Performance Comparisons of Co-Occurring Native *Baccharis* and Invasive *Delairea odorata*

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Abstract

Delairea odorata (Cape Ivy) is an ornamental vine native to South Africa, which has escaped and is invading natural areas in Australia, Europe, and the United States. It is a serious pest that currently occupies over 500,000 acres of California. This perennial vine climbs over native species blocking their light source. This rapidly growing invasive plant raises questions and calls for research into how it survives so well in an alien environment, and if it will be as successful in the future as atmospheric CO_2 increases. Our objective was to determine whether *Delairea* has a performance (physiological) advantage in shade and increasing CO_2. We compared photosynthesis, transpiration, stomatal conductance, and intracellular CO_2 rates of *Delairea* with co-occurring native *Baccharis pilularis*. In situ measurements were taken with the LiCor-6400 Portable Photosynthesis System. We recorded the different rates under various levels of applied CO_2 ranging from 200 to 800 µmols/mol in increments of 50 and at 800 to 2000 µmol photons/m^2/s. *Baccharis*' photosynthesis is greater than *Delairea* in all conditions tested ($p<0.01$). However, compared to *Baccharis*, *Delairea* has a significantly lower transpiration rate in lower light and higher intracellular CO_2 at higher atmospheric CO_2 partial pressure ($p<0.01$). Our findings suggest *Delairea* thrives in the shade it creates and that the more robust leaf gas-exchange characteristics of *Delairea* in response to external CO_2 partial pressure may enhance its competitive success over co-occurring native species with increasing atmospheric CO_2.

Aim

To compare physiological attributes of *Delairea* with native *Baccharis piluraris* at different levels of CO_2 and light.

Background

- Cape Ivy (*Delairea odorata)* was introduced to the U.S. as an ornamental vine from South Africa, and has escaped. *Delairea* invasion is associated with loss of species diversity (1).
- Originating in South Africa, *Delairea odorata* is invading natural areas in Australia, Europe, and the United States. It is a serious pest that currently occupies over 500,000 acres of California (4).
- The U. S. Park Service considers Cape Ivy a threat to 12 rare native plant species, two federally listed butterfly species, as well as compromising the habitats for freshwater shrimp and Coho salmon and has spent over one million dollars in an effort to eradicate the plant (2).
- Cape Ivy rapidly grows up and over native vegetation, including small trees, covering and eventually killing them (**Figure 1**). It quickly regrows after mechanical removal or treatment with herbicides (3).
- Atmospheric CO_2 is increasing at a steady rate. In 1987, atmospheric CO_2 was 350 µmol and in 2015 the average atmospheric CO_2 is around 400 µmol (5).

Figure 1. Cape Ivy forms large monocultures that block light from other plants.

Methods

- A LiCor-6400 Portable Photosynthesis System was used to measure transpiration, conductance, photosynthesis, and intracellular CO_2. CO_2 was applied from 200 to 800 µmol in 50 µmol-increments. Photosynthesis photon flux was applied from 500 to 2000 µmol photons/m^2/s in 100 µmol-increments.
- Stomatal ratios were determined by counting stomates on excised epidermis.
- Measurements were taken in situ from *Baccharis pilularis* (Coyote Brush) and *Delairea odorata* plants.
- Samples for each increment consisted of 10 different leaves.
- The t-test was used for statistical comparisons.

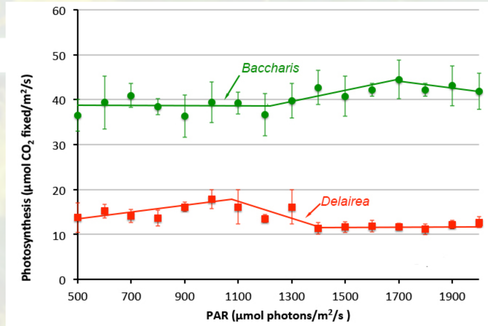

Figure 2. The photosynthesis rate of *Delairea* decreases with increasing light. Error bars = 1 S.D.

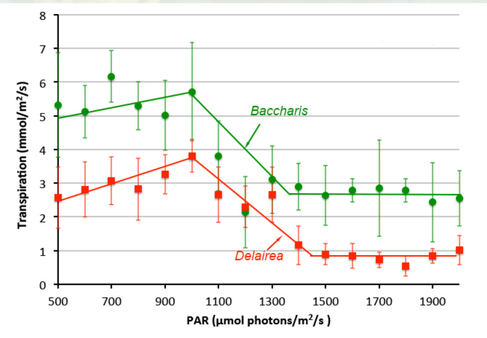

Figure 3. *Baccharis* loses more water than *Delairea* under all light conditions. *Delairea* has significantly less water loss at photon flux >1300. Error bars = 1 S.D.

Results

- *Baccharis*'s overall photosynthetic rate is higher than that of *Delairea* ($p<0.01$). However, *Delairea*'s rate decreases with increasing light (**Figure 2**).
- Normal photosynthetically active radiation ranges from 400-1000 µmol photons/m^2/s in the San Francisco Bay Area (6). Compared to *Baccharis*, *Delairea* has a 46% lower transpiration rate below 1000 µmol photons/m^2/s and a 63% lower transpiration rate above 1300 µmol photons/m^2/s. *Delairea* becomes significantly more efficient ($p<0.01$), that is less water loss, with increasing light (**Figure 3**).
- The photosynthesis rate of both plants increases with increasing CO_2 (**Figure 4**).
- The current atmospheric CO_2 concentration is ~400 µmol/mol. As atmospheric CO_2 increases, *Delairea* has higher intracellular CO_2 compared to *Baccharis*, which increases slightly up to ~400 µmol/mol, then drops (**Figure 5**).

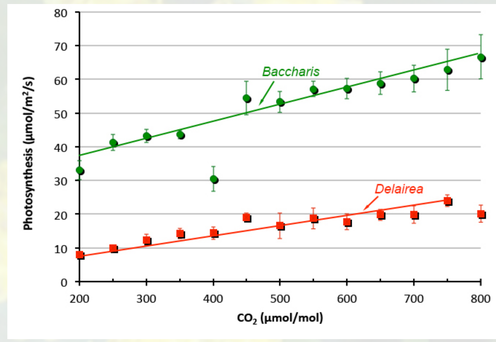

Figure 4. The photosynthesis rate of both *Baccharis* and *Delairea* increases with increasing CO_2. Error bars = 1 S.D.

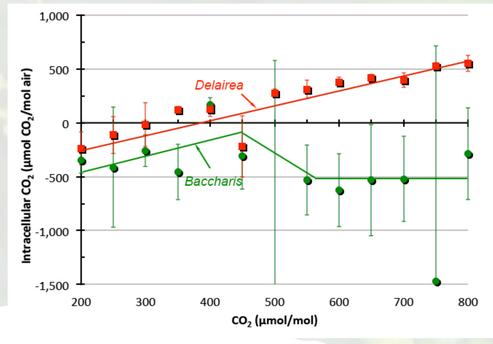

Figure 5. *Delairea*'s intracellular CO_2 increases with increasing atmospheric CO_2.. Current atmospheric CO_2 is ~400 µmol/mol. Error bars = 1 S.D.

Discussion & Conclusion

- *Delairea* has an advantage in less light compared to *Baccharis*. Lower transpiration rates cause less water loss to the atmosphere in shady areas.
- By growing over other plant species *Delairea* blocks 80% of the surface light creating an environment ideal for its own growth. As the top layer of *Delairea* dies off, it provides shade and nutrients for more seedlings to grow directly underneath creating and sustaining an unconquerable cycle.
- *Baccharis*' photosynthesis is greater than *Delairea* in all conditions tested ($p<0.01$). However, compared to *Baccharis*, *Delairea* has a significantly lower transpiration rate in lower light and higher intracellular CO_2 at higher atmospheric CO_2 partial pressure ($p<0.01$).
- Our findings suggest *Delairea* thrives in the shade it creates and that the more robust leaf gas-exchange characteristics of *Delairea* in response to external CO_2 partial pressure may enhance its competitive success over co-occurring native species with increasing atmospheric CO_2.

• Future Studies

Future studies will include analysis of *Delairea* root respiration and how it can survive through extreme drought and constant water loss.

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