Photosynthetic Characteristics of Invasive *Delairea odorata* and Native Coastal Sage Scrub Plants

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Abstract

Cape Ivy (*Delairea odorata*) is an invasive plant from South Africa, introduced to the U.S. in the mid-1800s. This herbaceous, evergreen vine out-competes native species and has created large monocultures along California's central coast, replacing native coastal sage scrub. To date, studies on Cape Ivy have focused on the result of its growth. Few studies have investigated the attributes that allow its successful invasion. We tested the hypotheses that leaf-level photosynthetic capacity and water-use efficiency were greater in *D. odorata* as compared with eight native coastal sage scrub plants in the same area. We compared the physiology of Cape Ivy with that of eight native perennial plants. Live leaves were measured and their stomatal conductance, photosynthesis, transpiration, and water use efficiency were determined using the LI-6400 Portable Photosynthesis System. Preliminary results show that the rate of stomatal conductance in Cape Ivy is half that of native plants on hot, sunny days, and its water use efficiency is >10% better than *Baccharis pilularis*, which suggests that Cape Ivy is better at closing its stomates and preventing water loss. We are continuing field measurements to compare all nine plants in fog and full sun. A better understanding of the attributes of invasiveness may be useful for predicting invasiveness.

Aim

The aim is to investigate a possible mechanism that allows Cape Ivy to successfully invade and overtake native coastal plant species.

Background

- Cape Ivy (*Delairea odorata)* was brought to the United States in the 1850s as a houseplant but it has become invasive along the central California coast (5). It is now the highest ranked invasive species problem in the Golden Gate National Recreation Area (3).
- Cape Ivy grows over native shrubs reducing light and trapping moisture (2).
- The decreased light intensity and increased moisture promote Cape Ivy's growth and decrease growth of native vegetation (5, 6).
- This drastically reduces native plant and insect diversity in coastal scrub and riparian habitats (2). Additionally, Cape Ivy is toxic to protozoa and copepods (4).
- In the Coastal sage scrub, Cape Ivy does not reduce atmospheric CO_2 because it does not sequester carbon and soil respiration is increased compared to native vegetation (1).
- Lettuce seed germination is inhibited by aqueous Cape Ivy extracts and Cape Ivy soil (4).
- A better understanding of the attributes of invasiveness may be useful for predicting invasiveness.
- We investigated the physiological properties of Cape Ivy that may promote invasiveness.

Figure 1. The east-facing study area included both native coastal sage scrub plants and Cape Ivy. The area is partially shaded by *Cupressus macrocarpa*. Cape Ivy growing over native twinflower in the photograph. Cape Ivy will eventually block light and trap moisture.

Methods

- A study plot on Sweeney Ridge (Golden Gate National Recreation Area) was chosen. The plot has native perennial shrubs and Cape Ivy (**Figure 1**). All plants studied have the same (east) exposure, sunlight, and moisture. Temperatures during the July study period were 19 to 31°C, relative humidity ranged from 30 to 67%.
- Stomates were counted on each species by microscopic examination of the excised leaf epidermis. These data were used to determine stomatal ratios for each plant.
- Photosynthesis, transpiration, and respiration were measured for native plants and Cape Ivy in the study area using a Licor Li-6400xt Portable Photosynthesis System. CO_2 was set at 400 µmol CO_2 mol^{-1}; light intensity was set at 800 µmol m^{-2} s^{-1}.

Table 1. Stomatal density of plants investigated in this study.

	Plant	Stomatal density (/3.14 cm^2)	Stomatal ratio	Leaf surface area
1	*Delairea odorata* (Asteraceae)	Bottom: 450	0	6
2	*Baccharis pilularis* (Asteraceae)	Top: 90 Bottom: 50	1.8	1.5
3	*Linnaea borealis* (Linnaeaceae)	Bottom: 100	0	6
4	*Scrophularia californica* (Scrophulariaceae)	Bottom: 400	0	6
5	*Anaphalis margaritacea* (Asteraceae)	Bottom: 130	0	3
6	*Toxicodendron diversilobum* (Anacardiaceae)	Bottom: 100	0	6
7	*Cornus sericea* (Cornaceae)	Bottom: 450	0	6
8	*Sambucus* sp. (Caprifoliaceae)	Bottom: 100	0	6
9	*Rubus ursinus* (Rosaceae)	Bottom: 100	0	6
10	*Marah fabaceus* (Cucurbitaceae)	Top: 10 Bottom: 300	0.03	6

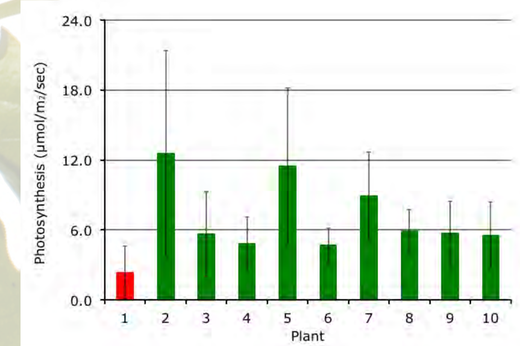

Figure 2. Photosynthesis rates. Rates are 81.50% lower in Cape Ivy than *Baccharis*. Average of 70-80 measurements taken during July 2014. Error bars = 1 S.D.

Results

- Stomatal ratio and leaf surface area of study plants were measured (**Table 1**). We focused on a comparison between Cape Ivy and *Baccharis* because *Baccharis* is the most abundant plant in the local coastal scrub community and its presence helps other coastal sage species become established. *Baccharis* is completely displaced by Cape Ivy in invaded areas.
- Cape Ivy has an 81.50% lower rate of photosynthesis than *Baccharis* (**Figure 2**).
- Transpiration in Cape Ivy is 79.25% lower than *Baccharis* (**Figure 3**).
- The respiration rate is 34.16% lower in Cape Ivy than *Baccharis* (**Figure 4**).
- Water use efficiency is 8.47% lower in Cape Ivy than *Baccharis* (**Figure 5**).

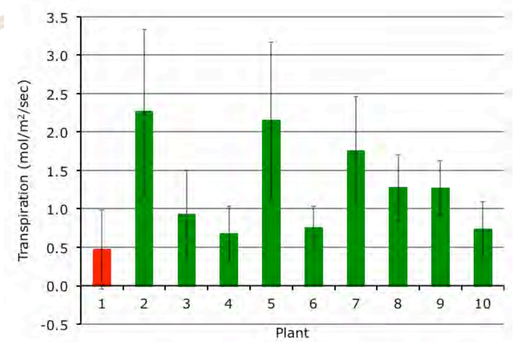

Figure 3. Transpiration rates. Rates are 79.25% in Cape Ivy than *Baccharis*. Average of 70-80 measurements taken lower during July 2014. Error bars = 1 S.D.

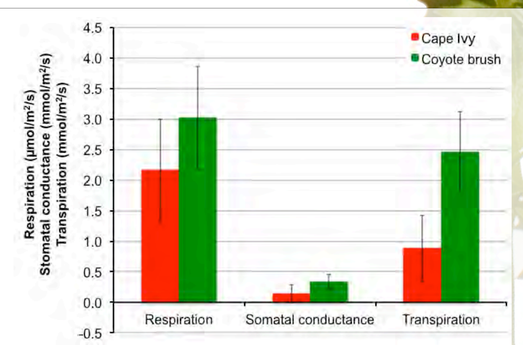

Figure 4. Respiration rates. Rates are 34.16% lower in Cape Ivy than *Baccharis*. Average of 70-80 measurements taken during July 2014. Error bars = 1 S.D.

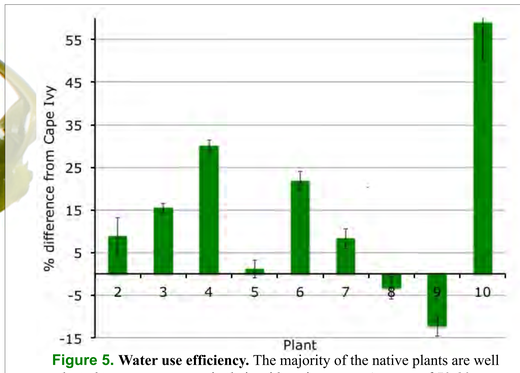

Figure 5. Water use efficiency. The majority of the native plants are well adapted to conserve water in their arid environment. Average of 70-80 measurements taken during July 2014. Error bars = 1 S.D.

Discussion & Conclusion

- As Cape Ivy doesn't photosynthesize or use water as effectively as *Baccharis*, it has to rely on other mechanisms in order to out-complete *Baccharis*.
- Although Cape Ivy does not have the thick cuticle of the native coastal scrub plants, it appears to manage water conservation by closing its stomates during the day.
- Cape Ivy's leaves and soil inhibit plant germination (4). This coupled with the fact that Cape Ivy resists water loss well could explain its success.
- Cape Ivy's apparent physiological advantage allows it to grow over native species, which may reduce available light and increase moisture to levels that the native plants can't tolerate.

Future Studies

Evaluate the effects of light and water (humidity and soil moisture) on Cape Ivy and native vegetation.

Literature Cited

1. Alvarez J. and D. Badong, 2013. "The Impact of The Invasive Plant *Delairea odorata* on Microbial Communities." *2013 SACNAS Conference Abstract,* San Antonio TX. Santa Cruz CA: Society for the Advancement of Chicanos and Native Americans in Science.
2. Alvarez, M. 1997. "Management of Cape-Ivy (*Delairea odorata*) in The Golden Gate National Recreation Area." *California Exotic Plant Council Symposium Hearings.*
3. Balciunas, J. et al. 2004. *Biological Control of Cape Ivy Project*. USDA: Agricultural Research Service.
4. Kozsiz, A. "Allelopathy and Biotoxicity of Cape Ivy *Delairea odorata*." *2013 SACNAS Conference Abstract,* San Antonio TX. Santa Cruz CA: Society for the Advancement of Chicanos and Native Americans in Science.
5. Kwasny, J. 2011. "Cape Ivy: U.S. Forest Service Lands - Big Sur Coast." California Weed Science Society Annual Meeting.
6. Robinson, R., G. Kyser, K. Rice, and J. DiTomaso. 2010. "Light intensity is a limiting factor to the inland expansion of Cape Ivy (*Delairea odorata*)." *Biological Invasions* 13: 35-44.

Acknowledgements

I would like to give my deepest thanks to Dr. Christine Case. Her help and insights were invaluable and her patience was never ending. Also, I would like to thank Dr. Jing Folsom for her instruction in the use of the Licor Li-6400xt Portable Photosynthesis system, without her assistance, this project wouldn't have been possible.