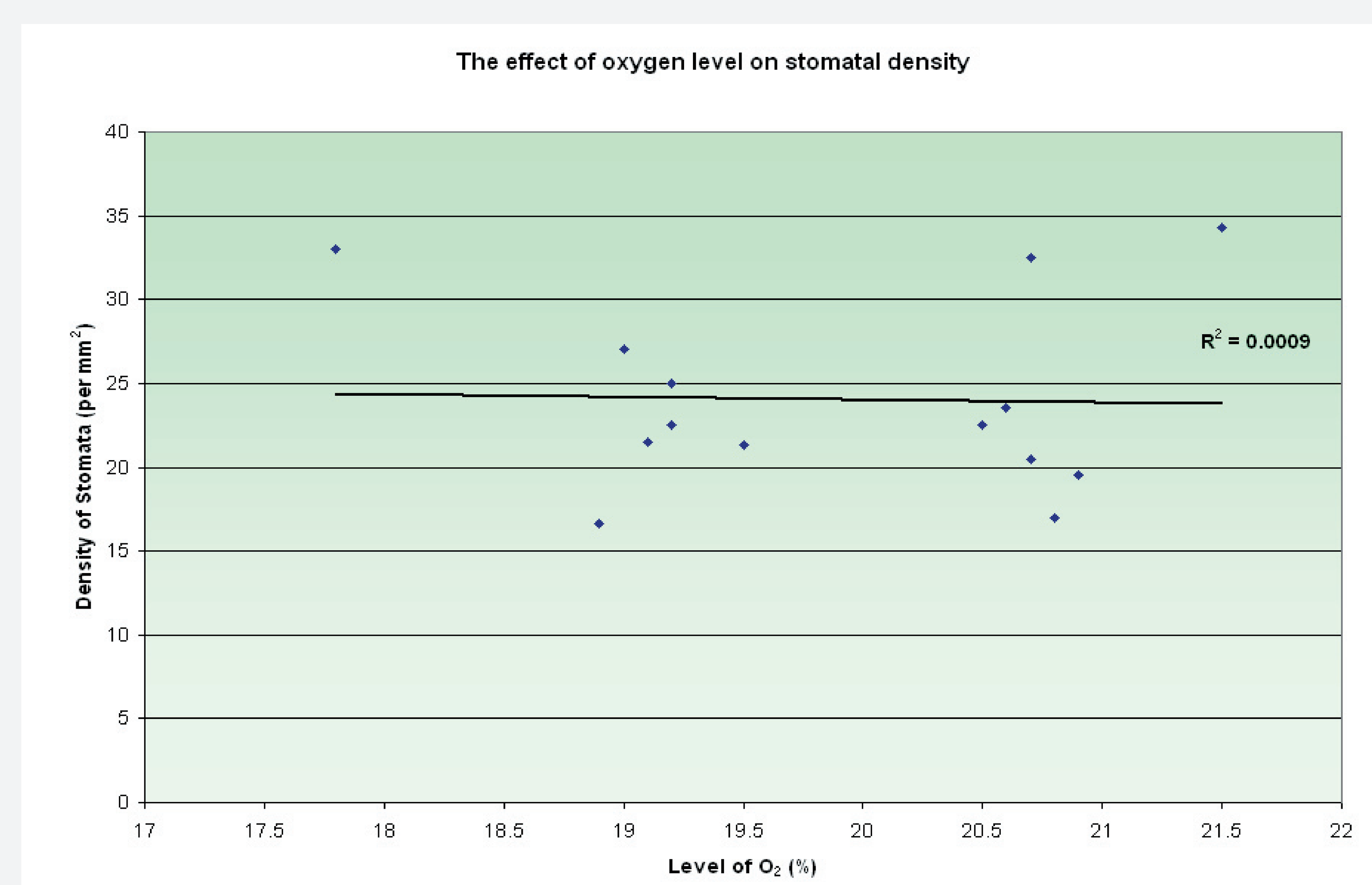
To get the stomatal density, we removed a section of the top layer of each leaf by swabbing a 1 cm^2 area with alcohol. We then peeled it off using clear tape and mounted it upon a glass microscope slide. We placed the slide under a total magnification of 400X and visually counted each stomata within the viewing area, whose dimensions we calculated. We divided the count by the area to get the density.

Results

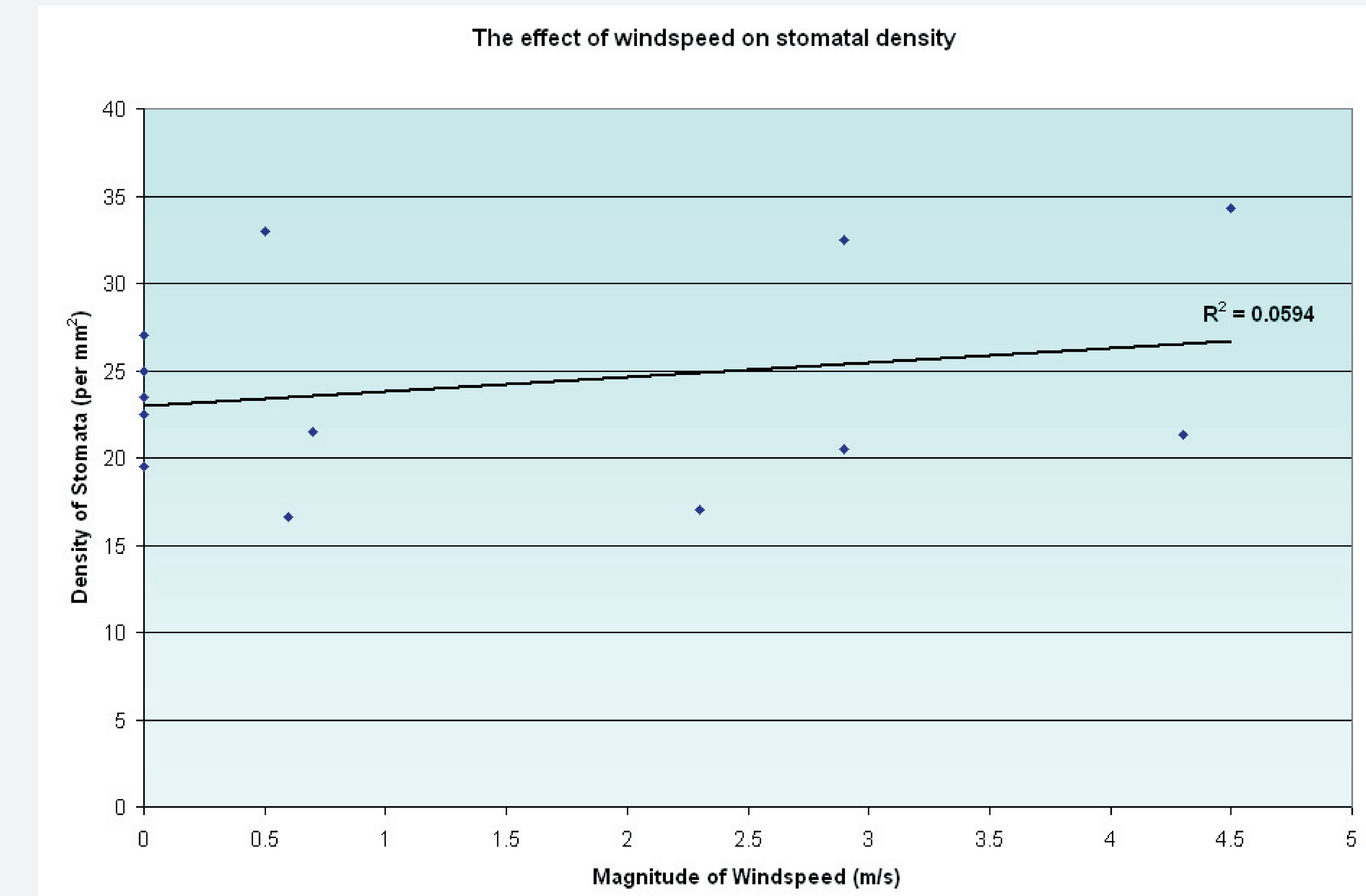
For our presented set of data, we only analyzed leaves from the sycamore tree. This allows us to control for any interspecies differences (such as physical toughness, surface waxiness, etc.)



It appears that stomata density does not show any relationship with carbon dioxide for the sycamore species. By contrast, the percentage damage does seem to act as a predictor of carbon dioxide levels -- as inferred from previous studies. This suggests that either stomata density is insensitive to carbon dioxide variation at these levels or is simply a poor bioindicator of carbon dioxide in the air.



There no distinct relationship between oxygen and stomata density. It appears to be slightly inverse, suggesting that in high oxygen concentrations, low numbers of stomata are present. We predicted this trend since oxygen -- essentially a waste product -- is intended to diffuse outward from the leaves, high oxygen in the environment may come close to reversing this diffusion. A build up of oxygen in the leaves may react with excess NADPH and ATP to form free radicals, which can damage cell structure and function. Over generations, leaves that minimize this effect by having less stomata may have an overall increased chance of survival.



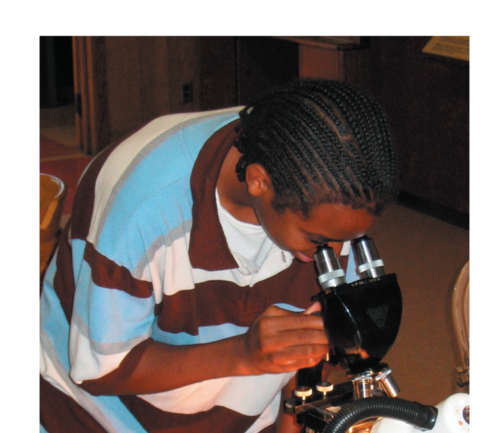
We had expected that higher windspeed would effect lower levels of stomata in the leaves. By contrast, our data suggests no such correlation. The absolute magnitudes of windspeed differed greatly from day to day, but showed no relationship with any parameter under examination, in particular location. Overall, the behavior of windspeed appeared to be random over the course of our study, although we expect it would exhibit trends over a longer period of time.

Conclusion

The data does not support our hypothesis that stomata density accurately reflects properties of the environment.

Discussion

Against what we expected, stomatal density proved to be quite insensitive to the quality of air around Lake Merritt. It should be noted that, on the whole, Lake Merritt's quality of air has been found to be quite consistent; therefore, better results may be garned from controlled experimentation than field observations. We posit two additional ideas that may be confounding factors in our project: the first is that stomata density is not a parameter that changes within one leaf, but rather generations of leaves. Because we are measuring local and recent properties of air quality, large variations may take some time to manifest changes in the make-up of any tree's leaves. Secondly, we suspect that the open and close states of guard cells around the stomata may yield much information than just stomata density, especially if local and recent variations in air quality are present. Guard cells react on a much shorter time scale, allowing us the benefit of temporal accuracy. However, we would need to adjust our protocol to make sure that we do not induce changes within the leaves while handling them -- this would change our collection and analytical methods considerably.



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