Effect of Salinity on Wetland Plant Establishment at Kendall Frost Marsh Reserve

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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 outlive the invasive plants. 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.

Figure 1: Restoration area of Kendall Frost Marsh Reserve. Experiment occurred in the lowest flat as outlined in the dark green and marked with an 'X'.

Methods

Plots were assigned numbers 1-14 as seen in Figure 4. Plots on the north side, numbered 1-3 and 8-10, were assigned salt water treatments. Plots to the south, 4-6 and 11-13, were assigned freshwater treatments. Plots 7 and 14 were an unfenced variable, but that data is not analyzed due to the plants being consumed within a day. Within each plot, were six species areas as seen in Figure 3. Each species was randomly assigned to one of the six spots in each plot through a 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].

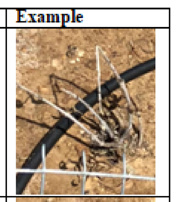
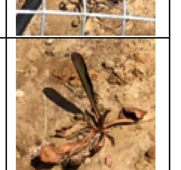
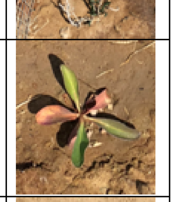
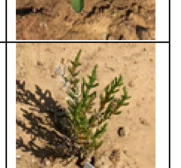
Rating	Traits	Example
0	The plant is missing or obviously dead	
1	Very minor signs of life, may appear dead but can only know by breaking the stem to check	
2	Signs of life, but mostly dry, loss of leaves, sparse	
3	Some dryness or limpness. Nearly equal parts green and not	
4	Mostly green with very few dropped leaves, rigid	
5	All green with signs of growth in flowers, new leaves, or buds. Dense and rigid.	No 5's recorded

Figure 2: Health rating chart for evaluation

Figure 3: Example of species set up in three plots

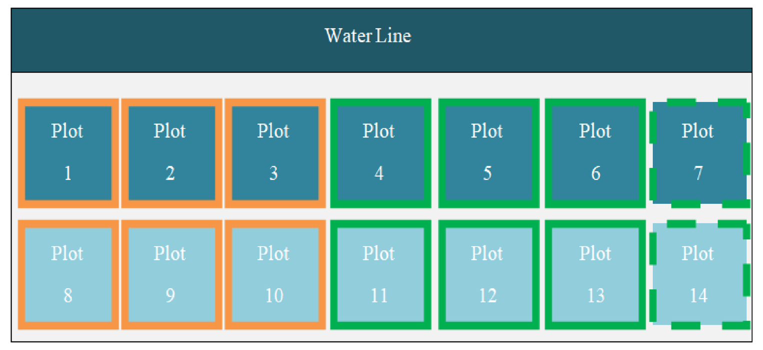


Figure 4: The set up of the treatment plots. The orange box indicates salt water treatment and the green indicates freshwater treatments. The lower plots are colored a darker blue to reflect the marsh waters influence on these plots. The dashes plots were unfenced and not included in this analysis.

Results

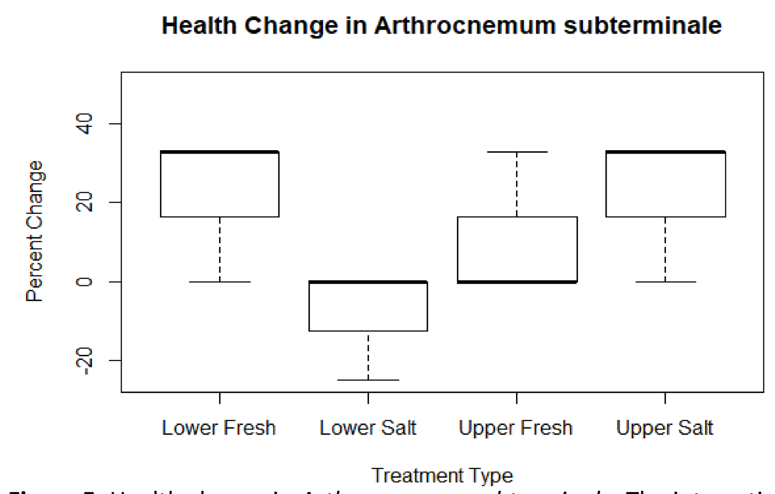


Figure 5: Health change in *Arthrocnemum subterminale.* The interaction between area and treatment is significant (P=0.08, $F_{1,8}$ *=3.95)*

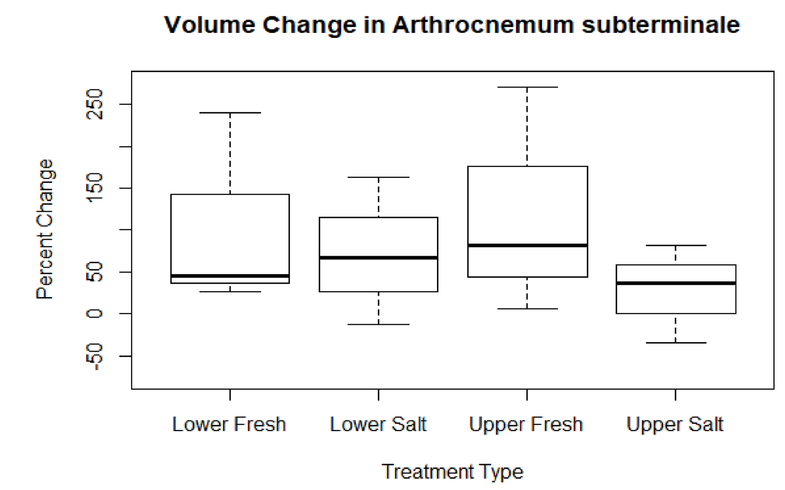


Figure 6: Volume change in *Arthrocnemum subterminale.* No significance.

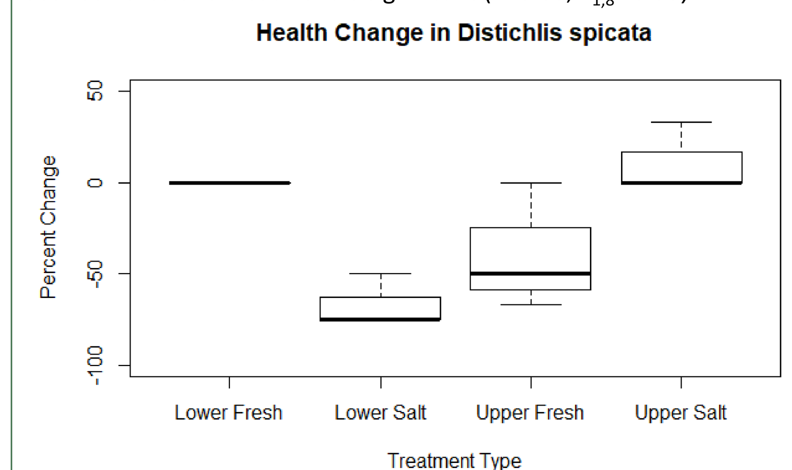


Figure 7: Health change for *Distichlis spicata.* The interaction between area and treatment is significant (P=0.001, $F_{1,8}$=22.9)

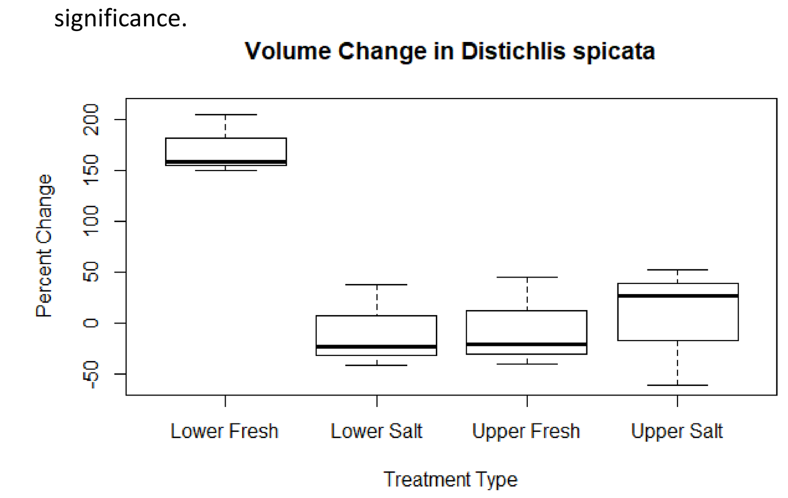


Figure 8: Volume change for *Distichlis spicata.* Significance was found in area (P=0.014, $F_{1,8}$=9.7), treatment (P=0.012, $F_{1,8}$=10.52) and their interaction (P=0.006, $F_{1.8}$=13.53)

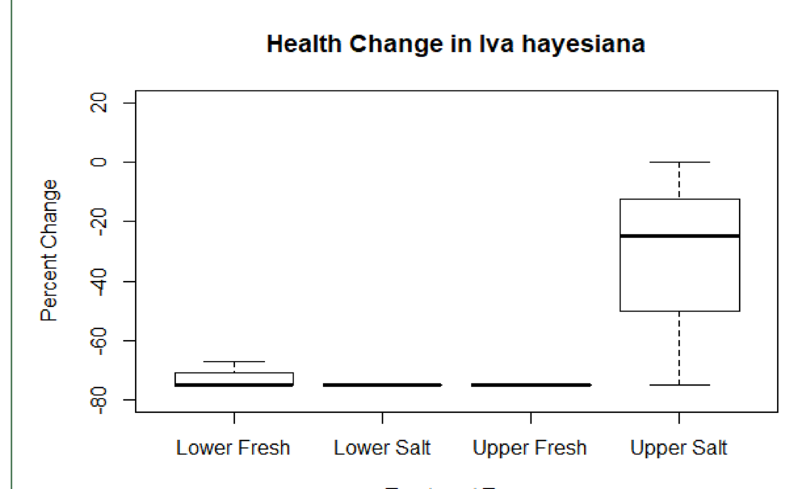


Figure 9: Health change for *Iva hayesiana.* The interaction between area and treatment is significant (P=0.081, $F_{1,8}$=3.99)

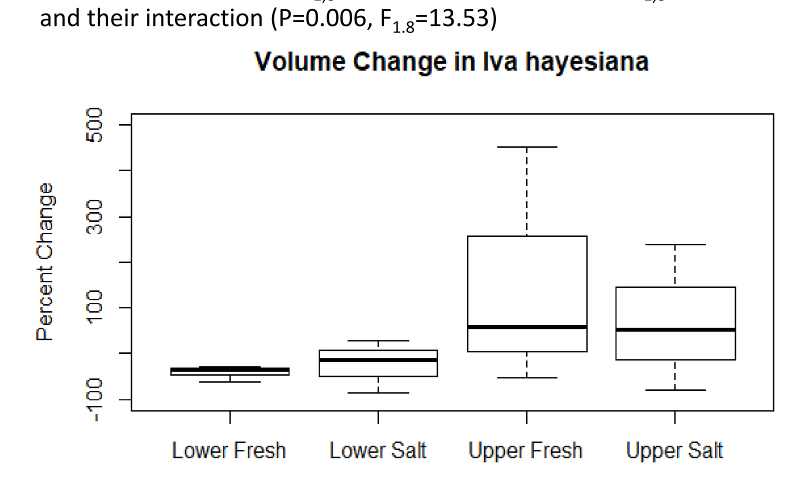


Figure 10: Volume change for *Iva hayesiana.* No significance.

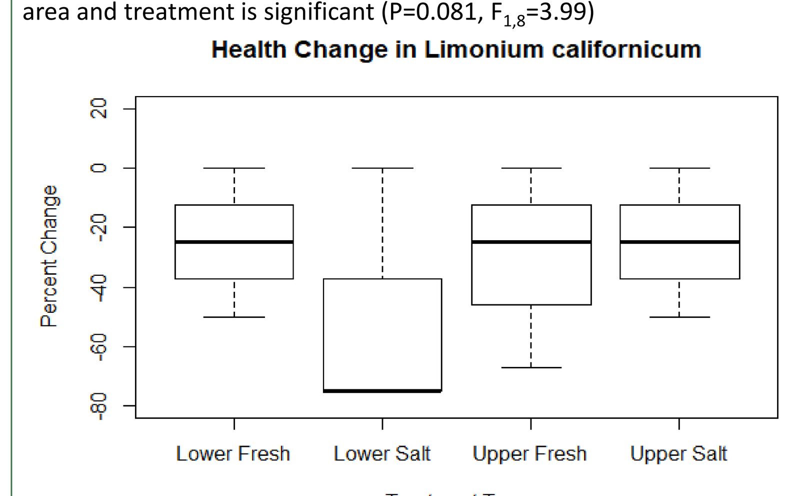


Figure 11: Health change for *Limonium californicum.* No significance.

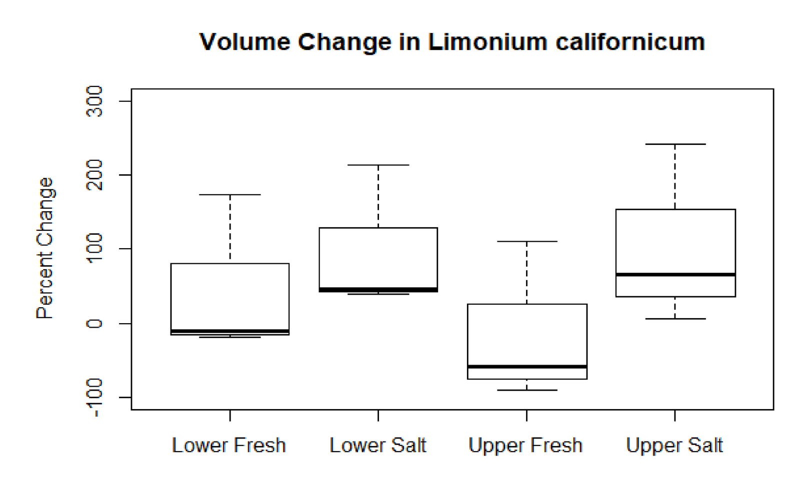


Figure 12: Volume change for *Limonium californicum.* No significance.

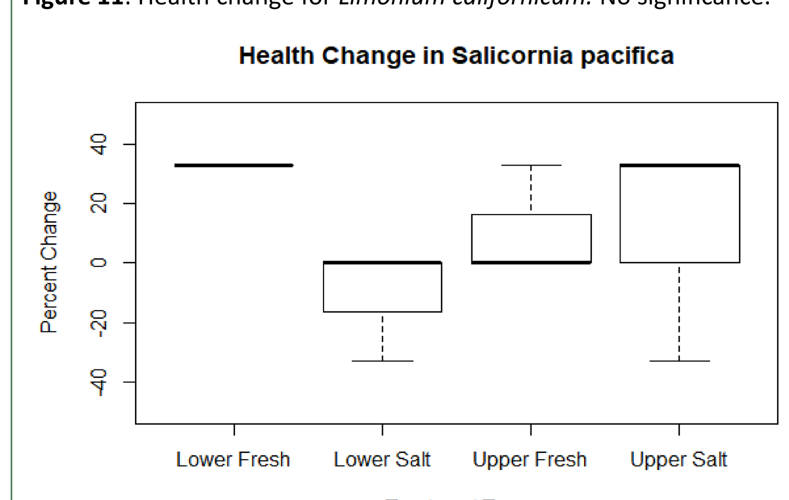


Figure 13: Health change for *Salicornia pacifica.* No significance.

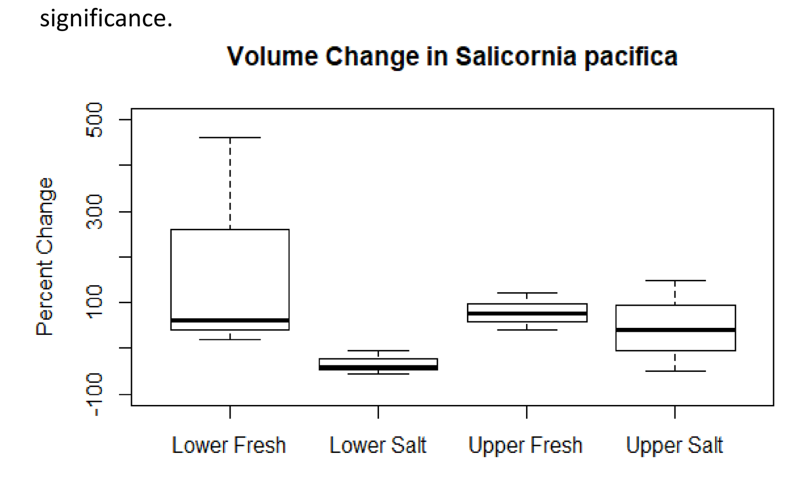


Figure 14: Volume change for *Salicornia pacifica.* No significance.

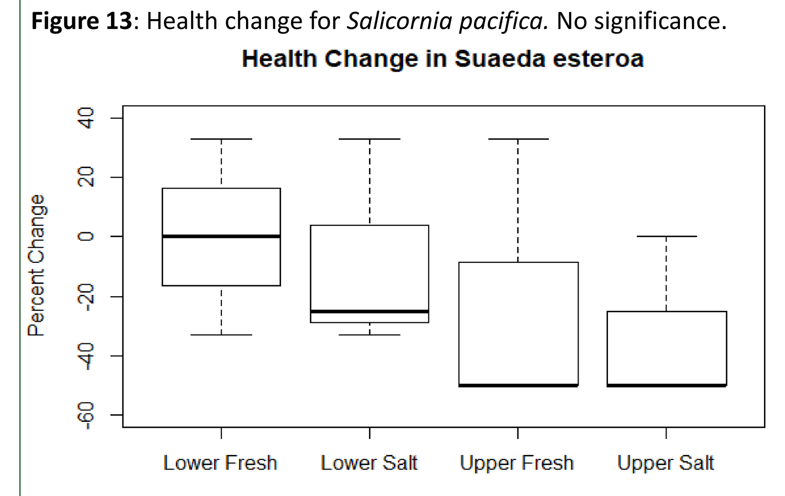


Figure 15: Health change for *Suaeda esteroa.* No significance.

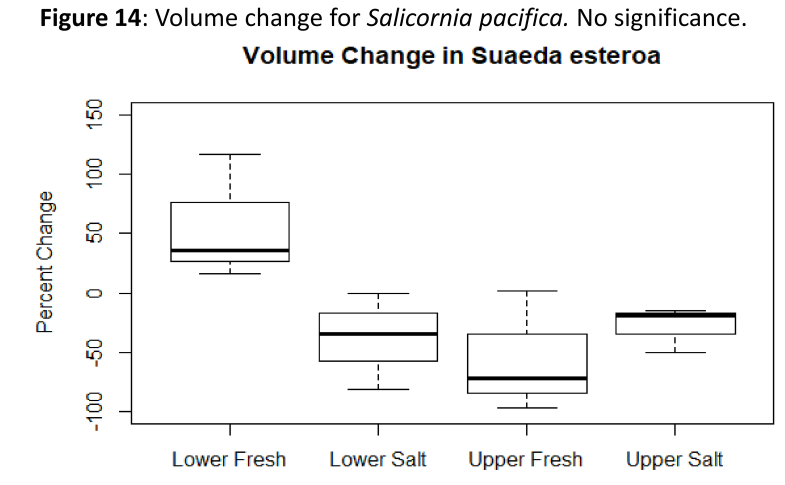


Figure 16: Volume change for *Suaeda esteroa.* The effect of area is significant (P=0.0768 $F_{1,8}$=4.12) and the interaction between area and treatment (P=0.0039, $F_{1,8}$=6.04).

Discussion

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 zonation 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 salt 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 the treatments. However, the dramatic increase in size may be over inflated due to the fact that it grows relatively flat, and any vertical growth increases the volume dramatically. The ability of *Limonium californicum* to grow in salt and fresh plots agrees with its classification as a mid marsh plant [5].
5. *Salicornia pacifica* had no significance between treatments. This species tends to be found in the middle zones of the marsh, which may explain why it reacted similarly to *Limonium* [5].
6. *Suaeda esteroa* 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 as sea level rises. 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.

Figure 17:Low tide looking west from the Crown Point Lookout at Kendall Frost Marsh Reserve. Credit: Isabelle Kay

Acknowledgements

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References

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