LICHENS AS BIOMONITORS OF AIR QUALITY IN THE SOUTH COAST AIR BASIN OF CALIFORNIA

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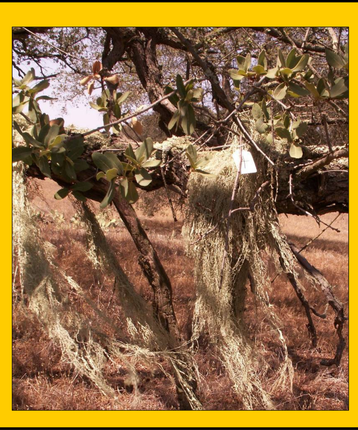
Overview

Lichens: Lichens have been used as biomonitors of air pollution for over a century, beginning in the industrializing European nations in the 1850's. Their usefulness is tied to the fact that lichen species are differentially responsive to pollutants, and lichen community composition changes readily with shifts in air quality. Monitoring changes in lichen communities allows for early detection of potentially greater ecosystem change due to air quality. However, for this type of monitoring to be effective, lichen responses need to be calibrated to pollution levels.

Pollution: Ozone (O_3) and gaseous nitric acid (HNO_3) pollutants often co-occur in urbanized arid regions, as they are formed by the same photochemical reactions between nitrogen oxide (mostly from automobile emissions) and volatile organic compounds. Research on the effects of O_3 and HNO_3 has focused on toxicity to plants and humans, and the toxicity of O_3 to both is well established. Much less is known about the effects of the individual pollutants on lichen biology. This research seeks to understand independent and combined effects of O_3 and HNO_3 on lichen biology and distribution.



Fumigation Experiments

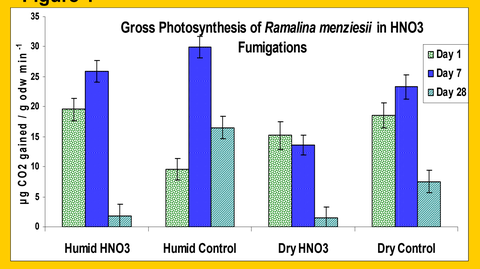
We used fumigation chambers[1] to conduct controlled investigations of each pollutant independently and in 2 x 2 factorial fumigations using the pollution sensitive lichen species *Ramalina menziesii*.

Gas levels can be controlled in each of our ten chambers, allowing for multiple levels of fumigations.

Nitric Acid Fumigations[2]

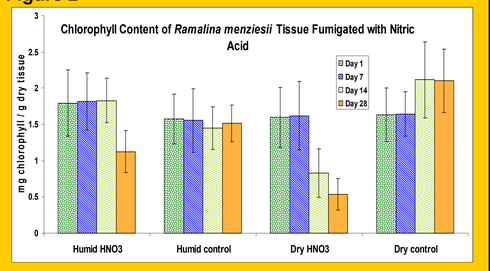
HNO3 levels ranged from 7 to 35 µg m-3 24 hour averages for one month. (Winter 2006-07)

Figure 1



Figures 1 and 2: Gross photosynthesis and chlorophyll content of *R. menziesii* in HNO_3 fumigation chambers. Treated thalli showed significant physiological decline in response to HNO_3 fumigations ($p < 0.001$ for photosynthesis and chlorophyll). Humidity was an important mitigating factor.

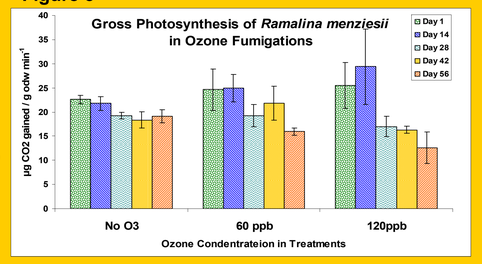
Figure 2



Ozone Fumigations

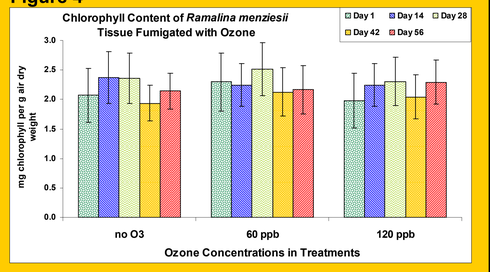
Ozone fumigations were conducted for two months, and O_3 levels were 0, 60 and 120 ppb. (Winter 2007-08)

Figure 3



Figures 3 and 4: Gross photosynthesis and chlorophyll content of *R. menziesii* in O_3 fumigation chambers. Treated thalli did not show significant physiological decline in response to O_3 fumigations.

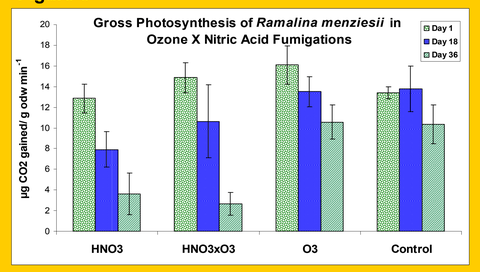
Figure 4



O_3 X HNO_3 Fumigations

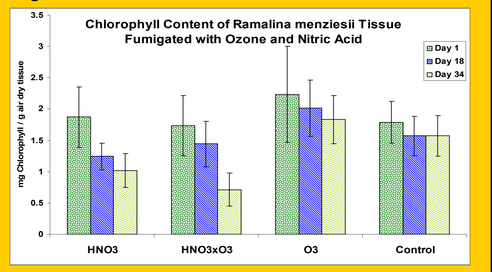
Lichen samples were treated with a 2x2 factorial fumigation: 80ppb O_3, 80ppb O_3X HNO_3, and HNO_3 for 36 days. (Winter 2008-09)

Figure 5

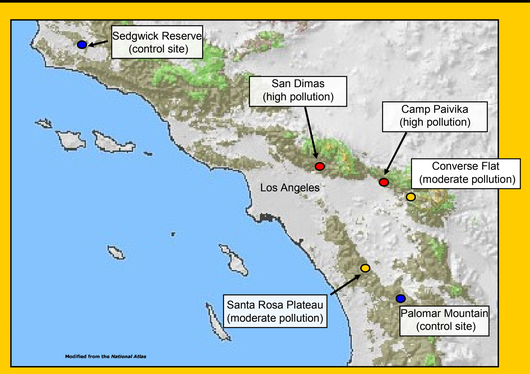


Figures 5 and 6: Gross photosynthesis and chlorophyll content of *R. menziesii* in O_3 x HNO_3 fumigation chambers. Ozone treatment responses did not differ significantly from control fumigations, but was significantly different from HNO_3 fumigations ($p<0.001$).

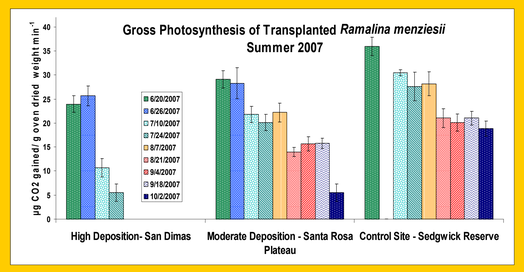
Figure 6



Ambient Air Transplant Experiments



With an understanding of the effects of the pollutants and independent toxicants on *R. menziesii* in fumigation chambers, we investigated the effects of ambient pollution under field conditions. We transplanted ***Ramalina menziesii* (left)**, a sensitive species extirpated from the area from pristine locations to moderate and high pollution sites, monitoring them over the summer and fall of 2007. The ma**p (above right) of S. California** shows transplant sites.



Pollution levels at sites were monitored with passive filter HNO_3, NH_3, and O_3 monitors at two week intervals over the course of the transplant experiment.

Figure 7: Gross photosynthesis of transplanted Ramalina menziesii thalli, which showed a sharp physiological decline after three weeks at San Dimas

Conclusions

Our fumigations to date have demonstrated that *Ramalina menziesii* is highly sensitive to gaseous HNO_3, and far less responsive to ozone, contrary to previous thought.

Our transplant experiments confirmed these results, with transplanted *R. menziesii* dieing within 5 weeks of being transplanted to high pollution sites. Other species, such as *Hypogymnia imshaugii*, are far more tolerant of nitrogen pollution, and some species thrive in the presence of high levels of ammonia.

We are also working with other species of lichens to capture a better idea of community responses. By developing a clear understanding of lichen responses to pollution, we hope to improve the usefulness of lichens as indicators of air quality and forest health.

References:

1. Padgett, PE and A Bytnerowicz, PJ Dawson. 2004. Design, evaluation and application of a continuously stirred tank reactor system for use in nitric acid air pollution studies. Water Air and Soil Pollution, 151 (1-4): 35-51
2. Riddell. J., T.H. Nash III, P. Padgett. 2008. The effect of HNO3 gas on the lichen *Ramalina menziesii*. Flora 204 pp.47-54.
3.Sigal, L. L. 1979. I. Lichen communities of southern California mountains : an ecological survey relative to oxidant air pollution. II. Gross photosynthetic response of lichens to short-term ozone fumigations. III. Preliminary studies of the gross photosynthetic response of lichens to peroxyacetyl nitrate fumigations. Thesis. Arizona State University.

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