Seed traits may predict species success in habitats dominated by thatch-producing annual grasses

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Background:

In the western United States, invasive thatch-producing annual grasses, like medusahead (*Elymus caput-medusae*), modify their environments and decrease the growth of more desirable species[1,2]. The trait-based filtering framework may help explain why[3]. In it, species in the regional species pool pass through dispersal, abiotic, and biotic filters at different frequencies resulting in the local community. The invasion of competitive annual grasses creates strong new dispersal, abiotic, and biotic filters. It has been hypothesized that some plant traits may promote success in these modified habitats[2].

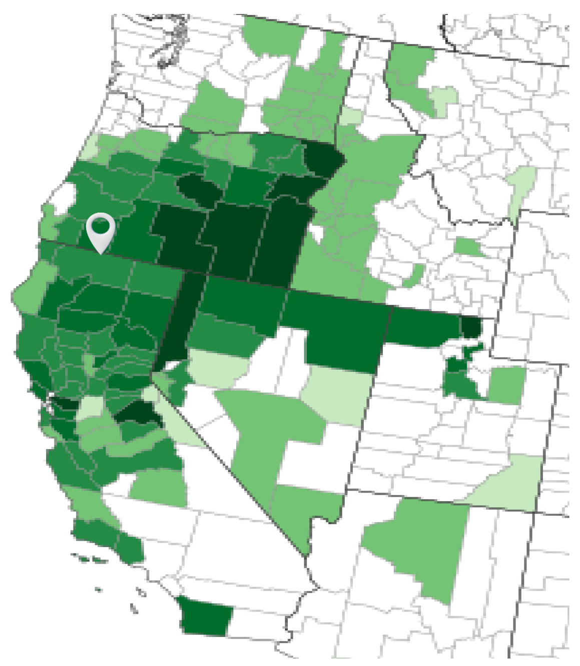

Figure 1. Map of medusahead range and density by county[1]. Darker colors indicate higher density. The white marker shows the location of our field site.

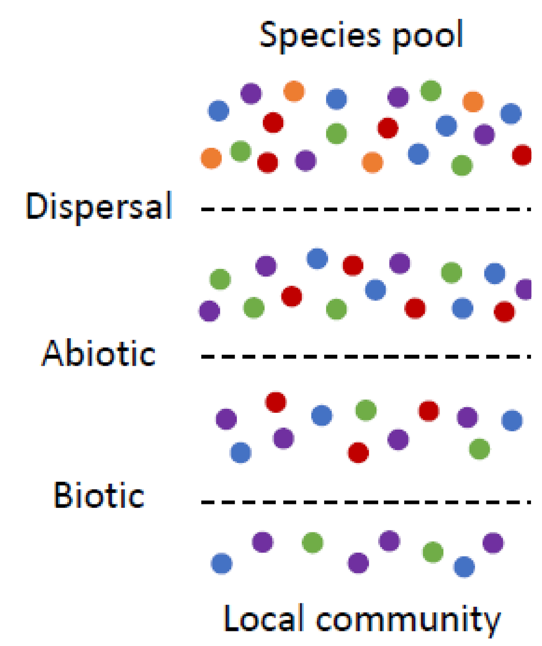

Figure 2. The trait-based filtering framework[3].

Objective:

Identify traits that allow species to grow better in medusahead-impacted habitats.

Hypotheses:

Heavier, narrower, and longer-awned seeds will correlate with a greater number of seedlings in control and thatch-only treatments compared to bare ground. Heavier, larger seeds will be more able to make their way through the thatch and provide energy to seedlings to grow out of the thatch. Narrower seed shape and longer awns will help seeds weave down through the thatch and make contact with the soil.

Methods:

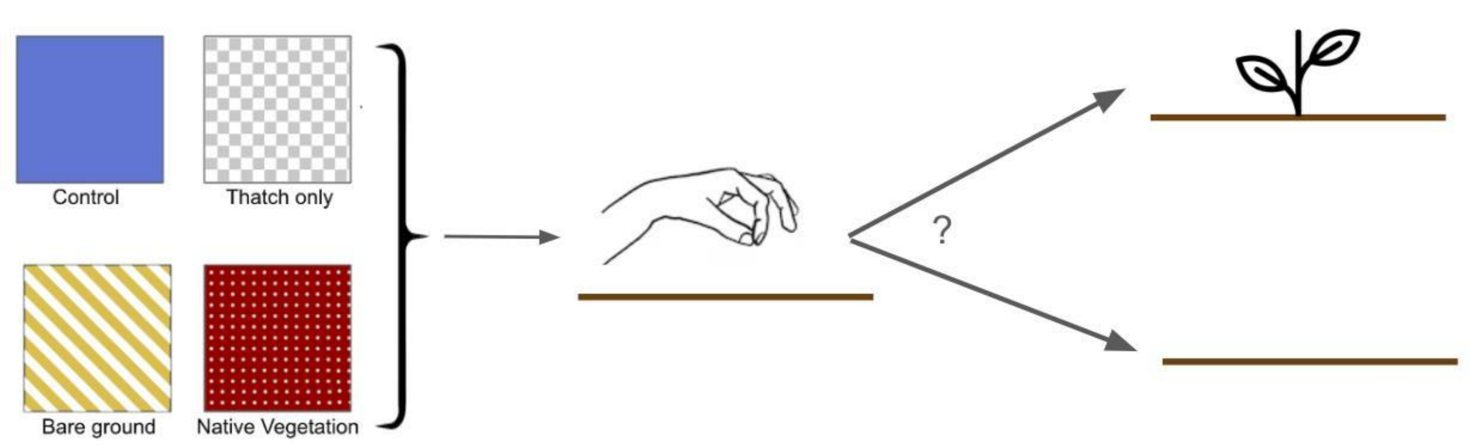

Figure 3. Created control (living medusahead+thatch), thatch-only, bare ground, and native vegetation treatments (n=5), planted 50 seeds of 27 different species with diverse traits, counted and weighed what sprouted. Analyzed results using a binomial glmmTMB model with zero inflation for species.

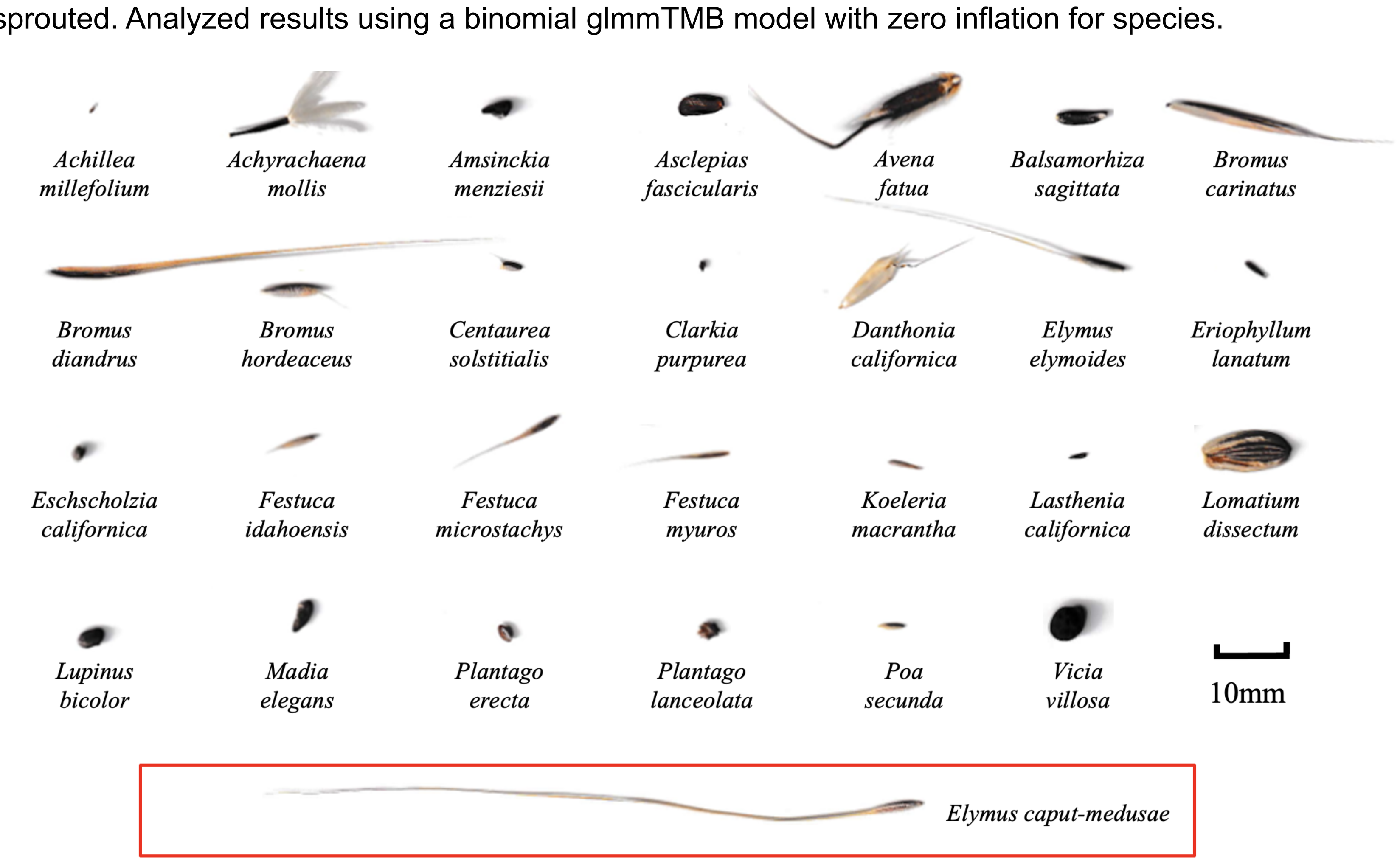

Figure 4. Seeds of species planted. A medusahead seed is shown in the red box for comparison.

Results:

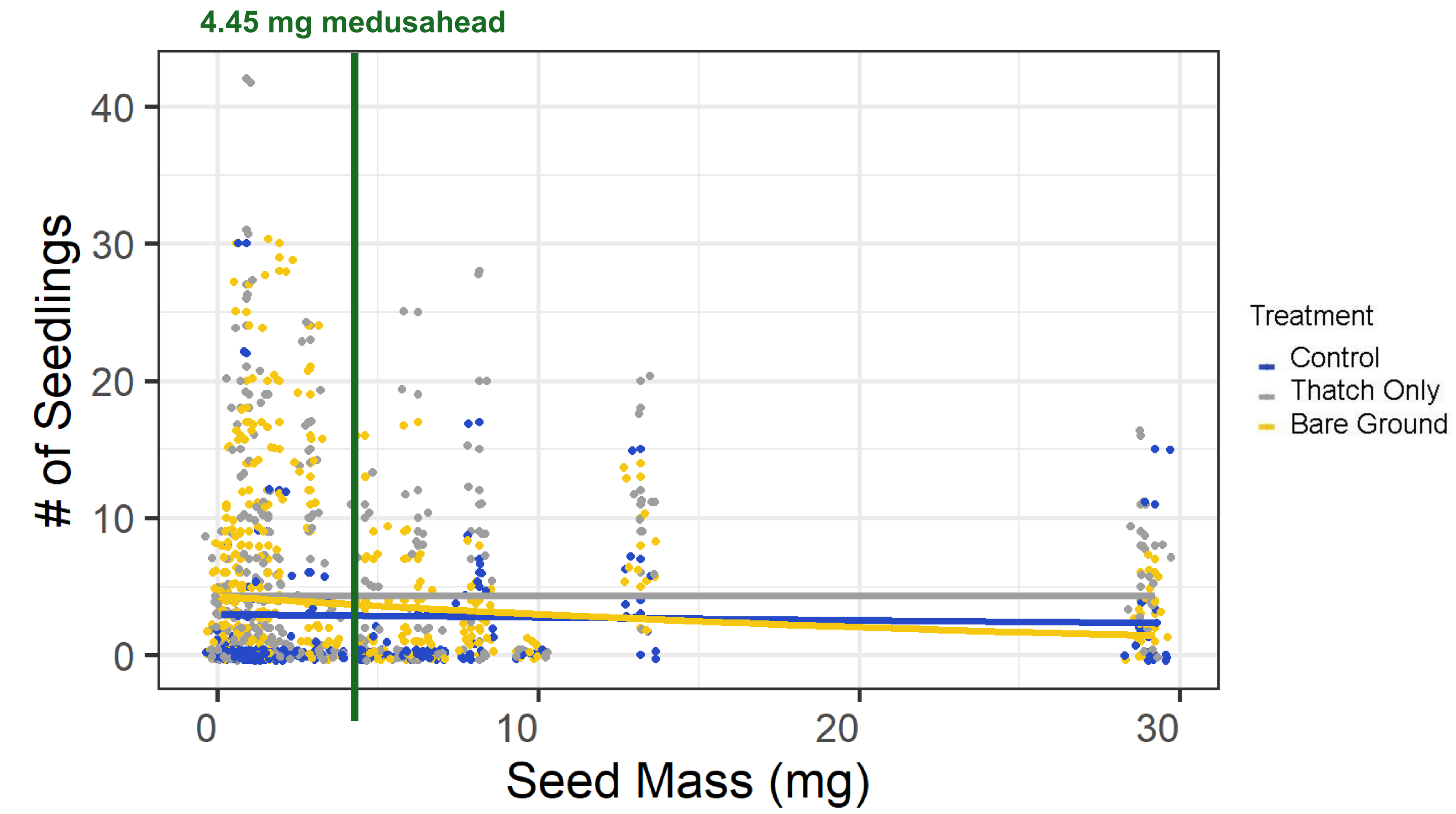

Figure 5. Seedling number by seed mass

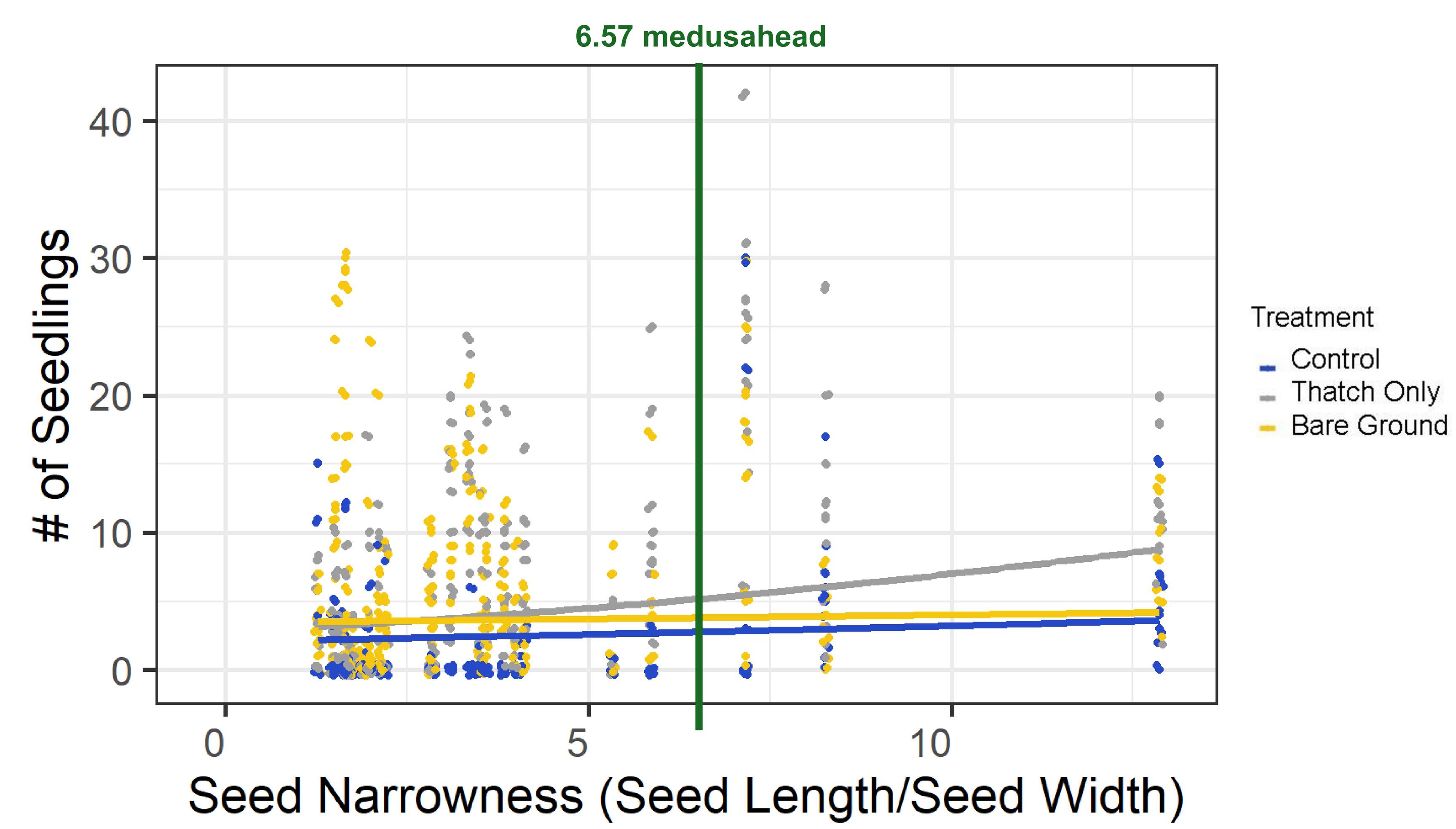

Figure 6. Seedling number by seed narrowness (seed length / seed width)

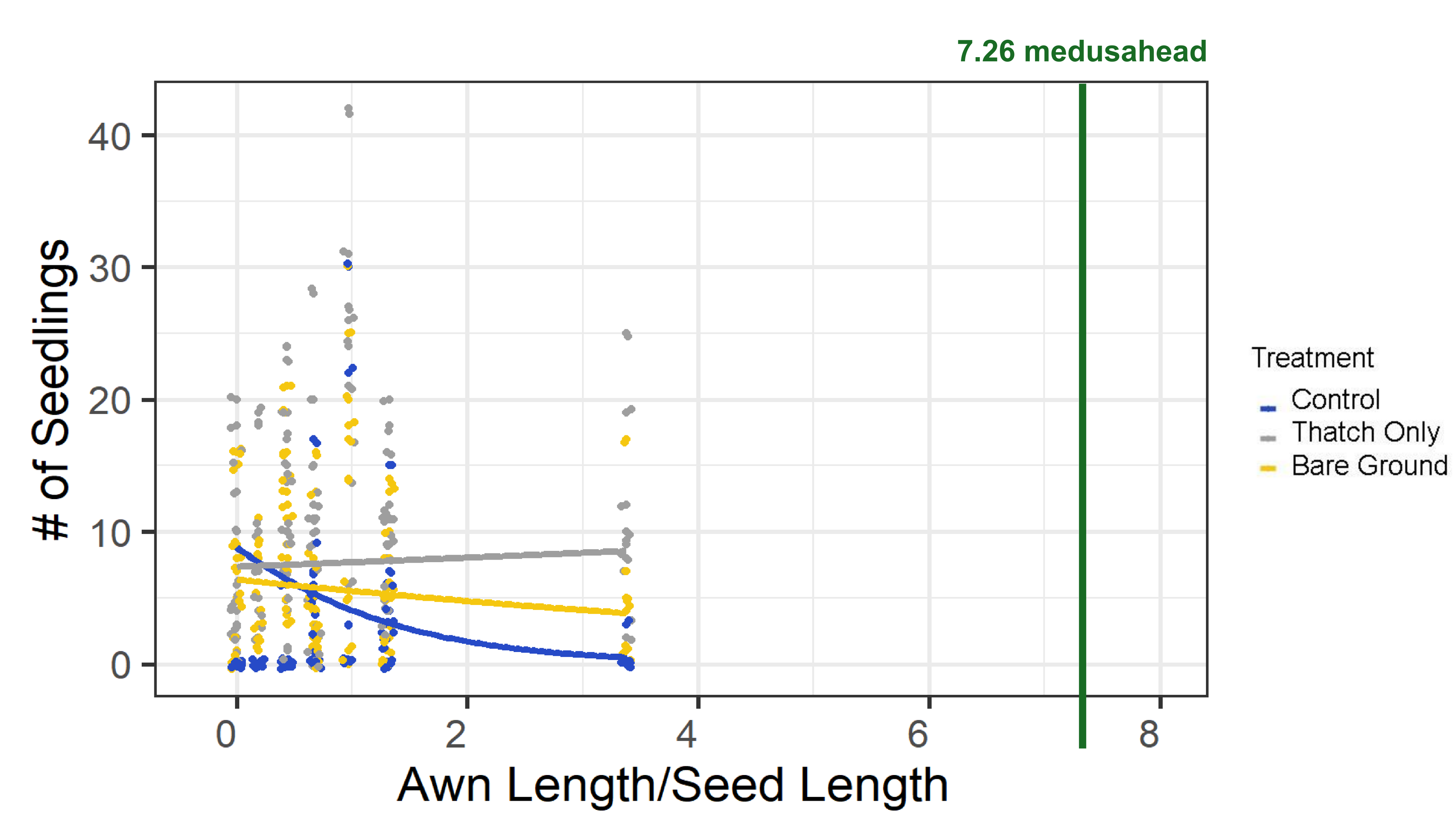

Figure 7. Seedling number by awn length / seed length

Results Continued:

Increased seed mass did not statistically correlate with increased seedling number in control and thatch-only treatments, but seed mass did significantly decrease (slope = -0.04239, $p < 0.0001$) with seedling number in bare ground. The control treatment's slope did not significantly differ from thatch-only. The bare ground treatment's slope differed significantly from control ($p = 0.0007$) and from thatch-only ($p < 0.0001$).

Increased seed narrowness significantly correlated with increased seedling number in control (slope = 0.0483, p-value = 0.0033) and thatch-only (slope = 0.1136, p-value < 0.0001) treatments, but did not correlate with seedling number in bare ground. The thatch-only treatment's slopes differed significantly from control ($p = 0.0014$) and bare ground ($p < 0.0001$), while bare ground and control did not significantly differ.

Increased awn length had a significant negative correlation with seedling number in the control (slope = -0.9466, $p < 0.0001$) and bare ground (slope = -0.1769, $p = 0.0004$) treatments, but had no significant correlation with seedling number in the thatch-only treatment (slope = 0.0578, $p = 0.1070$). All treatments' slopes significantly differed from each other.

Discussion and Tentative Conclusions:

It was surprising that heavier seeds did not correlate with increased seedling number in control and thatch-only treatments. Perhaps seed mass and ability to reach the soil through the thatch are not connected or seedling number is more tied to some other factor differentially influencing seeds based on size. While we did not expect heavier seeds to correlate with decreased seedling number, perhaps seed eaters are more easily able to find heavier, larger seeds? Additionally, seed eaters may prefer larger seeds? We expected the correlation between narrower seeds and increased seedling number in control and thatch-only treatments and the lack of correlation in bare ground. While we did expect seeds with longer awns would have increased seedling number in the thatch-only treatment and expected no correlation with awn length in the bare ground, we did not expect a strong negative correlation with seedling number in control. Perhaps living medusahead imposes some filter that overrides the benefits conveyed by long awns? Perhaps not just length, but some other awn-related trait (or traits) benefit the outrageously long-awned medusahead? Our results appear fairly robust; removing the heaviest two species (*V. villosa* and *A. fatua*) or narrowest and longest-awned species (*E. elymoides*) from the dataset did not change the results. It is an open question whether the correlations we found are biologically significant.

Next Steps:

This experiment is part of a larger study. We plan to continue to analyze the other traits (flowering time, life form, native status) and other measured metrics of success (biomass and life stage). We plan to continue our measurements of how medusahead treatments influence microclimate. We plan to produce a list of seed traits that are correlated with higher success in medusahead-impacted habitats.

References:

1. EDDMapS. (2025). Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health.
2. Kyser GB, et al. (2014). Medusahead Management Guide for the Western States. UC Weed Research and Information Center, Davis.
3. Funk, J.L. (2021). Revising the trait-based filtering framework to include interacting filters: Lessons from grassland restoration J. Ecol., 109(10), 3466-3472.

Acknowledgements and Funding:

This work was made possible by funding from the Grassland Research Awards for Student Scholarship, California Native Grasslands Association; Northern California Botanists Research Scholarship; Davis Botanical Society Student Research Grant Mitich Endowment; John Anderson Memorial Scholarship, California Native Grasslands Association; Native Plant Society of Oregon Field Research Grant; UC Davis Jastro & Shields Graduate Research Award; Center for Population Biology Research Award; National Science Foundation Graduate Research Fellowship; I acknowledge the Department of Plant Sciences, UC Davis for the award of a GSR scholarship funded by endowments, particularly the James Monroe McDonald Endowment, administered by UCANR; and Eugene Cota-Robles Fellowship.

I received invaluable assistance from many members of the Funk Lab; Valerie Eviner; Andrew Latimer; Land owner Art Coolidge; UC Davis Student Disability Center, especially Sarah Cohen; Tom Getts; UC Davis DataLab; and GGE Stats Support Group.