Flooding During the Summer Months with Different Durations of *Spartina Patens*

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Introduction

The condition of Louisiana's coastline is rapidly declining and 30-40% of coastal wetlands are disappearing due, in part, to tidal restriction (Roman, Niering, and Warren, 1984). Flooding of the marsh habitat with salt water, which can be affected by both subsidence and rising sea level, causes a decrease in viability of the grasses (Visser and Sandy, 2009). The input of freshwater into wetland areas is of upmost importance in providing a buffer against saltwater intrusion, increasing productivity through introduction of nutrients, and strengthening/build up the land through the addition of sediments (Visser, Day, et al. 2017). More than 50% of Louisiana's wetland loss along the coast is due to a combination of both subsidence and sea level rise(Penland, Wayne, et al. 2000; Visser, Day, et al. 2017). Wetlands may fail if they experience flooding with sea water, leading to increased salinity, and the eventual stress/death of the vegetation (Pennings, Grant, Bertness, 2005). Some wetland species are adapted to flood conditions, but increasing rates of relative sea level rise means prolonged exposure to flooding conditions, and unless the wetlands experience vertical growth, they will not survive (Warren, Niering, 1993).

Sediment load deposited into the delta has decreased by about half due to human interference(Meade 1995; Visser, Day, et al. 2017). Dams built along the Mississippi River's streams and main channels in its drainage basin have reduced the suspended sediment load because they trap sediments (Kesel, 1988,1989; Visser, Day, et al. 2017). Man-made levees, built to control flooding of the Mississippi River, restrict or eliminate freshwater input into areas of the delta and constrict the natural meandering path of the river. Wetland loss can be exacerbated by canals and navigation channels used by oil and gas companies, which alter the sensitive hydrology and reduce the total area of the marsh. The decrease of freshwater input coupled with the alteration of wetland hydrology will cause an increase in the distance saltwater enters the wetland. The isolation of the delta and the wetland habitats contained with in it, from the Mississippi River, is considered the most devastating factor when observing wetland loss (Visser, Day, et al. 2017).

The four most common marsh plants in Louisiana are *Spartina alterniflora*, *Spartina patens*, *Panicum hemitomon*, and *Sagittaria lancifolia* (Visser and Sandy, 2009). Some marsh plants are found to be resistant to the negative affects of flooding including, *Sagittaria lancifolia* and *Panicum hemitomon* while *Spartina alterniflora* and *Spartina patens* are observed as thriving in saline environments (Visser and Sandy, 2009). Many different experiments have been conducted on these plants testing flooding and salinity tolerance. Even plants with some resistance to flooding will experience a reduction in aboveground or belowground biomass due to extreme stress. Flooding of marsh areas from the Mississippi River occurs in multiple time spans and seasons, with varying sediment concentration peaks during winter and spring/summer, which may have different impacts on viability of the marsh species (Peyronnin, Caffey, et al. 2017).

The two treatments tested in this experiment are flood durations of different lengths (1 week, 2 weeks or 3 weeks) during the months of April, May and June. I hypothesize that flooding during the month of April for the 3-week duration will be most devastating to plant biomass, while flooding during the month of June for the 1-week duration will be least devastating. The plants flooded in April will have 1-2 stems and are trimmed to around 25 cm limiting their aboveground biomass. The plants which will be flooded in June will have a highly developed stem and root system, compared to plants flooded during April. The plants flooded in

June will be more likely to resist flooding stress and be able to recover more readily once removed from the flooding stress compared to plants flooded in April, due the differing amounts of biomass.

Since the Mississippi River output is constricted to the Birdsfoot Delta and the Atchafalaya Delta complex, the land building potential is concentrated to a small area of the coastline (Peyronnin, Caffey, et al. 2017). Sediment diversion techniques are an important tool that can be used to restore freshwater flow to specific areas of Louisiana's coast line (Peyronnin, Caffey, et al. 2017). Diversions must be introduced gradually so the existing environment, including vegetation and wildlife, can adjust accordingly and flooding/erosion can be reduced (Peyronnin, Caffey, et al. 2017). Waterlogging of marsh species is a growing concern, and the results of this study will be valuable in determining at what time during April, May, or June and for how long flooding can be tolerated by *Spartina patens* specifically, and contribute to how diversion restoration techniques are implemented along the gulf coast in Louisiana.

Methods

Spartina patens is a perennial and a common, native marsh grass that dominates intermediate and brackish marshes which appear in diversion areas. It is found in Canada, the lower 48 U.S. states, Puerto Rico, and U.S. Virgin Islands. It actively grows from 1 to 4 feet tall in the spring and summer, is fire resistant, and has a long life span. The grass has a high anaerobic resistance and is adapted to many soil textures including fine, medium, and coarse. The leaf blades are shiny, dark green on the upper surface and rough with prominent veins on the lower surface. It is also commonly known as saltmeadow cordgrass and is used for restoration and protection of land. *Spartina patens* has many adaptations that allow it to grow in wetlands, yet it is considered one of the least flood tolerant plants (Bush,2002).

The experiment consisted of three treatments, each with three levels with three replicates and an unflooded control group with three replicates, for a total of 30 plants, excluding the five plants which showed little to no growth. There was a simulated April, May, and June flood with each treatment lasting one week, two weeks, or four weeks. The experiment began by taking 35 *Spartina patens* plants gathered from a stock at Cade farm along with 35 pots. The individual plants were separated out by hand and individually planted with potting medium and labeled 1-35. The plants were evenly placed in four small pools, with holes along the sides to provide drainage and prevent overflow. The pools were filled with water roughly 5 cm from the bottom. Aboveground growth was measured for 2 weeks before beginning the experiment and the five plants with the lowest growth rate were discarded. Using a random number generator, the plants were assigned a treatment.

The plant assigned to a flood treatment was put in the bucket and it was slowly filled with water to prevent all the soil from floating out of the pot. The bucket was then placed inside the pool from which the plant came from. Total leaf length of each plant was measured weekly during the experiment and recorded. Once the flood weeks were finished the plant was removed from the bucket and placed back inside the pool. Using the total leaf length, growth rate was determined by linear regression. At the end of the growing season the plants were harvested and both above and belowground biomass will be determined. Analysis of variance will be used to determine the significance of differences among treatments.

Results

Figure 1, **2**, and **3** are bar graphs representing biomass averages for aboveground, belowground, and total measurements in grams. In the month of April during the 1-week flooding duration, the biomass values were highest in all three figures. In the month of June during the 1-week and 4-week flood duration the biomass values were lowest in all three figures. The subjects that did not experience flooding produced roughly the same aboveground, belowground, and total biomass that subjects flooded for the 4-week duration in April and 1-week duration in May produced.

Figure 4, **5**, and **6** are line graphs representing the average stem length measured in cm with the durations of flooding identified by different colored lines. In all three figures the subjects which received the 2-week flooding duration had the highest overall average stem length. The 1-week and 4-week flood durations had variable average stem length. **Table 1** represents recalculated averages due to the exclusion of subjects with negative growth or a value of zero for biomass which resulted in the death of the plant. Flooding for a 1-week duration during the month of April produced the greatest biomass values, while 4-week flooding in April had the highest growth at 14.49976 cm/day.

Plants 22 and 25 stayed in the flood condition for two weeks instead of one week during the month of April, so only plant number 16 is representative of the 1-week flooding duration. Plant 22 was observed as having no aboveground biomass on 05/24/17. Plant 30 was observed to have no aboveground biomass on 06/04/17. Plant 13 was observed to have no aboveground biomass on 06/14/17. Plant 28 flowered on 06/21/17. Plant 31 was partly consumed by a caterpillar which altered stem length on 06/07/17.

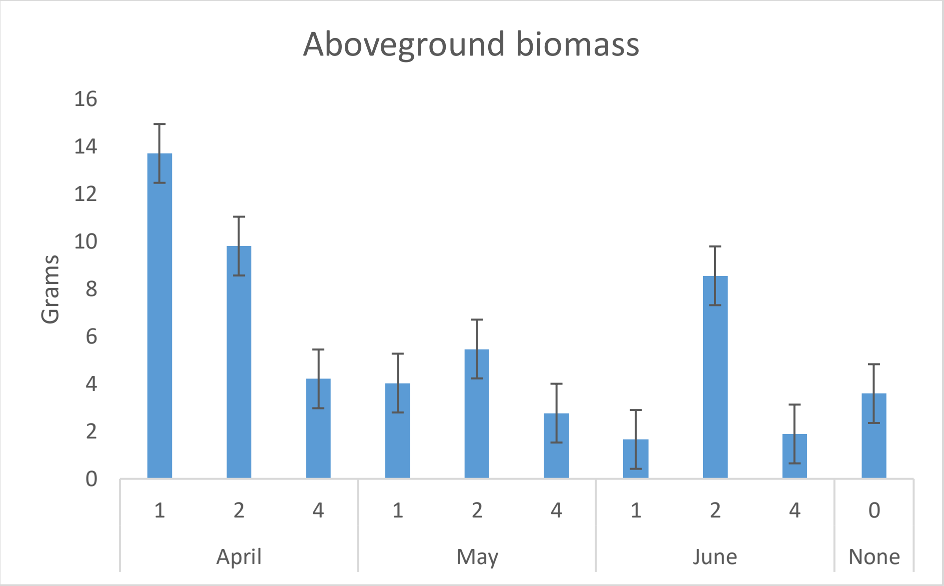

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Figure 1 Plotting the average aboveground biomass for each month and duration flooded indicted by a 1,2 or 4 and with the inclusion of subjects that were not flooded indicated by a 0.

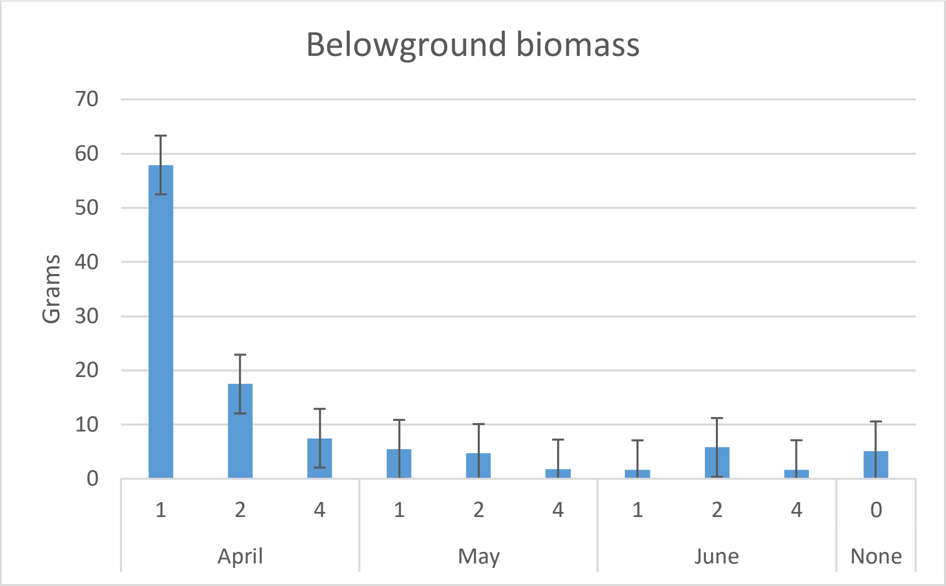

Figure 2 Plotting the average belowground biomass for each month and duration flooded indicated by a 1,2, or 4 and with the inclusion of subjects that were not flooded indicated by a 0.

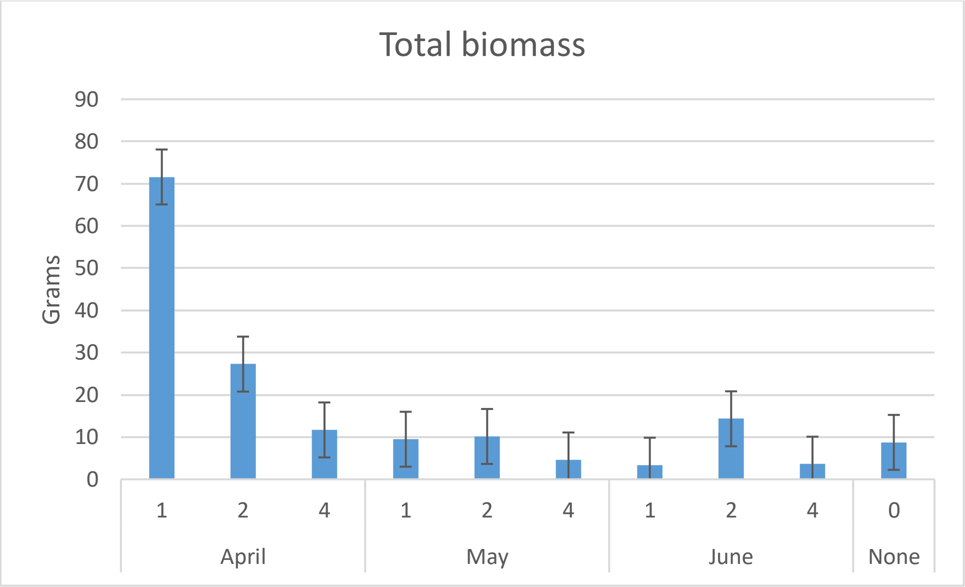

Figure 3 Plotting the average total biomass for each month and duration flooded indicated by a 1,2, or 4 and with the inclusion of subjects that were not flooded indicated by a 0.

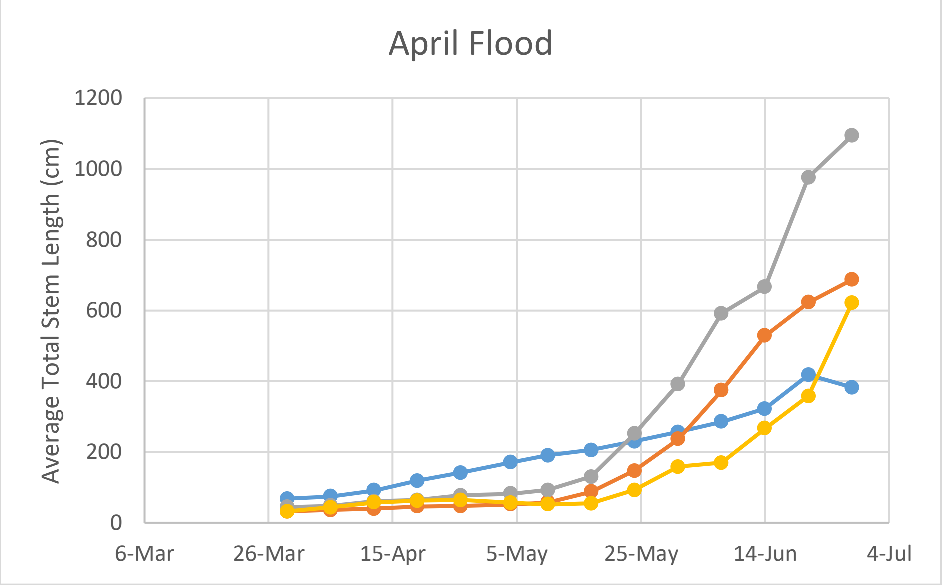

Figure 4 Plotting the average total stem length in cm of each flood duration in April. The blue line indicates no flooding. The orange line indicates a 1-week duration of flooding. The gray line indicates a 2-week duration of flooding. The yellow line indicates a 4-week duration of flooding.

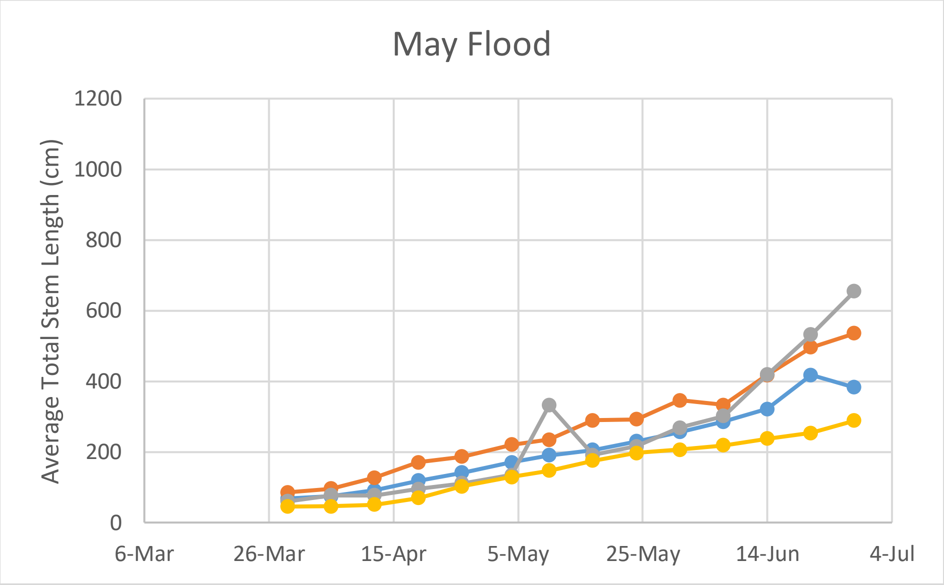

Figure 5 Plotting the average total stem length in cm of each flood duration in the month of May. The blue line indicates no flooding. The orange line indicates a 1-week duration of flooding. The gray line indicates a 2-week duration of flooding. The yellow line indicates a 4-week duration of flooding.

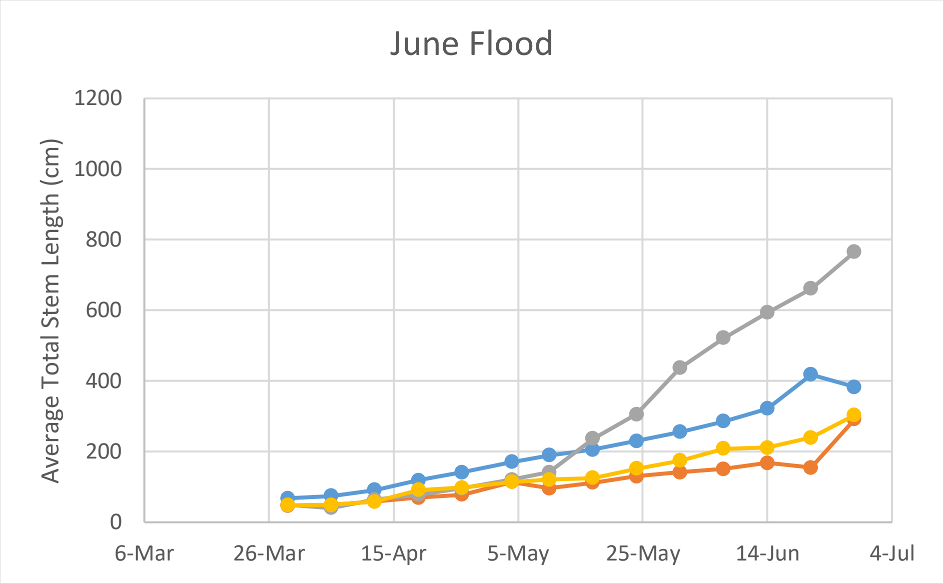

Figure 6 Plotting the average total stem length in cm of each flood duration in the month of June. The blue line indicates no flooding. The orange line indicates a 1-week duration of flooding. The gray line indicates a 2-week duration of flooding. The yellow line indicates a 4-week duration of flooding.

Table 1 Averages of aboveground biomass (ABM), belowground biomass (BBM), total biomass (TBM), and growth measured in cm per day. The subjects which had a negative growth or values of zero for biomass were excluded from this data.

Month	**Duration**	**ABM**	**BBM**	**TBM**	**Growth (cm/day)**
April	1	13.7	57.9	71.6	14.1
April	2	12.3	21.8	34.1	11.2
April	4	12.6	22.1	34.8	14.5
June	1	1.7	1.7	3.3	1.8
June	2	8.6	5.8	14.3	5.1
June	4	1.9	1.7	3.6	2.5
May	1	4.0	5.4	9.5	4.7
May	2	5.4	4.7	10.1	5.9
May	4	2.8	1.8	4.6	2.8
None	0	3.6	5.2	8.7	3.5

Discussion

Each of three flood durations during April, May, and June impacted the plants differently as shown in the previous collections of data. The end result of this experiment should determine during which month and flood duration are the plants most likely to produce the most biomass and also contribute to the discussion to determine what month and duration sediment diversion gates should be opened (Peyronnin, Caffey, et al. 2017). In my hypothesis I predicted the 3-week duration of flooding during the month of April to be most detrimental to plant biomass. The 1-week flood in April produced the plants with the highest biomass production and the plants flooded in the weeks of June had the lowest biomass production, which directly contradicts my hypothesis. T

The flooding in April encouraged growth from the *Spartina patens* and was ultimately responsible for the largest aboveground, belowground, and total biomass values shown in **Figure 1**, **2**, and **3**. The 2-week flooding duration had the highest average total stem length shown in **Figure 4**, **5**, and **6**. Only flooding during the summer months, April, May, and June was studied and extended duration of the experiment could have yielded different results or a more defined trend in the data. For most of the biomass measurements the 4-week flood duration was the most devastating and caused the least production, indicating that increased duration of flooding causes a decline in both aboveground and belowground biomass (Peyronnin, Caffey, et al. 2017).

The Mississippi River and the coastal wetlands are deeply connected. Flooding, which is a natural occurrence in the marsh habitat on the coast of Louisiana, comes from the Mississippi River and contributes to the health of the marsh by introducing sediment, nutrients, and fresh water (Peyronnin, Caffey, et al. 2017). Flooding can negatively impact the marsh as well and rising sea level is overcoming the input of sediment into the marsh land which is considered a major cause of wetland loss (Warren, Niering, 1993). Flooding is part of the natural cycle of the marsh, and when the balance of sediment and fresh water input is altered it causes a loss of habitat. Wetlands experience both RLS, relative sea level rise and also subsidence, which constitutes rapid land loss (Visser, Day, et al. 2017).

Diversion techniques are one way to combat coastal land loss without altering human development along the Mississippi River. According to the data collected during this experiment the ideal summer month to flood *Spartina patens* is April and the duration is for 2 weeks. For marsh areas with *Spartina patens* belowground biomass increased with flood duration under fresh conditions but decreased with flood duration under brackish conditions, indicating that encroaching sea water will negatively effect the marsh species (Peterson, Visser, 2015). Wetlands, along Louisiana’s coast where sea level rise is highest, will eventually convert into salt water habitats due to both subsidence and rising sea level, which is not ideal for many species who thrive in the freshwater marsh. To conclude the coast is in dire need of assistance and diversion techniques will certainly help alleviate and revive the wetlands.

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