PRODUCTIVITY OF *SPARTINA ALTERNIFLORA* IN PROXIMITY TO MANGROVES

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Productivity of *Spartina alterniflora* in proximity to mangroves

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Mangroves are salt-tolerant trees that coexist with marsh grasses and forbs at subtropical latitudes. Occasional freeze events keep mangroves from completely overgrowing marsh plants. There have not been severe freeze events within recent years which are changing the abundance of mangroves. Black mangroves (*Avicennia germinans*) could be outcompeting marsh plants for light or nutrients and that may decrease smooth cordgrass (*Spartina alterniflora)* productivity. The purpose of this study is to determine if mangroves are out-competing *Spartina alterniflora* by limiting nutrient availability. Field measurements of above and belowground data were quantified by measuring the growth, chlorophyll-a content, and nutrient content (carbon, nitrogen, and phosphorus) of S. alterniflora roots in plants growing within the *A. germinans* rhizosphere and in plants outside the area influenced by mangrove roots. The number of new leaves results suggest that *A. germinans* affects the productivity of *S. alterniflora* by limiting the above ground production.

DEDICATION

I am dedicating this thesis to my parents Michelle and Mike McGuinness. Not only did they fund my education but they shaped me into the person I am today. I truly couldn't have accomplished all the things I have without them. They always let me chase my dreams no matter how outrageous they were. I love you both and appreciate everything you do for me.

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CHAPTER I

INTRODUCTION

Background

Black mangroves (*Avicennia germinans*) grow along the Texas coastline. Mangrove populations on the Gulf of Mexico coastline have been expanding into salt marshes, largely due to milder winter temperatures (Osland 2013). The tall stature of mangroves suggests that they may be out-competing marsh plants for light and space. Marsh plants that are not directly underneath the mangrove canopy may also experience competition from mangroves, possibly through alterations of nutrient availability. The direct and indirect effects of mangrove competition on salt marsh plant productivity within this mangrove-marsh transition zone have not yet been quantified.

Spartina alterniflora is a smooth cordgrass that inhabits coastal salt marshes of the Atlantic and Gulf Coasts of America (Wang et al. 2006). Salt marshes, locally dominated by smooth cordgrass, *(Spartina alterniflora),* serve many critical ecosystem functions (Gedan 2009). In particular, marsh plants provide trophic support for many invertebrates (Gratton 2006),(Silliman 2001). Mangroves may alter these functions by altering *S. alterniflora* productivity and subsequently reducing trophic support for wetland-associated herbivores.

S. alterniflora, like other marsh plants, help prevent erosion and contribute to food webs in estuarine ecosystems (Engle 2011). Estuaries are vital ecosystems; they act as nurseries for birds, fish, and invertebrates. It is important to quantify the relationship between *A. germinans* and *S. alterniflora* because if the mangroves are out-competing the marsh plant the ecosystem could drastically change.

The productivity of aboveground *S. alterniflora* was quantified by field measurements including height, amount of new leaves, length of leaves, and SPAD reading. The below ground productivity of *S. alterniflora* was quantified by measuring root biomass, and the degree of nutrient limitation was assessed with carbon, nitrogen, phosphorus analysis of below ground tissue. Studying the belowground contents of *S. alterniflora* is important because the mangroves could be competing for a multitude of nutrients underground (Casper and Jackson 1997). The aboveground and belowground measurements of *S. alterniflora* create a quantifiable view of the productivity.

Objectives

The objective of this work is to measure *S. alterniflora* production in close proximity to mangroves and away from mangroves. We hypothesize that:

1) *S. alterniflora* growing within the *A. germinans* rhizosphere (the area around the A. germinans trunk influenced by roots) will have higher productivity

2) This increased productivity will be invested in belowground biomass in order to enhance the *S. alterniflora* ability to compete with *A. germinans* for nutrients; therefore, *S. alterniflora* near *A. germinans* will have higher belowground biomass than will *S. alterniflora* plants outside the *A. germinans* rhizosphere.

CHAPTER II

METHODOLOGY

Field Methods

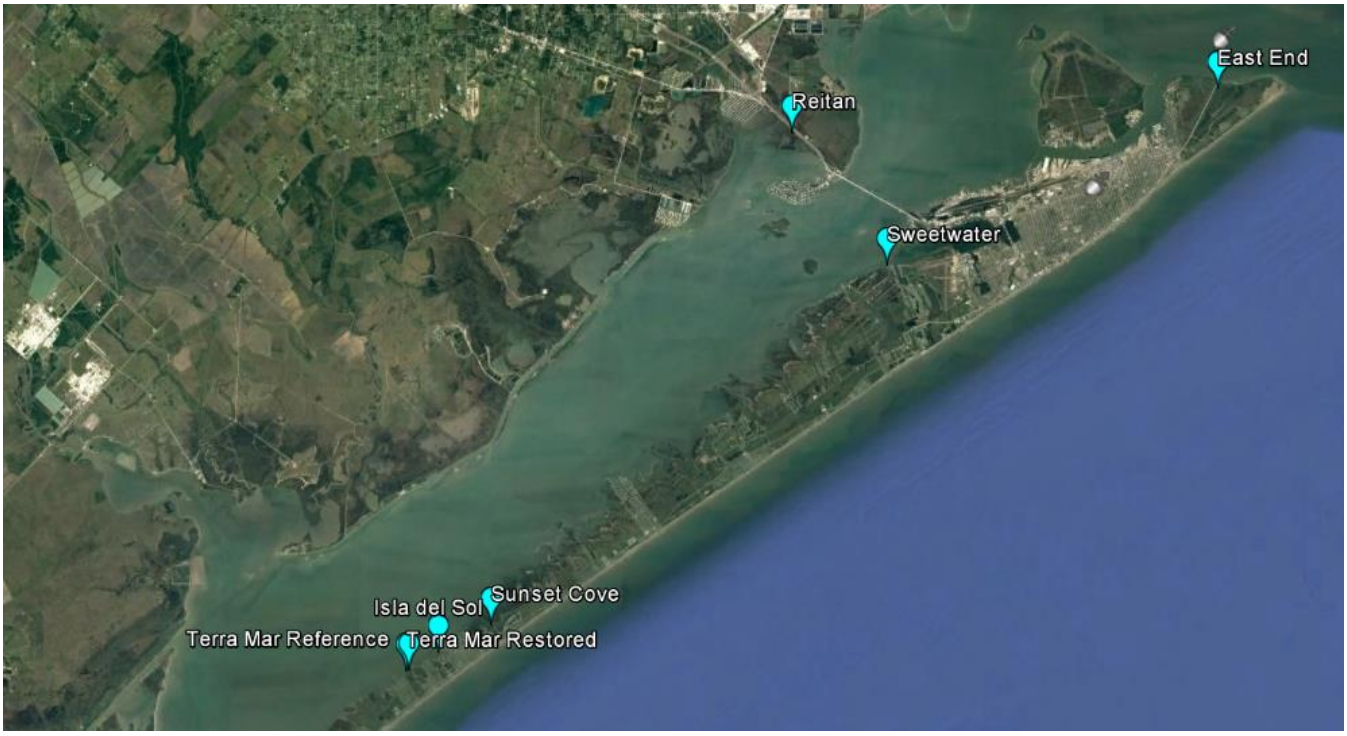

Figure 1 Google Earth Map of sample sites in Galveston, Texas

The locations that the samples were collected from were on Galveston Island (Figure 1). Two types of sampling locations were utilized: tidal wetlands with marsh and mangrove vegetation, and salt marshes without mangroves. There were four sites with mangroves: East End, Terra Mar Restored, Isla Del Sol, and Sweetwater. At each site, four 100 m^2 circular plots were placed. In each plot, five *S. alterniflora* plants were marked near mangroves (less than one meter away) and five plants were marked away (more than one meter away); marking methods

are described below. In addition, two 20 cm belowground cores were collected, one near mangroves and one away. There were three sites without mangroves Terra Mar Reference, Sunset Cove, and Reitan. Plots were established as described above. One belowground biomass core was collected from each plot at each site, and five plants were marked in each plot.

In order to monitor the growth of *S. alterniflora*, the leaves were marked with a pinhole punch at the base of the youngest leaf (Zieman 1974). Each plant that was surveyed was marked with flagging tape. After a period of 14-21 days, productivity was measured as the distance between the stem and the mark; leaf growth was calculated as mm/day (Zieman 1974). In addition, the number of new leaves was counted to calculate leaf production rate. Chlorophyll-a content was recorded with a Konica Minolta SPAD 502 meter, which provides a relative measure of chlorophyll-a activity in instrument-specific units.

Laboratory Methods

Belowground *S. alterniflora* biomass cores were rinsed with regular tap water to wash away dirt and any other debris that was not belowground plant matter. Root material was then rinsed with distilled water, and placed in an oven at 60 degrees Celsius for ten days before weighing to determine biomass. Once the cores were weighed they were individually ground up for further analysis.

To measure root phosphorus content, I followed the colorimetric methods of Forqurean et al. (Fourqurean et al. 1992). In brief, sub samples that weighed between 17 and 21 mg were removed and placed in glass vials. Distilled water and $MgSO_4$ was added to each sample and heated in an oven at 70 degrees Celsius overnight in uncapped vials. The vials were placed in the furnace at 500 degrees Celsius for four hours. Once cooled hydrochloric acid was added to each sample and capped. The vials were heated at 80 degrees Celsius for 30 minutes. Distilled water

was added to all of the samples and shaken. They were left overnight to settle. One mL of extract was taken from each sample and placed in a test tube and then distilled water was added to each test tube. Reagent was added to each test tube and vortexed; they were left to sit for 20 minutes before they were run in the UV-1800 spectrophotometer.

To measure root carbon and nitrogen content, sub samples that weighed between 1-2 mg were placed into D 1008 tin capsules. The samples were places in a well plate for labeling. Once the samples were weighed, the Costech 200 elemental analyzer was used to measure the carbon nitrogen content in the samples.

The belowground biomass samples of *S. alterniflora* were compared to one another by close or far proximity (within one meter or outside one meter) of *A. germinans*. The effects of *A. germinans* on *S. alterniflora* SPAD readings, number of new leaves, and the belowground biomass of plants near mangroves were analyzed with a 1-way ANOVA, where the mangrove proximity factor had three levels: near *A. germinans*, away from *A. germinans*, and no *A. germinans* present.

CHAPTER III

RESULTS

Study Errors

The above and belowground data from the site East End may introduce slight error. The week after the plants were marked there was a large storm; there was a great loss in recovery due to this. There may also be slight error in the belowground biomass cores from East End. The tray that was used to accurately measure the cores was left behind, thus the cores were estimated to be 20 cm in length rather than precisely measured. This potential error is acknowledged however it was unlikely to have significant effects on the results.

Aboveground Data

The average SPAD readings from all the sample sites near *A. germinans*, away *A. germinans*, and *A. germinans* absent were averaged together by site distance from *A. germinans* (Figure 2). The SPAD readings were significantly different among *A. germinans* proximity treatments (1-way ANOVA, $p < 0.001$). The highest SPAD readings were in plants near *A. germinans*, indicating the *S. alterniflora* productivity was highest in plants near *A. germinans*.

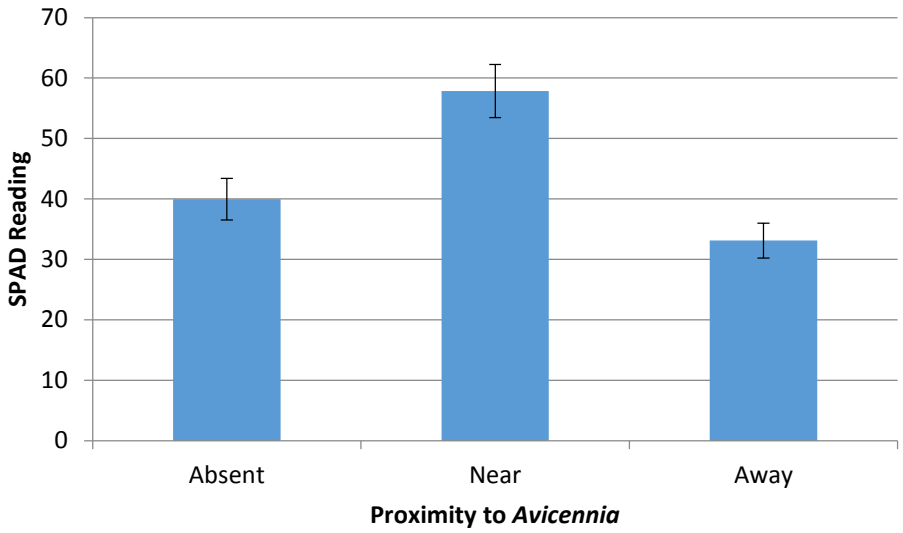

Figure 2 SPAD readings of *Spartina alterniflora* in proximity to *Avicennia germinans*

The average number of new leaves counted on *S. alterniflora* (Figure 3). The Single Factor ANOVA run for the amount of new leaves shows that the data is statistically significant. The amount of new leaves of each parameter has a P-Value of 0.001 which is less than 0.05; this data is statistically significant.

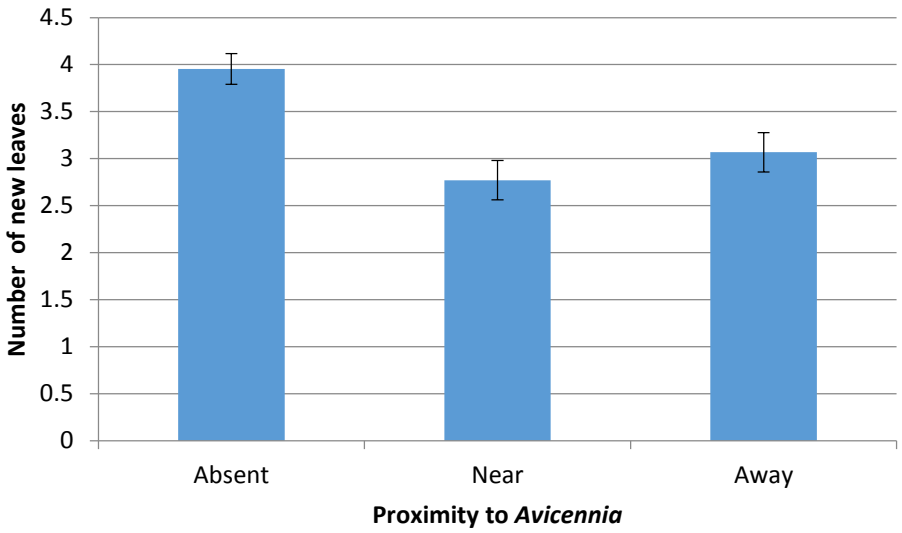

Figure 3 Number of new *Spartina alterniflora* leaves in proximity to *Avicennia germinans*

Belowground Data

There were no treatment effects on any of the *S. alterniflora* belowground metrics. *A. germinans* did not have a significant effect on belowground biomass of *S. alterniflora* (1-way ANOVA, $p = 0.827$; Figure 4). Carbon: nitrogen ratios of root tissue were not significantly different among treatments (1-way ANOVA, $p = 0.245$; Figure 5). Phosphorus concentrations were not significantly different among treatments (1-way ANOVA, $p = 0.057$; Figure 6).

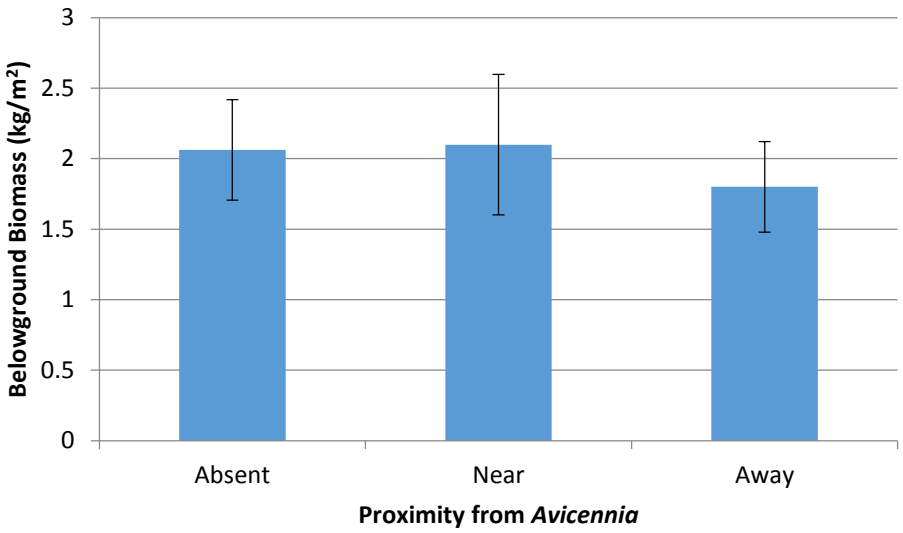

Figure 4 Belowground biomass

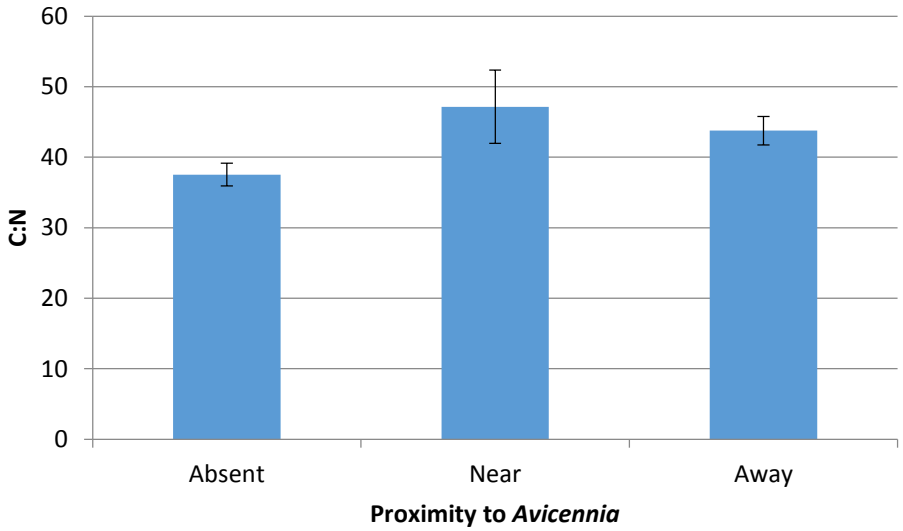

Figure 5 Carbon: nitrogen ratio of belowground tissue

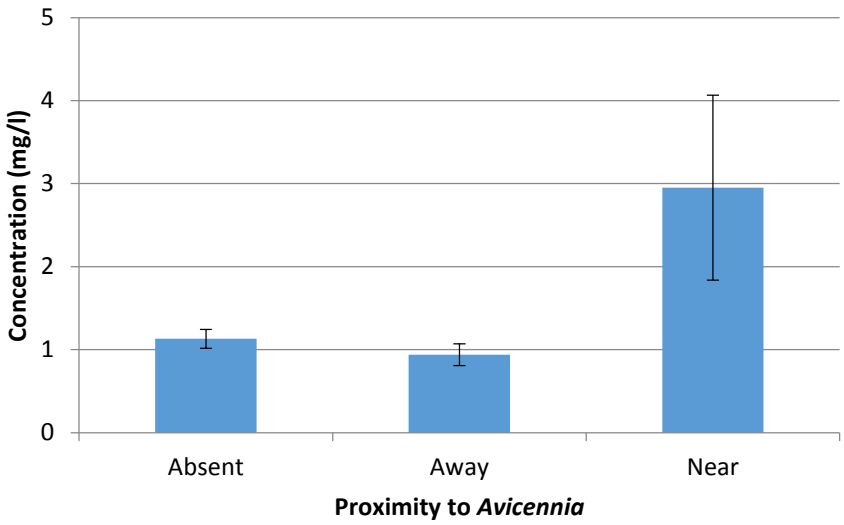

Figure 6 Phosphorus concentrations of belowground tissue

CHAPTER IV

DISCUSSION

Overview

The *S. alterniflora* near *A. germinans* did have higher chlorophyll a concentration, which suggests higher productivity, but didn't appear to be routing that extra energy to aboveground or belowground biomass. The carbon nitrogen ratios suggest that *S. alterniflora* at sites with mangroves tend to be more nitrogen limited, so perhaps the higher productivity is an internal metabolic compensation for nutrient stress, and is therefore not being converted to extra biomass.

The SPAD readings quantified the amount of chlorophyll-a content being produced at the time of measurement. Higher SPAD numbers correspond with, higher chlorophyll-a content. Productivity is directly and positively correlated with high chlorophyll-a content. Therefore, this study reveals that *S. alterniflora* productivity was increased when plants were within one meter of *A. germinans* (Figure 2). SPAD readings have been used in other studies to quantify the chlorophyll content of *S. alterniflora* (Li et al. 2010).

The number of new leaves counted quantified the average growth rate of *S. alterniflora* within the 14-21 day period. This study suggests that *S. alterniflora* produced more aboveground biomass where *A. germinans* was absent (Figure 3). This suggests the *S. alterniflora* growth is higher when there are no mangroves, possibly because there is no competition for nutrients.

The number of new leaves suggests that the aboveground growth of *S. alterniflora* is highest when *A. germinans* is absent but the SPAD trend suggests that photosynthetic activity is the highest when the *S. alterniflora* is within a meter of *A. germinans*. The opposing SPAD and

number of new leaves results lead to the instigation of other sources of productivity allocation such as belowground biomass, Carbon nitrogen ratios, and phosphorus concentration.

Belowground biomass was used as a proxy of belowground productivity of *S. alterniflora*. The belowground biomass was similar across all treatments (Figure 4). The influence of *A. germinans* on S. *alterniflora* photosynthetic activity appeared to have no effect on the belowground productivity (Figure 4). This suggests the increased photosynthetic productivity is not being converted into belowground tissue development, and therefore the extra productivity measurements can possibly be routed to metabolic compensation.

Nitrogen concentrations in *S. alterniflora* belowground tissue were analyzed to assess potential competition for nutrients. The plants within a meter of *A. germinans* had the lowest concentration of nitrogen, but variability was high and the differences among treatments were not statistically significant. Previous studies have shown the higher nitrogen concentration does not influence the productivity of *S. alterniflora* (Mendelssohn 1979). This suggests that even though the site closest to *A. germinans* shows the highest nitrogen concentration it may have had little to no effect on the productivity of *S. alterniflora*.

Phosphorus analysis concentrations also test nutrient availability (Fourqurean et al. 1992). The largest concentrations of phosphorus were within a meter of *A. germinans* (Figure 6), although variability was high and these differences were not statistically significant. The slightly higher concentrations of phosphorus on *S. alterniflora* within a meter of mangroves could be from the interaction of *A. germinans* roots. *A. germinans* tend to have higher levels of phosphorus than *S. alterniflora*, this could account for the higher levels of phosphorus in *S. alterniflora* without an increase in belowground tissue (Feller et al. 2003). This phosphorus

influx from *A. germinans* to *S. alterniflora* could be allocated into internal processes instead of belowground biomass.

Conclusions

In this study, statistical evidence from the SPAD readings supports the hypothesis that the *S. alterniflora* within one meter of *A. germinans* had higher photosynthetic activity than *S. alterniflora* outside the *A. germinans* rhizosphere, but that growth was highest at sites where *A. germinans* was absent. This suggests that *S. alterniflora* and *A. germinans* may be competing for resources in some way. This study did not show strong evidence that *S. alterniflora* and *A. germinans* were directly competing for nutrients, but there may be other resources, such as light or space, that influence the co-existence of the two species. Higher photosynthetic productivity in *S. alterniflora* was being allocated into belowground tissue. This suggests that the extra productivity was being allocated to other processes such as internal metabolic processes that weren't quantified in this study.

This study showed that *S. alterniflora* and *A. germinans* were likely competing for some limiting resources, but it is unclear if they were directly competing for nutrients, or whether the coexistence of the two species altered nutrient and photosynthetic energy allocation. The evidence in this study does not support the idea that *A. germinans* may be out-competing *S. alterniflora* for nutrients, and it remains unknown if and how increasing abundances of mangroves may alter estuarine ecosystem functions. Further studies can be done in order to understand the limiting resources that may drive S. *alterniflora* and *A. germinans* competition. It would be beneficial to further study the metabolic responses (e.g., water use, CO_2 consumption) of *S. alterniflora* to the presences of mangroves. Studies have been done on stress tolerance in *S.*

alterniflora including, pH and salinity stress (Li et al. 2010). These parameters should be tested along with the proximity to mangroves to see the affect it may have on *S. alterniflora*.

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