Mapping Traits of Three Perennial Grasses in the Northeastern Californian Desert

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Introduction:

Identifying appropriate seeds for use in restoration is crucial for halting the spread of destructive annual species in northeastern California and the greater Great Basin Desert, an area spanning five states. Working with three perennial bunchgrasses (*Elymus elymoides, Achnatherum thurberianum,* and *Poa secunda* in Figure 1), we sought to:

1. Identify the plant traits most associated with survival in a field common garden
2. Determine if these traits are correlated with environmental conditions at the collection site
3. Spatially predict where these traits occur

Figure 1. Species of Interest. A. *Achnatherum (Stipa) thurberianum* B. *Elymus elymoides* C. *Poa secunda.* Photos courtesy of CalFlora

Methods Overview:

We collected seeds from 22 populations and established three common gardens in heavily-invaded areas in Nevada, Oregon and California. Seeds were planted in October, and we monitored their emergence and survival through June.

We also screened seedling traits in a greenhouse, planting 100-150 seeds per population, and measured multiple phenotypic traits (Fig. 2) for seeds and seedlings. Using PCA and ANOVA, we identified a subset of traits with limited multicollinearity that are most associated with field survival (Table 1 and Fig. 2) and asked whether they were associated with site environmental variables (Fig. 3). Using GLM model selection and semivariograms to account for spatial autocorrelation, we interpolated seed weight using universal kriging for each species across the region and visually compared these areas to established EPA level three ecoregions (Fig. 4).

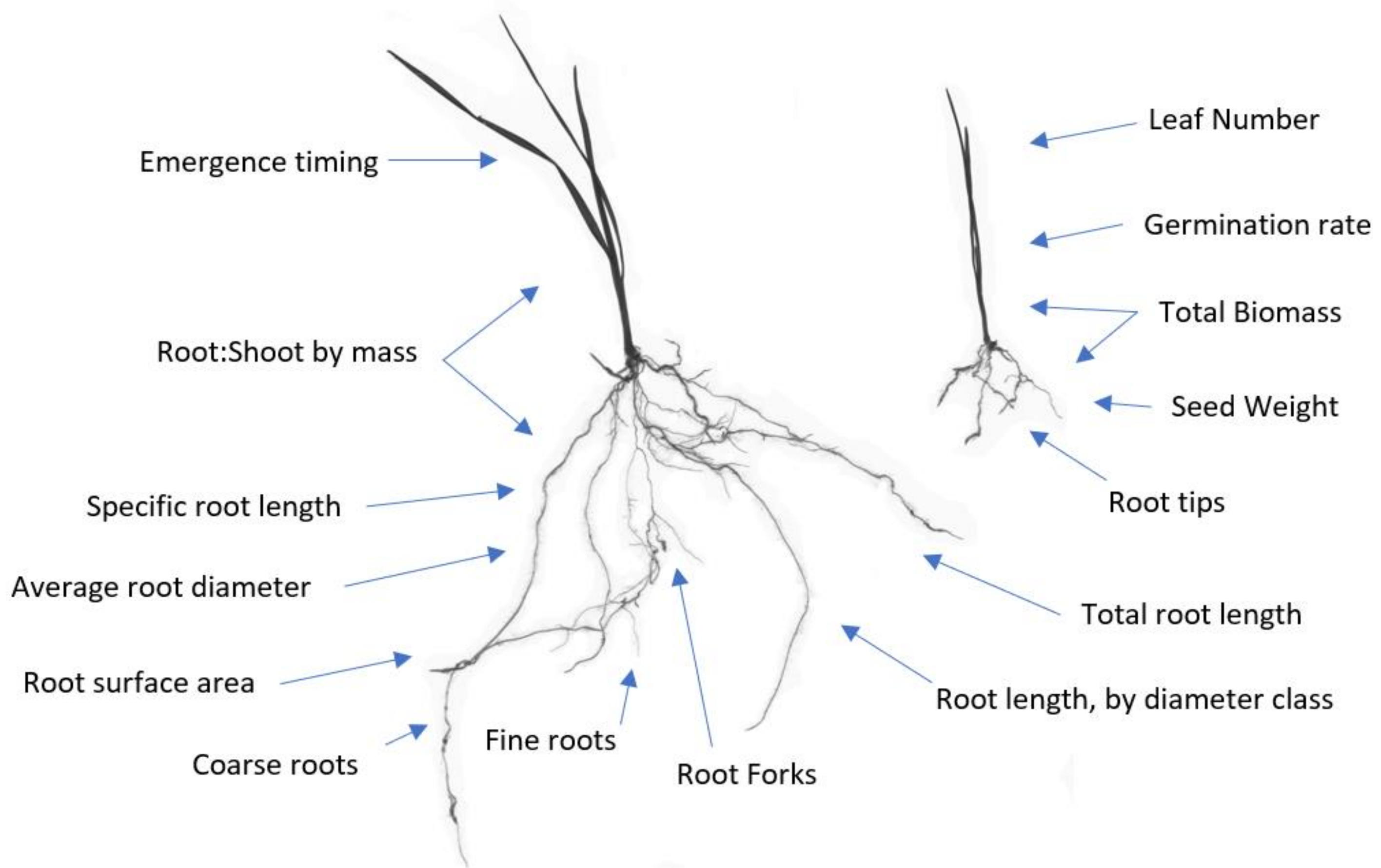


Figure 2. Two examples of 40-day *Poa secunda* seedlings, and traits measured.

Figure 4. Three surface interpolations of seed weights using universal kriging throughout the entire study area with the EPA's Level 3 ecoregions overlaid using annual precipitation and annual minimum temperature as predictive covariates. Black outlines show state boundaries (straight lines) and ecoregions (curved lines). POSE and ELEL show similar patterns, with larger seeds predicted in areas outside the central Great Basin, while ACTH shows the opposite pattern, with larger seeds predicted within the Great Basin, and smaller outside.

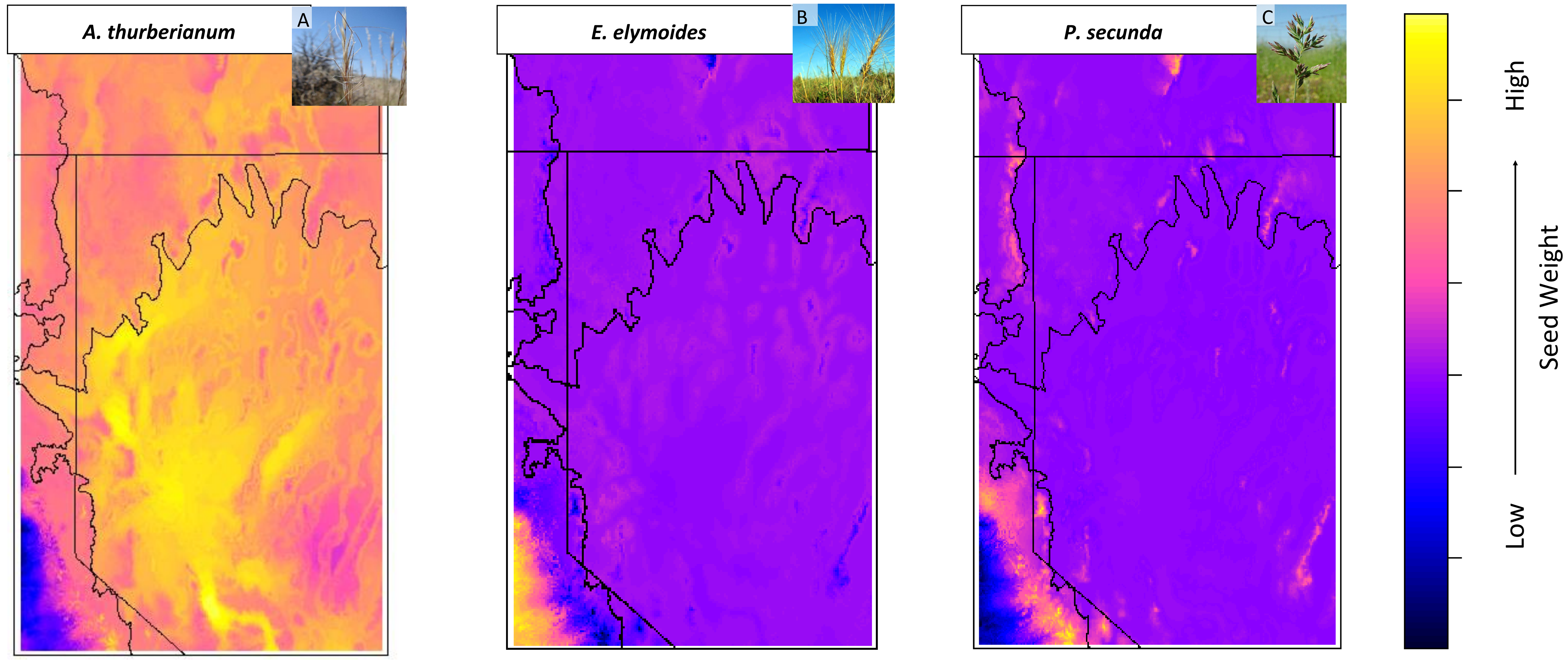


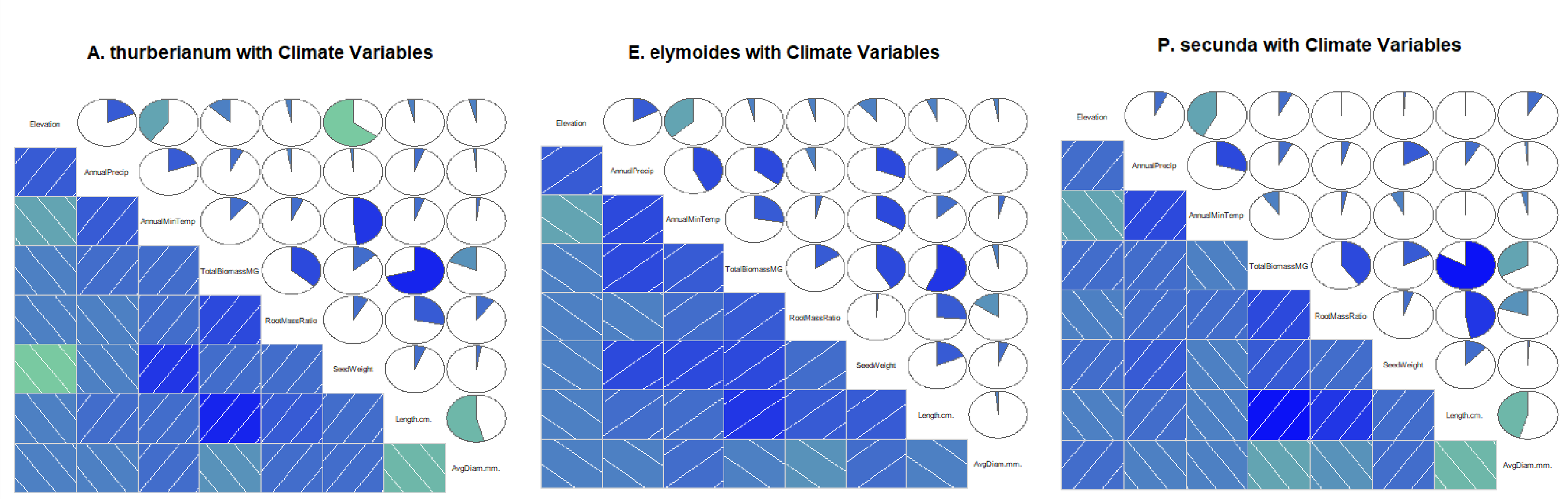
Table 1. Relationship between phenotypic traits and field survival. Traits were reduced to a subset of variables with Pearson correlation coefficients <0.70, and GLM was then used to select the models that best fit the data. Here, we present the significance of individual traits within these best models.

Species	Total Biomass	Seed Weight	Root Biomass	Shoot Biomass	Root Length	Specific Root Length	Root Tips	Days to Emergence	Root Mass Ratio	Average Root Diameter
A. thurberianum	Sig*	Sig***	Sig*	N/S	N/S	N/S	N/S	N/S	N/S	N/S
E. elymoides	Sig***	Sig***	Sig***	Sig***	Sig***	Sig***	Sig***	N/S	N/S	N/S
P. secunda	Sig'	Sig***	N/S	Sig'	N/S	N/S	N/S	N/S	N/S	N/S

Significance codes: ***<0.001; ** <0.01; * <0.05; ' <0.1

N/S - No significant results

Figure 3. Correlograms depicting a subset of trait relationships with climate variables. Traits with multicollinearity were then discarded from the GLM model selection.
Note: Blue indicates positive correlation; green indicates negative. Strength of relationship shown in hue and pie charts. For instance, *A. thurberianum* is negatively correlated with elevation in the first correlogram.



Results and Conclusions

We found populations differed significantly in traits (data not shown), and these differences were correlated with site environmental conditions (Fig. 4), with different relationships for each species. Further, phenotypic traits affected restoration potential. For instance for *E. elymoides*, total biomass and seed weight were strongly correlated with field survival. For *P. secunda* and *A. thurberianum*, seed weight was the most important factor (Table 1), but the result was in different directions, with a negative relationship for one and positive for another (data not shown).
Our predictive maps followed established Level 3 ecoregions for seed weights, with few exceptions (Fig. 3). There were differences among species in the importance of seed weight for survival, as well as differences in the area where large/small seeds were predicted to be found. Our results indicate that detailed studies of specific traits under selection will be needed to find the best seed sources for restoration for individual species of the Great Basin.