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Research Article

Relationship between soil sodium concentration and plant height in *Salicornia virginica* in the Ballona Wetlands in Los Angeles, California

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Abstract. Previous studies have shown a positive relationship between biomass of the common wetland halophyte, *Salicornia virginica*, and salinity. This study implements a new technique that is less invasive than measuring total plant biomass that involves uprooting the plant. Instead, plant height was used as an indicator of sodium content in surrounding soils. This technique is based on the hypothesis that plant height of *S. virginica* corresponds to soil sodium concentrations. There was a significant variation in plant height at higher soil sodium concentrations than at lower soil sodium concentrations. Furthermore, in areas of higher soil water content (%), sodium concentration was elevated.

Introduction

Salicornia virginica, also known as pickleweed, is a vascular wetland species with the highest salt-tolerance in the world (Mahall et al., 1976). The habitat of *S. virginica* is widespread along the Pacific coast ranging from Puget Sound, Washington to the southern tip of Baja California, Mexico (Boyer et al., 2001). Because species of Salicornia are halophytes, various studies have related salinity to factors such as seed germination, growth, and plant distribution (Keiffer et al., 1994). For example, it has been reported that there were greater numbers of nodes formed on *S. europaea* in saline solutions (Keiffer et al., 1994). Studies have also noted that *S. virginica* shows greater biomass with higher salinities (34 ppt) (Callaway and Zedler, 1998). Biomass determination is an invasive technique and in threatened wetland environments it is damaging to not only the plants, but surrounding species as well. This study will investigate a less invasive technique to determine the effect of soil sodium concentrations on *S. virginica*. In theory, sodium content in soils would positively correlate with *S. virginica* plant heights.

Materials and Methods

Thirty *S. virginica* plants were selected randomly and the heights were recorded within ± 0.5 cm along a wetland channel between two sites (site 1, Boy Scout Platform and site 2, West Tide Gate) in the Ballona Wetlands in Los Angeles, CA, on 17 November 2009 (1500 hrs) and 18 November 2009 (1400 hrs) during low tide (Figure 1). Heights (cm) of *S. virginica* were recorded as a linear distance from base of the plant to the tip of the longest branch. Soil samples

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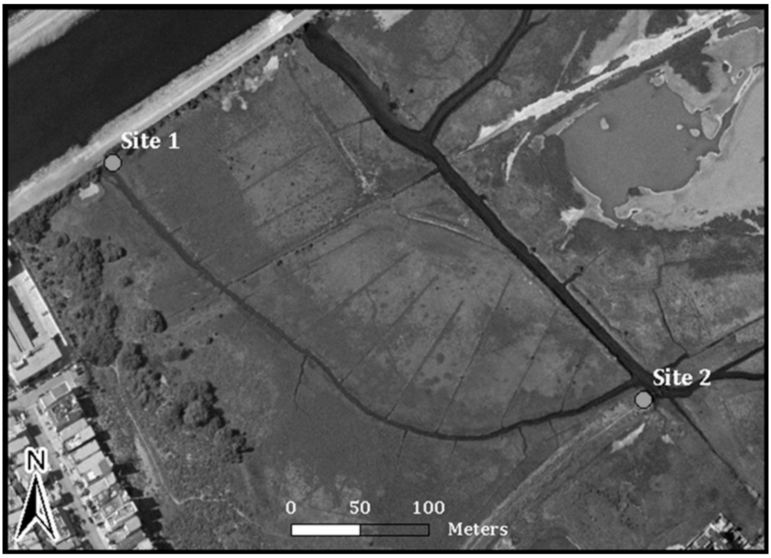

Figure 1. Map of the Ballona Wetlands. Sample locations were between the Boy Scout Platform (site 1) and the West Tide Gate (site 2).

were collected directly below the selected plant to a depth of approximately 7 cm.

Five grams of wet soil were weighed to within ± 0.001 gm and then dried at 75°C for 10 days. One gram of dry sample was placed into a test tube with 10 mL of DI water and covered with Parafilm to prevent evaporation. The soil suspension was vortexed to allow sodium to dissolve into solution for 24 hrs. The supernatant was diluted 1:100 and then introduced into the

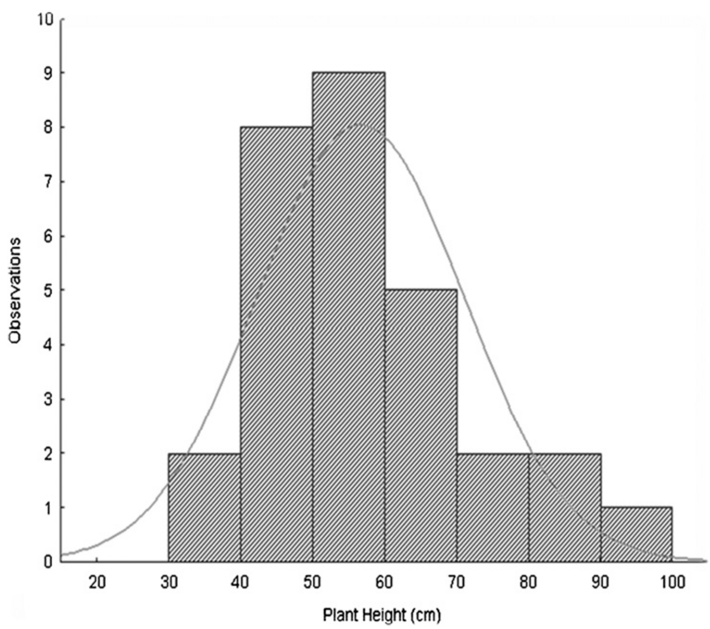

Figure 2. Histogram comparing height of *S. virginica* plants to an expected normal distribution.

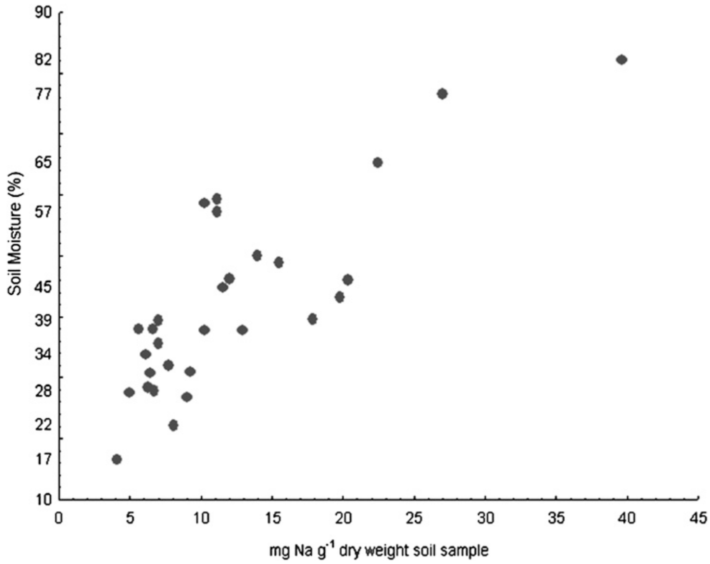

Figure 3. Relationship between soil sodium concentration and soil moisture (%) ($p < 0.05$).

Jenway Clinical PFP7 flame photometer to determine the mg/g sodium concentration. The histogram normality of plant heights was determined using Statistica version 6. We then looked at the difference in means between high and low sodium concentrations. High and low sodium concentrations were calculated as the midpoint of the minimum and maximum values with high sodium content between 21.82-39.62 mg Na g^{-1} dry weight soil sample and low sodium concentrations

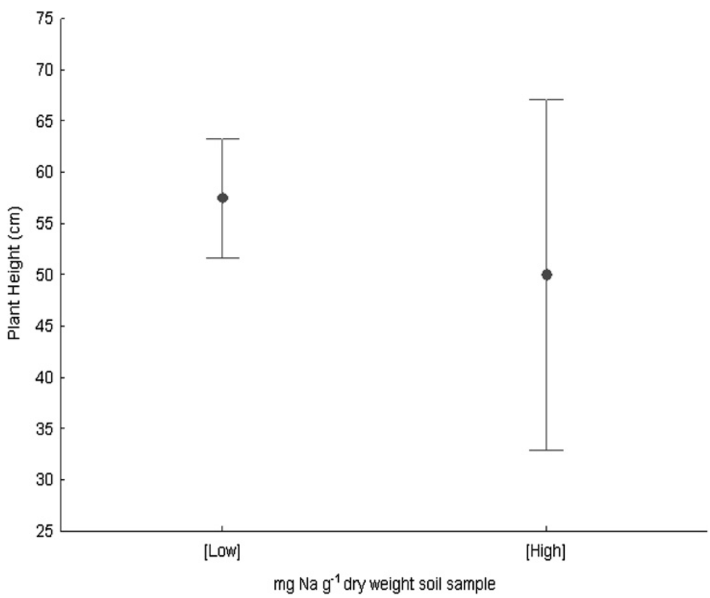

Figure 4. *S. virginica* plant heights at low (4.019-21.82 mg Na g^{-1} dry weight soil) and high (21.82-39.62 mg Na g^{-1} dry weight soil) sodium content. The difference between means of plant heights at low and high soil sodium concentrations was not significant ($p = 0.4059$). The difference between plant heights at high and low sodium concentrations varied significantly ($p < 0.05$). (Bars = standard deviation).

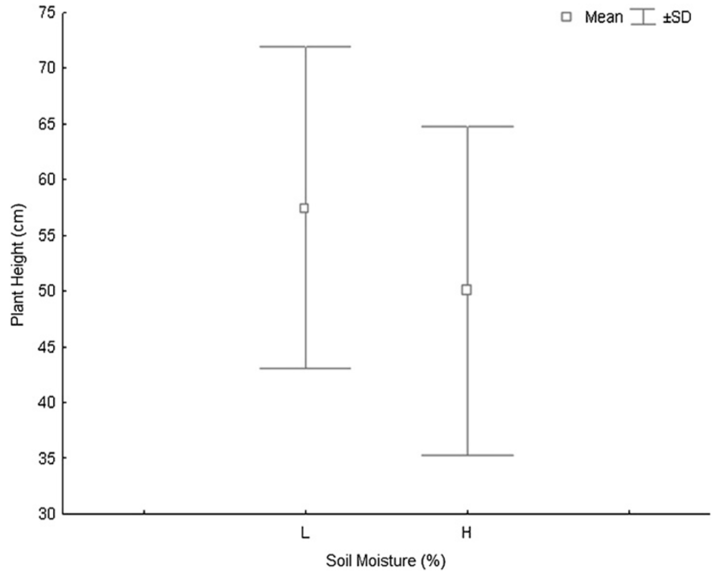

Figure 5. *S. virginica* plant height at low (16.61%-49.44%) and high (49.44%- 82.28%) soil water content (%). Plant heights did not vary significantly between high and low soil moisture (%) ($p = 0.6654$). (Bars = standard deviation).

between 4.019-21.82mg Na g^{-1} dry weight soil sample. The variance between plant heights and sodium concentration was analyzed by an analysis of variance using Excel 2007. The difference between the means of plant heights with high soil moisture (between 49.44% - 82.28%) and low soil water moisture between (16.61% - 49.44%) was calculated using a t-test in Statistica version 6.

Results and Discussion

Plant heights of *S. virginica* were normally distributed ($p > 0.05$, Figure 2). Soil moisture (%) was positively correlated with soil sodium concentration ($r = 0.810$, $p < 0.05$, Figure 3). There was a significantly greater variance in plant heights at high sodium concentrations ($p < 0.05$, Figure 4), but plant heights did not differ between high and low soil moisture (%) ($p > 0.05$, Figure 5).

The common wetland halophyte, *S. virginica* is known to be able to withstand highly saline environments (Mahall et al., 1976). Previous studies suggest that high soil salinities lead to increased nitrogen nutrient concentrations and a greater *S. virginica* biomass (Boyer et al., 2001). The objective of this study was to determine if plant height would positively correlate with soil sodium concentrations because it is a less invasive technique than measuring biomass.

However, this hypothesis was rejected and instead there was a significant difference between variances of plant heights at high and low sodium concentrations ($p < 0.05$, Figure 4). Thus, our results indicate that *S. virginica* heights do not positively correlate with the surrounding soil sodium content.

In this study there was a greater variation in heights of *S. virginica* at high sodium contents than at low sodium concentrations (Figure 4). Salinity, and therefore sodium concentration, is in flux with the tides in the wetlands. In this study, there was a positive correlation between soil moisture (%) and soil sodium concentrations, although soil water concentration alone did not account for variations in plant height (Figure 3, Figure 5). Increased evaporation rates in areas of greater tidal influence will result in higher sodium concentrations (Callaway and Zedler, 1998). Plants found in areas of high sodium concentrations may be receiving more tidal flow and therefore increased sodium and nutrient deposition leading to increased plant growth. Tidal flow may also result in the plants being more susceptible to harmful pollutants which could inhibit plant growth. In addition there are soil characteristics other than sodium concentrations that affect plant growth including pH, redox potential, hydrogen sulfide levels, and decomposition process (Boyer et al., 2001).

It is important to study how abiotic factors contribute to the biology of wetland plant species. With increased urbanization, wetland communities are under increased stress due to rising levels of pollutants entering wetland ecosystems and the destruction of habitat due to development. It would be beneficial to study how urban pollutants are impacting plant ecophysiology in conjunction with a less invasive means to determine the affect of salinity and other abiotic factors that are influencing wetland plants.

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