Salinity Exposure Duration Effect on Coastal Wetland Plants

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Introduction

Wetlands are and will continue to disappear at alarming rates throughout the globe. In Louisiana wetland loss is generally due to subsidence and sea level rise. Subsidence is a complex geological and soil process that causes the land to sink (Yuill et al. 2009). As the land sinks the land becomes increasingly inundated and finally turns into bays and lakes. Sea level rise is occurring in Louisiana, but in conjunction with subsidence Louisiana's relative sea level rise is much higher than other gulf coast states (Penland and Ramsey 1990). Relative sea level rise is causing plant communities that are associated with water salinity levels to move further into Louisiana's coast (Mitsch and Gosselink 2000). Three dominate plant regimes in Louisiana are *Spartina patens, Panicum hemitomon, and Sagittaria lancifolia*. *Spartina patens* can withstand high salinity levels whereas *Panicum hemitomon* has very low salinity tolerance but both are dominate species in their respective niche (Greiner La Peyre et al. 2001)

In this experiment we examined the effect of different flooding periods and salinity levels. It is known that changing salinity levels and hydrology can in turn change the species composition and species abundance in a wetland ecosystem (Mitch and Gosselink, 2000, Greiner La Peyre et al. 2001). The project objective was to determine how flooding duration affects plant growth and if the salinity of flood waters have an effect on plant growth. The three plants examined in this experiment were *Spartina patens, Panicum hemitomon, and Sagittaria lancifolia*. *Spartina patens* is wide spread throughout the eastern part of North America (NRCS Plant Database). *Panicum hemitomon* has a much smaller range than *S. patens*, it is only found in the southeastern region of the United States (NRCS Plant Database). This is probably due to its low tolerance for salt and need for a long growing season. *Sagittaria* *lancifolia* range is not as wide spread as S. patens but also in the southeast region of the U.S. but it does extent into Oklahoma whereas *P. hemitomon* does not extend that far west (NRCS Plant Database).

Previous research has evaluated the effect of flooding comparing continuously flooded plants with plants grown under saturated conditions using water with different salinities (Willis and Hester 2004; Spalding and Hester 2007). Little is known about the effect of different flooding regimes. Although it is known that oxygen depletion in the soil and associated biogeochemical changes can take up to a week to develop. Sulfide from saline water has a strong influence on these changes and the resulting stress on plants (Mitch and Gosselink 2000). The different plant species have different abilities to withstand these flooding and salinity stresses.

Methods

The experiment was conducted in the green houses at the University of Louisiana at Lafayette's Center for Ecology and Environmental Technology (CEET) in Carencro, LA. Three common species of coastal wetland plants were used *(Panicum hemitomon, Sagittaria lancifolia*, and *Spartina patens).* Plants were collected on April 6, 2010 from healthy stands on Mandalay Nation Wildlife Refuge and Apache Corporation lands southwest of Houma, Louisiana. Pieces of sod were transplanted into a 5 gallon bucket and brought back to CEET. Sods were then placed into 300 gal. Containers, watered up to the soil surface and acclimatized to the greenhouse for two weeks.

After two weeks, sods were separated into individual plantlets. Where necessary, roots and stems were pruned to minimize size differences among plantlets of each species. *Spartina patens* plantlets consisted of three stems that were pruned to 30 cm height. *Sagittaria lancifolia* plantlets had rhizomes pruned. *Panicum hemitomon* plantlets consisted of one stem. Plantlets were planted in 1 gallon trade pots with a substrate that consisted of 83% peat moss, 13% sand, and 4% potters' clay by volume. Pots were filled to 5 cm below the rim and holes were drilled in the side of the pots above the substrate level. The plants were left to recover from the transplant stress in the experimental containers under saturated soil conditions for 1 week.

The experiment consisted of a complete factorial design with three flooding durations (day, week, month) and two salinity regimes (0 ppt and 6 ppt) for a total of six treatments. The experiment was repeated in two blocks (rows in the green house). Locations of each treatment within the block were randomly assigned. Two plants of each species were randomly assigned to each treatment container (total six pots per container).

The daily flooding treatment tubs were raised up on four cinder blocks and connected to a 75 gal. drainage basin with PVC pipe 22cm above the soil surface. A MagDrive 350 pump programmed to turn on at 7pm then trun off the next day at 7pm maintaining 15 cm of water above the soil surface. Draining the containers to the soil surface took approximately one hour. The weekly and monthly treatments were manually filled at the start of the flooding period and drained at the start of the saturated period. Water was circulated in each treatment container with a KSP 2500 pond pump.

Saline water was stored in 55gal. drums and reused while fresh water was replenished every new flooding period. The 6 ppt water was prepared by adding Instant Ocean in the appropriate containers until the salinity level was between 5.9 to 6.1ppt. Salinity in the brackish treatments was measured weekly with a YSI salinity meter. If salinity exceeded 6.1 ppt fresh water was added to restore the 6 ppt condition.

Each stem was measured form the soil surface to the tallest point on that stem and each stem in every pot was measured once a week throughout the experiment. At the end of the experiment each plant that was still living was measured for aboveground and belowground biomass. Biomass was separated by cutting the aboveground biomass away from the belowground biomass at the soil surface. The soil was then washed away from the roots until all of the soil material was out of the root mass. The biomass was then dried in ovens at 70˚C for 48 hours and weighed to get the dry weight. Graphs were made of the aboveground and belowground biomasses for each species.

Once data was collected it was entered into an Excel spreadsheet. Statistical analyses were performed using R statistical software. We used linear regression to determine growth rates based on the total stem heights that were measured weekly throughout the experiment. The growth rate of each plant is the slope of the regression line. Growth rates were than compared between treatments for each species using analysis of variance (Anova). The Anova test looked at two factors, salinity and flood duration, to see if they affected growth rate. The same anova was also used to examine the effect of the treatments on biomass.

Results and Discussion

Growth rate. There were three treatment species combinations that did not have a significant slope (P<0.05, Table 1). Those three were all *Sagittaria lancifolia* (fresh weekly, fresh monthly, and salt daily). A none significant slope means that the plants did not grow during the experiment. A positive slope means that the plants grew, while a negative slope indicates that the plants decreased in size during the experiment. The actual growth of the plants is presented in Figure 1.

Table 1. Regression fitted to each treatment and species combination. Significance codes '***' <0.001 '**'< 0.01 '*'< 0.05

Species	Salinity	Flooding Duration	**Intercept**	**Slope**	**Std. Error**	**Pr(>I+I)**
Panicum hemitomon	0 ppt	Day	82.10	2.48	0.30	***
		Week	98.50	3.15	0.48	***
		Month	166.90	3.65	0.51	***
	6 ppt	Day	26.36	-0.40	0.15	*
		Week	115.78	-1.58	0.27	***
		Month	51.76	-0.72	0.14	***
Sagittaria lancifolia	0 ppt	Day	269.32	3.86	0.83	***
		Week	276.07	0.78	0.68	
		Month	136.18	0.07	0.70	
	6 ppt	Day	71.69	-0.11	0.37	
		Week	171.86	-1.04	0.42	*
		Month	89.78	-1.07	0.26	***
Spartina patens	0 ppt	Day	210.40	3.64	0.82	***
		Week	287.01	4.55	0.54	***
		Month	230.99	6.32	0.49	***
	6 ppt	Day	163.07	5.57	0.76	***
		Week	191.71	4.53	1.00	***
		Month	293.26	5.12	0.83	***

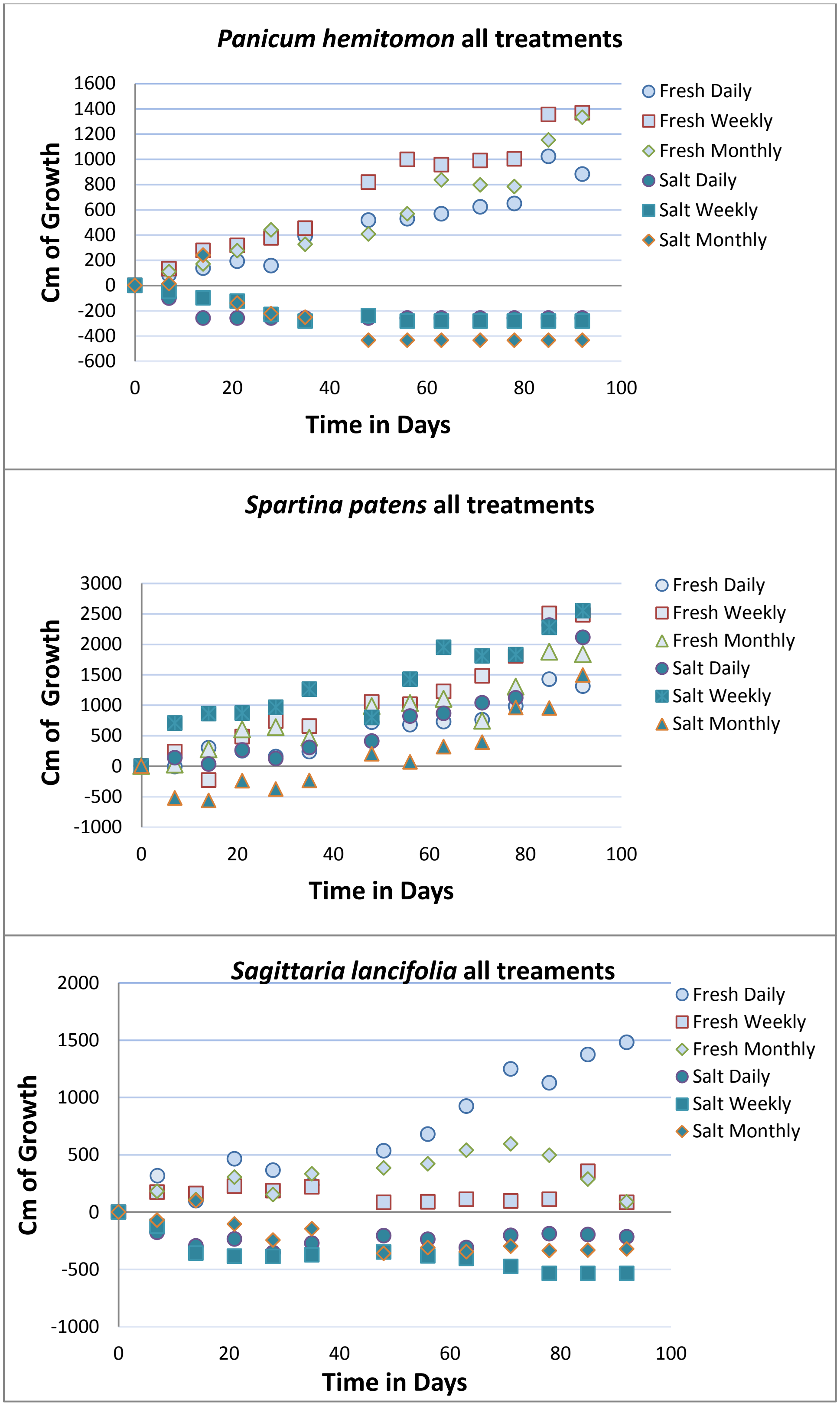

Figure 1. Shows is the actual growth of each species in each treatment.

Panicum hemitomon in the salt treatment did not survive to the end of the treatment as did Sagittaria lancifolia in the monthly flooded with salt water treatment (Table 2, Figure 1).

Table 2. Shows the day of the experiment in which no aboveground stems were found in any of the pots.

Plant Species	**Salinity**	**Flooding Duration**	**Day of Death**
Panicum hemitomon	6 ppt	Day	21
Panicum hemitomon	6 ppt	Week	48
Panicum hemitomon	6 ppt	Month	56
Sagittaria lancifolia	6 ppt	Month	78

The Anova on *S. lancifolia* growth rate showed a significant effect of both salinity and flood duration. *Sagittaria lancifolia* seemed to grow better at shorter flood durations in both of the saline treatments, but growth was significantly larger in the fresh treatment compared to the saline treatment. The Anova on *Panicum hemitomon* growth showed high significance related to salinity and no significance related to flood duration. Panicum hemitomon died with the saline treatment, but showed no difference in growth with flooding duration (Figure 1). *Spartina patens* revealed that neither salinity nor flood duration had an effect on the growth. Growth was very similar in all treatments for *Spartina patens* (Figure 1)..

Table 3. Analysis of variance on the growth rates of the different species.

Sagittaria lancifolia						
	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Flooding	2	27.673	13.836	3.5577	0.049886	*
Salinity	1	34.488	34.488	8.8679	0.008063	**
Residuals	18	70.003	3.889			
Panicum hemitomon						
	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Flooding	2	1.944	0.972	1.0666	0.363	
Salinity	1	98.376	98.376	107.9322	1.66E-09	***
Residuals	20	18.229	0.911			
Spartina patens						
	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Flooding	2	2.904	1.4521	0.3527	0.7071	
Salinity	1	0.329	0.329	0.0799	0.7803	
Residuals	20	82.343	4.1171			
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1						

The biomass data collected at the end of the experiment follows what we observed with growth rates (Figure 2). The belowground biomass does not seem to be significantly different than the aboveground, but no statistical tests have been done to confirm this. *Panicum hemitomon* died in the saline treatments and so no biomass was harvested. There is an indication that both above and belowground biomass increased with flooding duration. Previous work on *P. hemitomon* showed an increase in belowground biomass under permanent flooding vs. non-flooded treatments (Mayence and Hester 2009).

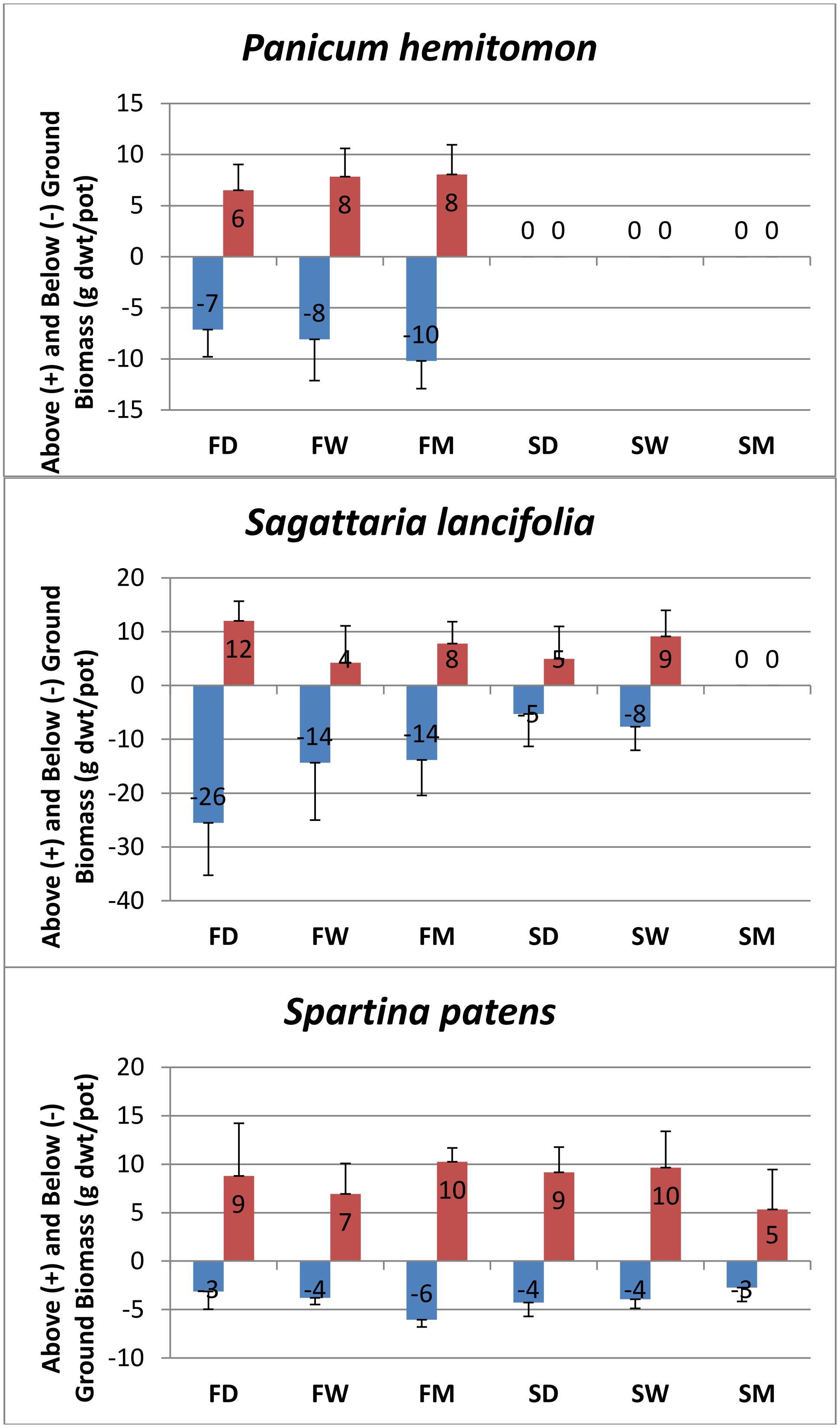

Figure 2. Biomass harvested at the end of the experiment. Treatment codes are F= 0ppt, S= 6 ppt, D = daily flooding, W = weekly flooding, M = monthly flooding

Sagittaria lancifolia under fresh conditions seems to have higher biomass under the daily flooding treatment and similar biomass for the weekly and monthly treatments (Figure 2). This is similar to the decrease in biomass observed under increasing time of flooding observed by Visser and Sandy (2009) for this species. Although our percentage of time flooded was 50% for all species, the 80% flooding treatment in Visser and Sandy (2009) has a weeklong flooding event followed by on a few days of drying. Therefore our weekly flooding may affect soil microbial processes in much the same way. Under saline conditions the combined stress of salinity and the month of flooding were sufficient to kill *Sagittaria lancifolia* and so no biomass was harvested from this treatment (Figure 2). *Sagittaria lancifolia* produced lower biomass under the salinity treatment than under the fresh treatment, but the daily and weekly treatments were similar under the 6 ppt treatment (Figure 2). This effect of coping with one stress and not showing the effects of other growth enablers was also seen on *S. patens* by Merino et al. (2010).

Spartina patens showed little response to the treatments (Figure 2). However, biomass in the most stressful treatment (Monthly flooding with 6 ppt) had the lowest biomass both above and belowground.

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