Functional Traits of Invasive and Native Annual Plants in California Coastal Sage Scrub

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Introduction

- Southern California Coastal Sage Scrub (CSS) is threatened by urban development, increasing fire return intervals, and the resulting invasion of non-native grasses and forbs.
- Although adapted to drought and fire, annual plants in CSS are often dominated by a few, highly competitive invasive plants.
- Plant functional traits give insight into how plant communities are assembled, including the mechanisms by which they become invaded.
- Effect traits reveal how a species affects the abiotic and biotic aspects of its environment, while response traits show how a species responds to the constraints of its environment.[1]
- Functional traits can also be used to improve the success of native species in restoration. In CSS, native annuals that possess traits which confer greater competitive ability may be able to successfully compete with their invasive counterparts.

Objectives:
1) To measure the functional traits of several native and invasive annual plants typical of a CSS.
2) To identify native species with traits similar to invasive species.

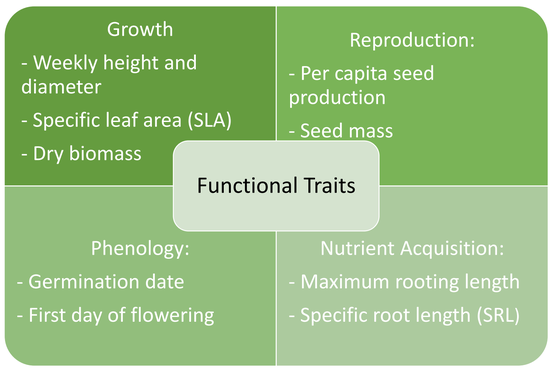
Methods

- Thirteen native and six invasive annual species were grown to maturity in optimal greenhouse conditions and sampled for several functional traits beginning in December, 2018.
- Ten individuals were grown per species, for a total of 190 individuals.
- Species were chosen to represent a diversity of families and growth forms, including grasses (Photo 1a), rosette forming forbs (Photo 1b), and erect forbs (Photo 1c).

Native Species	Invasive Species
Amsinckia intermedia	*Bromus diandrus*
Calandrinia ciliata	*Bromus madritensis*
Castilleja exserta	*Centaurea melitensis*
Clarkia purpurea	*Chenopodium murale*
Croton setiger	*Hirschfeldia incana*
Cryptantha intermedia	*Stellaria media*
Deinandra fasciculata	
Emmenanthe penduliflora	
Festuca microstachys	
Muhlenbergia microsperma	
Phacelia minor	
Plantago erecta	
Pseudonaphalium californica	

Photo 1. Different growth forms of CSS annual plants.

- Traits were selected to represent the overall life-history strategy of each annual species. They were measured daily, weekly, and at the end of the growing period.



Results

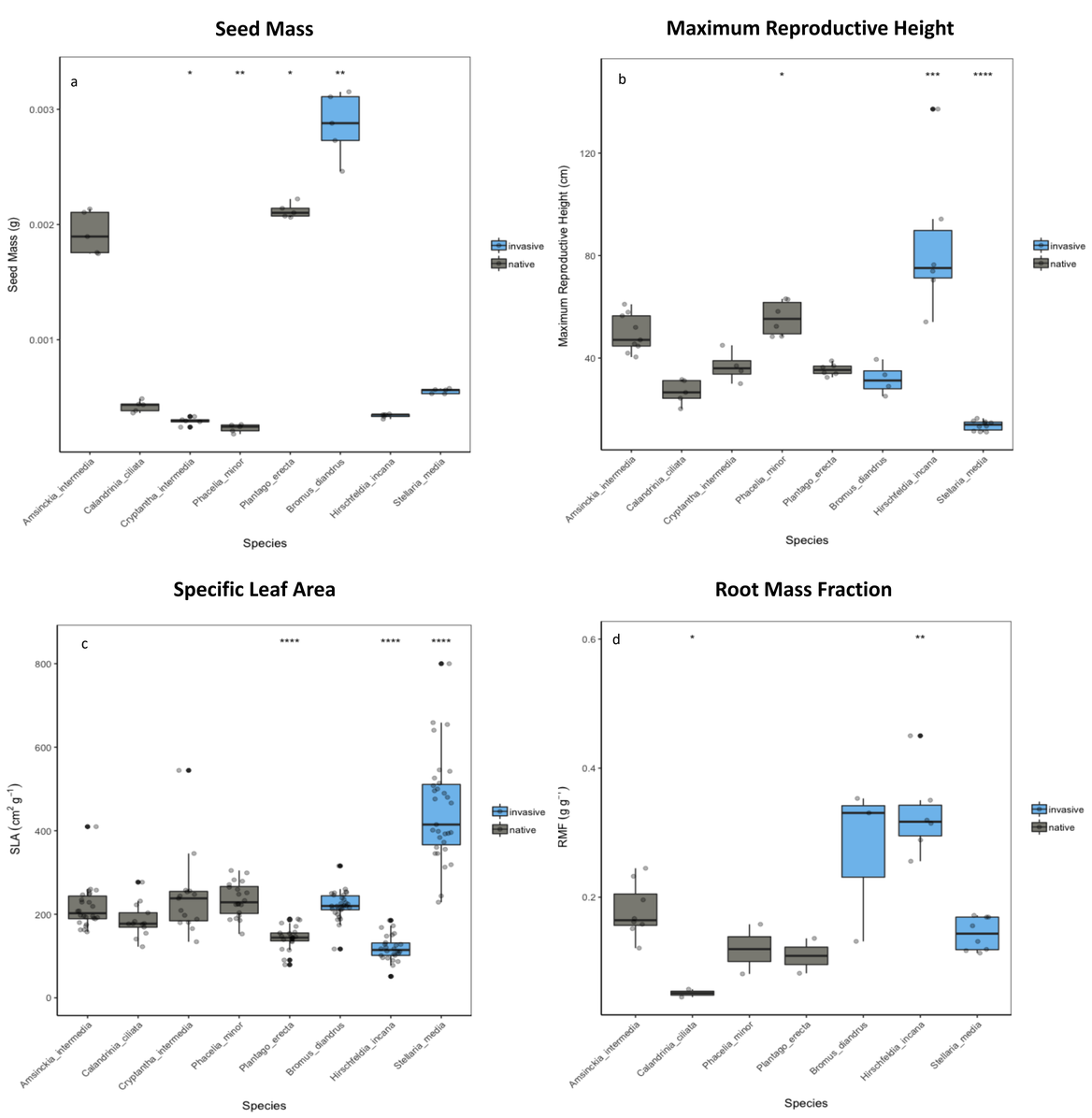


Fig. 1: (a) Seed mass, (b) maximum reproductive height, (c) specific leaf area, and (d) root mass fraction of eight species that reached full maturity in the first three month growing period. Significant difference determined using Wilcoxon Test (* $p \leq 0.05$,** $p \leq 0.01$, *** $p \leq 0.001$, **** $p \leq 0.0001$).

- Overall, invasive species had higher seed mass than native species (Fig. 1a). Although heavier seeds may result in smaller dispersal distance, increased seed size may also facilitate more rapid growth after germination.
- *Hirschfeldia incana* had the highest maximum reproductive height, but was followed by two native species – *Amsinckia intermedia* and *Phacelia minor*, which may be able to challenge the potential shading factor of this common invasive plant (Fig. 1b).
- *Stellaria media*, a small, weedy forb, had very high SLA, indicating its ability for fast resource capture and rapid growth rather than resource conservation and long-term establishment (Fig. 1c).
- Two invasive species - *Hirschfeldia incana* and *Bromus diandrus* had the highest root mass fraction (RMF), showing that they invested more in root production than the native species (Fig. 1d). Higher production of roots allows for greater resource acquisition and overall drought tolerance in the Mediterranean climate. *Amsinckia intermedia* was the next annual to have a highly developed root system, so it may be a potential competitor for resources among these invasive species.

Photo 2. *Hirschfeldia incana,* one of the most dominant invasive plants in scrub and chaparral, allocates resources to tall growth and utilizes dense roots to facilitate its rapid resource capture.

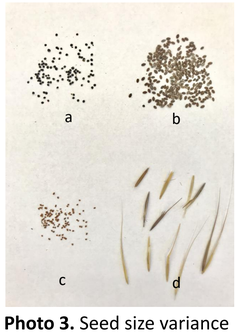


Photo 3. Seed size variance between native and invasive species: *Calandrinia ciliata* (a), *Plantago erecta* (b), *Hirschfeldia incana* (c), *Bromus diandrus* (d).

Photo 4. Although it does not reach the maximum reproductive height of *Hirschfeldia*, the native forb *Phacelia minor* is one of the tallest native forbs studied.

Results

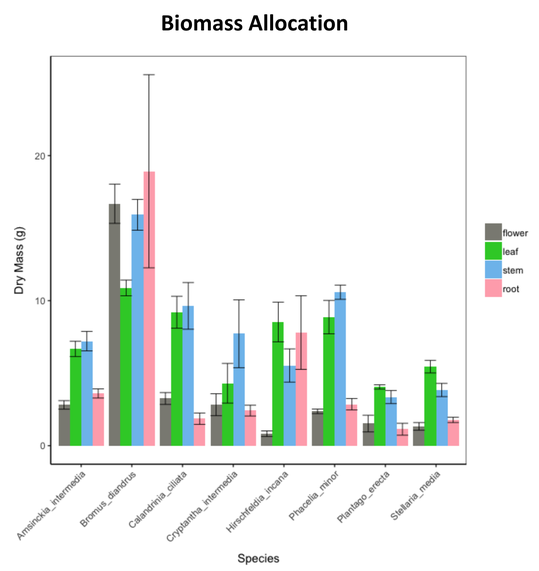


Fig. 2: Mean allocation of mass to different organ parts of each species.

- *Bromus diandrus,* an invasive grass, has the greatest biomass, with a large portion dedicated to reproduction (flower).
- Species that allocate most biomass to aboveground organs include several natives, such as *Calandrinia ciliata* and *Phacelia minor*.
- *Hirschfeldia incana* and *Bromus diandrus* have a large amount of mass within their root systems, allowing for greater nutrient and water acquisition. *Amsinckia intermedia* is the next species to invest most in roots.

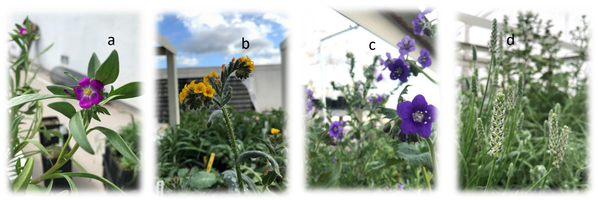


Photo 5. Native annuals, including *Calandrinia ciliata* (a), *Amsinckia intermedia* (b), *Phacelia minor* (c), and *Plantago erecta* (d) tend to invest more in aboveground growth, which includes stems, leaves, and flowers.

Summary and Future Directions

- Common native forbs of CSS tend to occupy similar trait spaces, characterized by lower SLA, smaller maximum reproductive height, and lower RMF than their invasive counterparts.
- Thus, native species are less competitive because they are smaller, tend to be resource conservative, and have less dense root systems to capture water.[2]
- Conversely, dominant invasive species of CSS, including *Hirschfeldia incana* and *Bromus diandrus* are large growing resource capturers with dense root systems that allow them to persist and dominate in CSS's arid climate.
- There are some native species that may be potential competitors of these invaders, including *Amsinckia intermedia,* which grows taller and forms denser roots than some smaller natives.
- In restoration, native species with traits that resemble those of common invasive species are potential candidates for reintroduction and can be identified using functional traits.
- The continuance of the project will include measuring and analyzing more traits of eleven other species, as well as comparing greenhouse measurements to plants growing in the field.

References
[1]Funk et al., 2016. Revisiting the Holy Grail: using plant functional traits to understand ecological processes. *Biological Reviews* 92: 1156-1173.
[2]Drenovsky, et al., 2012. A functional trait perspective on plant invasions. *Annals of Botany* 110: 141-153.

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