# Seedling competition between Stipa Pulchra (Purple Needlegrass) and Centaurea solstitialis (Yellow Starthistle).


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## Introduction

Yellow Starthistle (*Centaurea solstitialis* or YST for brevity*)* is a common annual invasive found in the grassland habitats of California. A common species native to these ecosystems is Purple Needlegrass (*Stipa Pulchra* or PNG for brevity*)*, a perennial grass. It has been shown that established Purple Needlegrass individuals can reduce the vigor and thus invasive ability of Yellow Starthistle (Morghan and Rice 2005). However, the recruitment of successive generations of Purple Needlegrass is necessary if this invasive resistance is to continue. This study looks at the ability of Purple Needlegrass to compete with Yellow Starthistle as a seedling.

Figure 12. Pots during seedling stage

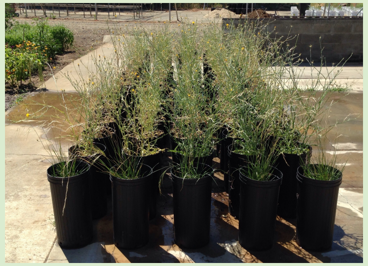

Figure 11. Pots after flowering

## Methods

The experiment in this study was a multi-density replacement series (Radosevich et al. 2007), with the two species used being Purple Needlegrass and Yellow Starthistle. The three total densities used were 40, 24, and 16 seeds per pot and five replicates of each experiment (except for the 18:6 Starthistle: Needlegrass trial which had four replicates due to one pot where every individual disappeared, likely due to herbivory). The pots had an area of 506.5 square $cm^2$ and a total soil volume of 25084.5 $cm^3$. Each different density was grown in five different mixtures, 100% Purple Needlegrass (PNG) & 0% Yellow Starthistle (YST), 75% PNG & 25% YST, 50% PNG & 50% YST, 25% PNG & 75% YST, and 0% PNG & 100% YST, resulting in 75 total pots. The plants were grown outdoors in full sun at the Chico State University Farm. They were planted December 10th, 2016. They were irrigated with natural rainfall until May, after which each pot was given approximately 4 L of water once a week until harvest on July 24, 2017. At harvest, the roots were washed, and then plants were dried and weighed.

## Works Cited


Morghan, K. J., and K. J. Rice. 2005. *Centaurea solstitialis* invasion success is influenced by *Nassella pulchra* size. Restoration Ecology **13**: 524-528.

Radosevich, S. R., J. S. Holt, and C. Ghersa. 2007. Ecology of weeds and invasive plants: Relationship to agriculture and natural resource management. Wiley, Hoboken, New Jersey, USA.


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## Results

Yellow Starthistle abbreviated as YST and Purple Needlegrass abbreviated as PNG on all graphs

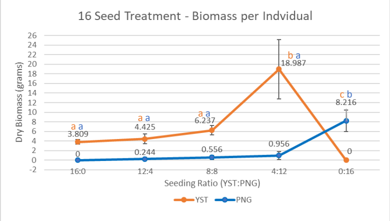


Figure 1. Average Biomass of each individual plant. Error Bars represent one standard deviation. Some error bars are too small to see at this scale. Two Factor Anova showed significant interaction between species and seeding ratio factors. Colored letters represent significance groupings based on Tukey-Kramer post hoc analysis for each corresponding species. (α = 0.05)

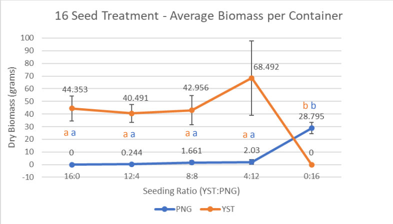


Figure 2. Average combined biomass of all plant of a species in a container. Error Bars represent one standard deviation. Some error bars are too small to see at this scale. Two Factor Anova showed significant interaction between species and seeding ratio factors. Colored letters represent significance groupings based on Tukey-Kramer post hoc analysis for each corresponding species. (α = 0.05)

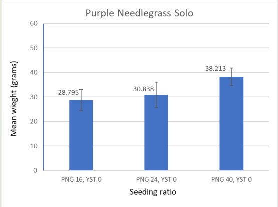


Figure 7. Average biomass per container of Purple Needlegrass grown without Yellow Starthistle. Single Factor ANOVA shows a significant difference between groups. Tukey-Kramer post hoc analysis showed significant differences between 40 seed density and all other densities.(α=0.05)

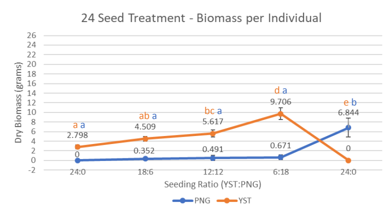


Figure 3. Average Biomass of each individual plant. Error Bars represent one standard deviation. Some error bars are too small to see at this scale. Two Factor Anova showed significant interaction between species and seeding ratio factors. Colored letters represent significance groupings based on Tukey-Kramer post hoc analysis for each corresponding species. (α = 0.05) *One pot out of five destroyed by likely herbivory in the 18:6 trial, data from that pot not included.

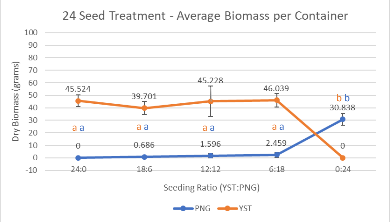


Figure 4. Average combined biomass of all plant of a species in a container. Error Bars represent one standard deviation. Some error bars are too small to see at this scale. Two Factor Anova showed significant interaction between species and seeding ratio factors. Colored letters represent significance groupings based on Tukey-Kramer post hoc analysis for each corresponding species. (α = 0.05) *One pot out of five destroyed by likely herbivory in the 18:6 trial, data from that pot not included.

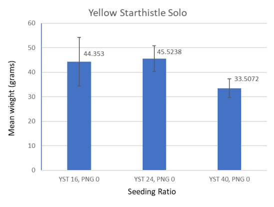


Figure 8. Average biomass per container of Yellow Starthistle grown without Purple Needlegrass. Single Factor ANOVA showed a significant difference between groups. Tukey-Kramer post hoc analysis showed significant differences between 24 seed density and 40 seed density. 16 seed not quite significantly different than 40 seed density (Absolute difference 10.85, critical value 11.25)(α=0.05)

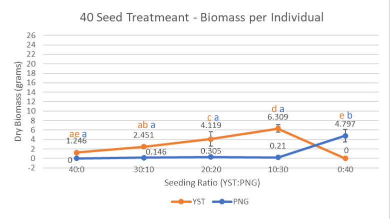


Figure 5. Average Biomass of each individual plant. Error Bars represent one standard deviation. Some error bars are too small to see at this scale. Two Factor Anova showed significant interaction between species and seeding ratio factors. Colored letters represent significance groupings based on Tukey-Kramer post hoc analysis for each corresponding species. (α = 0.05)

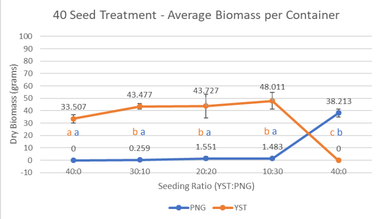


Figure 6. Average combined biomass of all plant of a species in a container. Error Bars represent one standard deviation. Some error bars are too small to see at this scale. Two Factor Anova showed significant interaction between species and seeding ratio factors. Colored letters represent significance groupings based on Tukey-Kramer post hoc analysis for each corresponding species. (α = 0.05)

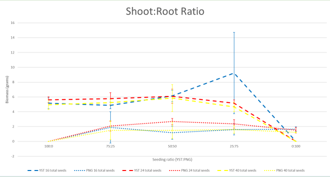


Figure 9. Average shoot biomass per container divided by average root biomass per container. No significant differences between total seed densities of 16, 24, and 40. No significant difference between different seed ratio. Based on single factor ANOVA (α=0.05).

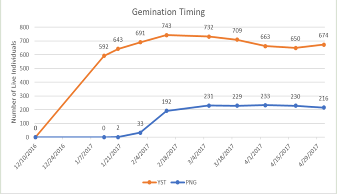


Figure 10. Number of live individuals of each species until last count on May 2, 2017. At harvest on July 24, 2017 totals were 670 YST and 218 PNG.

## Conclusion and further research

This experiment provides some evidence to suggest that populations of Purple Needlegrass are susceptible to competition from Yellow Starthistle. While adult Purple Needlegrass individuals may be able to resist invasion to some degree (Morghan and Rice 2005), there needs to be management practices in place that promote the recruitment of new Purple Needlegrass individuals and suppress Starthistle, if the populations are to survive long term. This experiment is part of a larger study into the recruitment of Purple Needlegrass, and was done to support a still in progress field experiment to look at the efficacy of planting seeds vs planting pre-grown individual grasses (plugs) in a restoration context at sites degraded by Yellow Starthistle.

## Discussion

For all trials (figures 1-6) the only significantly different levels of Purple Needlegrass biomass production was when it was grown in the absence of Yellow Starthistle. While most containers with Purple Needlegrass seed had at least a few individuals, these plants remained small as they may have been crowed out by the Yellow Starthistle seedlings (figure 12). The Yellow Starthistle average biomass per container was found to only be significantly different in the highest density trial (40:0 YST:PNG, figure 6), likely due to crowding, and of course when no Yellow Starthistle was planted. However, Yellow Starthistle average biomass per container in the 4:12 trials fell just short of being significant at α=0.05 (Tukey-Kramer results, absolute differences of 28.00 with a critical range of 28.67, figure 2). For the Yellow Starthistle average biomass per individual, the lower densities of Yellow Starthistle seeding had significantly more biomass that higher seeding densities in all trials (Figures 1, 3, and 5). This seems to indicated that no matter what the density of Yellow Starthistle growing in an area, the individual plants have the growth plasticity to use all available space.

The one exception to Yellow Starthistle's ability to avoid limiting biomass production through intraspecific competition seemed to be at the highest planting density used (40YST:0PNG, figure 5, 6, and 8). When comparing trials of Yellow Starthistle grown independently of Purple Needlegrass we find that the lower density of 24 seeds has a significantly higher average biomass per container than the 40 seed density trials. The 16 seed trial was nearly significantly more than the 40 seed density but it was not, likely due to high variability. The solo comparison of PNG showed an opposite trend with more seeds resulting in significantly more biomass. The 40 seed trial produced significantly more biomass than 16 or 24 seeds trials (figure 7).

A possible reason for Purple Needlegrass's poor performance in competition with Yellow Starthistle many be illustrated with the germination timing of each species (figure 10). The Yellow Starthistle germinates much earlier than purple needlegrass. The first gemination data was recorded 34 days after planting, and at that point 592 Yellow Starthistle seedlings were recorded, while not a single Purple Needlegrass had emerged yet. The majority of Purple Needlegrass seedlings did not start to emerge until approximately 2 months after planting. In total, 67.4% of Starthistle seeds germinated and survived while only 21.6% of the Needlegrass seeds germinated and survived. This could have been caused any number of factors including higher seed dormancy rates or lower viability in Purple Needlegrass seeds. It also could have been from direct competition with the Yellow Starthistle seedlings due to crowding (figure 12).

Examination of shoot:root ratios shows that neither the total seed density, nor the seeding ratio significantly effects the ratio at which the plants put on above and below ground biomass (figure 9). The only difference in shoot:root ratio was between Yellow Starthistle and Purple Needlegrass themselves, which is too be expected given one is an annual and the other a perennial.