

# Western Sword Fern Avoids the Extreme Drought of 2012-2014<sup>1</sup>

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The California drought of 2012 to 2014 was the most severe drought on record for the last century and likely millennium. Warm temperatures with below-average precipitation compounded over the three-year period, creating significant and sustained aridity over the course of three growing seasons throughout the coast redwood ecosystem. The citizen science project, Fern Watch, tracked the morphological response of *Polystichum munitum* (Western sword fern) in the coast redwood forest to the recent drought across a plot network spanning 10 sites and a latitudinal gradient of more than 800 km. Annually, tagged *P. munitum* individuals in the study were monitored for changes in crown size.

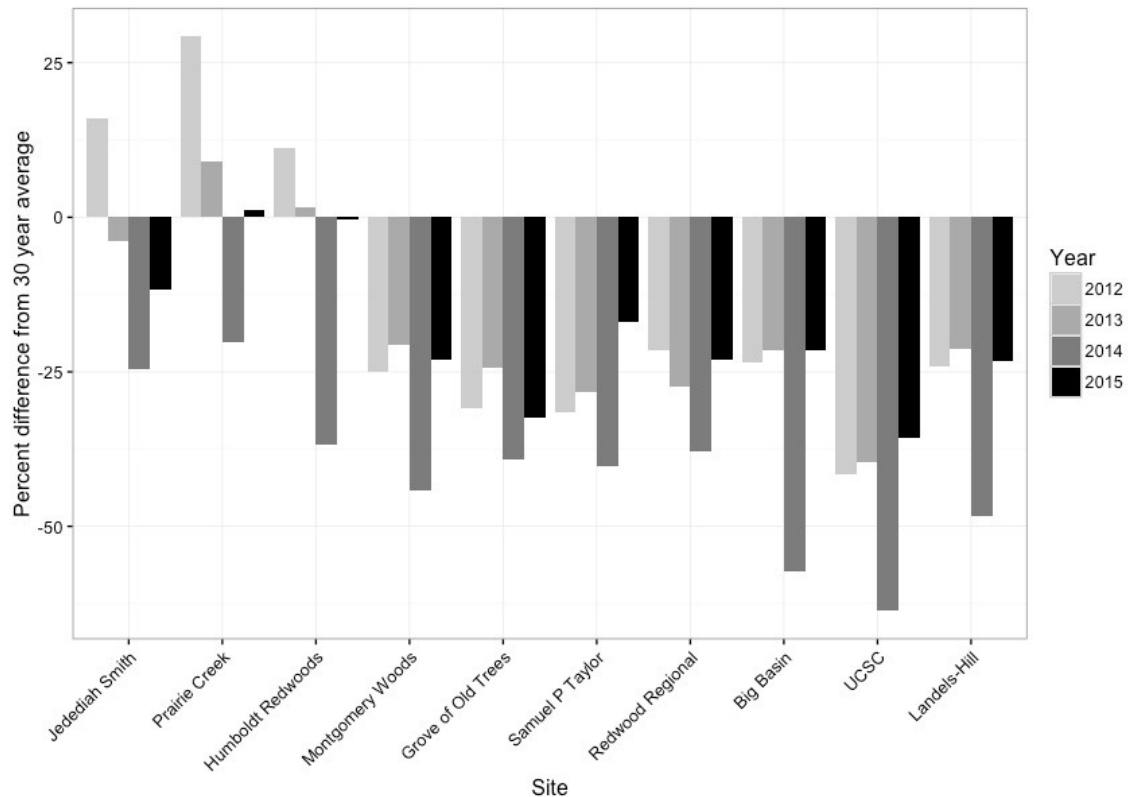


Figure 1 – The percent difference in total annual precipitation from the 30-year historic precipitation average by year and site. Sites are listed from north (left) to south (right) along the latitudinal gradient of the coast redwood ecosystem.

<sup>1</sup> A version of this paper was presented at the Coast Redwood Science Symposium, September 13-15, 2016, Eureka, California.

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When compared to the 30-year climatic averages, the 2012-2015 drought manifested differently across the ecosystem (fig. 1). The three northernmost sites received >10% above-average total annual precipitation in 2012, while all sites to the south had significantly below-average annual precipitation with the most severe decrease in annual precipitation of 35% at the University of California, Santa Cruz Natural Reserve. In 2013, total annual precipitation showed a similar trend to 2012, with two of the three northern sites still receiving above-average precipitation (Prairie Creek Redwoods State Park and Humboldt Redwoods State Park) and the remaining sites receiving below-average precipitation. In 2014, the lowest total annual precipitation was recorded for each site, with three of the four most southern sites receiving less than 50% of historic total annual precipitation. In 2015, precipitation increased across the ecosystem, though 12 of the 14 sites still received below-average total annual precipitation by as much as 30%.

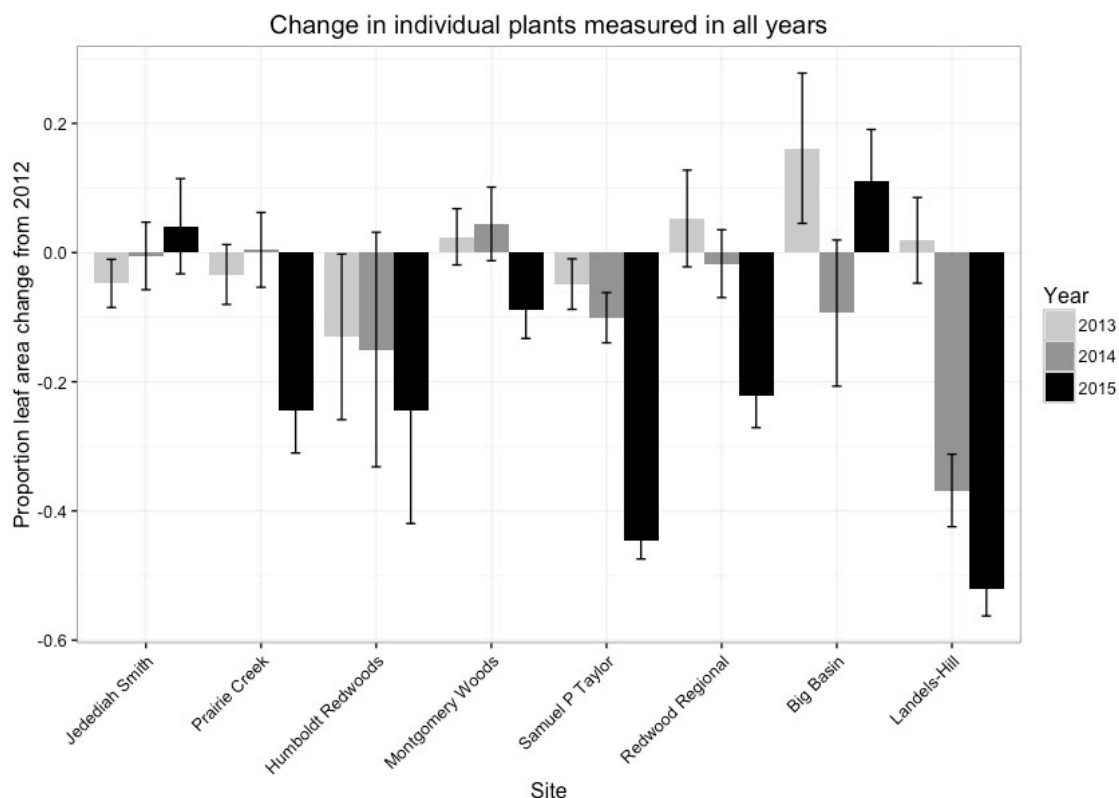


Figure 2 – Trends in mean ( $\pm$  standard error) total leaf area of *Polystichum munitum* across Fern Watch sites.

Results showed that *P. munitum* throughout the ecosystem range avoided the drought by reducing total crown leaf area by approximately one third, though leaf area increased over the drought period at the northernmost site (fig. 2). Individual ferns in several of the northern and wettest coast redwood forests had the highest average leaf area when the study began in 2012 and drought-induced reductions in leaf area caused these northern ferns to shrink and become more similar to *P. munitum* individuals in southern forests by 2015. Slightly higher precipitation levels in 2015 did not cause *P. munitum* to increase leaf area in the final year of the study. This may be because the winter rains occurred significantly earlier than the onset of new leaf growth, causing the 2015 spring growing season to be as dry as in previous years of the drought. Generally, the observed reduction in leaf area for *P. munitum* was caused by the production of shorter fronds and a reduction in the number of fronds per crown during the drought. While the lifespan of individual fronds was not tracked over the

study, the reduction in crown leaf number could be the result of earlier frond senescence in the fall (shorter leaf lifespan), the production of fewer new fronds in the spring, or a combination of both.

Survivorship of *P. munitum* during the recent drought suggests that this hardy perennial fern species is capable of withstanding extreme drought events, providing insight into why this is the most common herbaceous species in the coast redwood ecosystem.

## **Acknowledgements**

The authors are grateful for the many volunteers who helped collect data for this study and access provided by California State Parks, East Bay Regional Park Districts, and the University of California Natural Reserve System to conduct this research on public lands. Funding for this research was provided by Save the Redwoods League.