Introduction

Wetlands are one of the most important ecosystems on this planet, as they have high productivity and wildlife, many of which can be found at San Diego's Kendall Frost Marsh Reserve [1]. Even though this land is protected, Kendall Frost marsh still faces many threats, particularly from invasive species. Kendall Frost Marsh Reserve may be particularly in danger due to its location near housing and recreational areas [2].

Invasive species can be incredibly difficult to remove once established. It has been found that the combination of top-down control and bottom-up control is the most effective at invasive species removal in highly degraded areas [3]. Currently, Kendall Frost uses mainly top-down control in the form of weed removal as chemical pesticides cannot be used due to the damage on the marsh water and native plants. As a solution, it has been proposed to use excess salt as a form of a natural pesticide.

The thought is that the native species, which are adapted to dealing with the marshes high salt environment, may be able to survive the excess salt. However, this treatment will not be useful if it prevents future plant establishment or only allows one native species to thrive. So before salt treatments can be used, we need to understand its effects on native plant establishment.

Methods

Plots were assigned numbers 1-14 as seen in Figure 4. Plots on the north side, numbers 1, 3 and 6-10, were assigned salt water treatments. Plots to the south, 4, 6 and 11-13, were assigned freshwater treatments. These treatments were randomly assigned to one of the six spots in each plot through random number generator. Each plot received water until saturation, averaging about 1 liter of water each. Treatment occurred an average of once a week due to tides and rain. The salt water plots received the water from the marsh, which measured an average salinity of 2.6 on the refractometer. Plants were rated on a score of 0-5 on a health scale that was predetermined, as seen in Figure 2. For volume, the maximum plant height, the longest width, and its perpendicular length were measured. These values were used to calculate a cylindrical volume. This data was analyzed using the R statistical package [4].

Results

1. *Arthrocnemum subterminale* grew with no significance between treatments. Health wise, it succeeded in the lower fresh plots and upper salt plots. This is surprising since this species tends to grow in the upper marsh areas, and is expected to not tolerate salt treatments or inundation [5].

2. *Distichlis spicata* increased drastically in size in the lower fresh plots with no change in health, and was unable to tolerate the extreme salt content in the lower salt plots. This is consistent with its provenance as a mid to upper marsh plant [5].

3. *Iva hayesiana* struggled in all plot types. However, it did decrease the least in health in the upper plots. This is surprising as it was predicted to do best in the upper fresh plots, since it is a high to inland species that can only tolerate the occasional salt and flooding [6].

4. *Limonium californicum* grew well on average in all plots, as there was no significant difference between treatments. However, the health in the middle of the marsh decreased drastically, possibly due to over inundation in the lower salt plots, which is unforeseen but can be explained. This species tends to do well in the upper salt plots and lower fresh plots, but not in the middle of the marsh, which may explain why it reacted similarly to *Limonium* [5].

5. *Salicornia pacifica* had no significance between treatments. This species tends to be found in the upper marshes of the marsh, which may explain why it reacted similarly to *Limonium* [5].

6. *Suaza estera* is a mean high tide plant, meaning it is inundated with seawater relatively infrequently [7]. However, it grew best in the lower plots, specifically the lower fresh plots.

Conclusions

Since some species reacted poorly to the salt treatment, it would not be advisable to apply this treatment across the entire restoration site. However, it may be a viable option to be used in patches where species like *Limonium californicum* and *Salicornia pacifica* are found and struggling with invasive plants. However, even in patches caution should be used to not discourage the establishment of other native species.

Although this experiment was not promising for the wide use of salt treatments, the plants’ responses to the treatment are still useful data. Accurate results on species response to additional salt inundation will become increasingly important on our sea level rise. With sea level rise comes more frequent and longer inundation of the plants in salt water, which can shift the low marsh and high marsh interactions. Since many plant species have proven to not tolerate this, this can threaten plant productivity and biodiversity. The threat sea level rise poses to biodiversity on our coastlines calls for more studies and research.

Acknowledgements

I would like to thank Isabelle Kay, the Reserves Manager, for her guidance, knowledge, time, and skills that supported me throughout the whole year. I would also like to thank my fellow intern at the marsh Daniela Laterro for being able to exchange ideas. Thanks to Doctor Joshua Kohn for his guidance and assistance as my mentor. Finally, I would like to thank all of the other staff, interns, and volunteers at Kendall Frost Marsh Reserve for their assistance in planting, irrigating, and construction as well as their time and energy spent at the reserve.

References