Phragmites australis removal project at Currituck Banks
Final Report - April 2009
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Introduction

Phragmites australis (*Phragmites*) is an invasive member of the grass family (Poaceae) that grows in fresh and brackish wetlands. *Phragmites* can grow to a height of six meters and reproduces both sexually and vegetatively through root rhizomes. Once established this fast growing species can quickly crowd out native wetland plants forming a monoculture. This monoculture alters the native wetland ecology, potentially causing overall decreased functionality.

In 2004, the *Phragmites* stands in the Kitty Hawk Woods and Currituck Banks Reserve components of the North Carolina Coastal Reserve (NCCR) were mapped using GPS and aerial photographs. A 1.7 acre stand was located in the center of an undisturbed 4.9 acre marsh on the soundside of Currituck Banks (Figure 1).

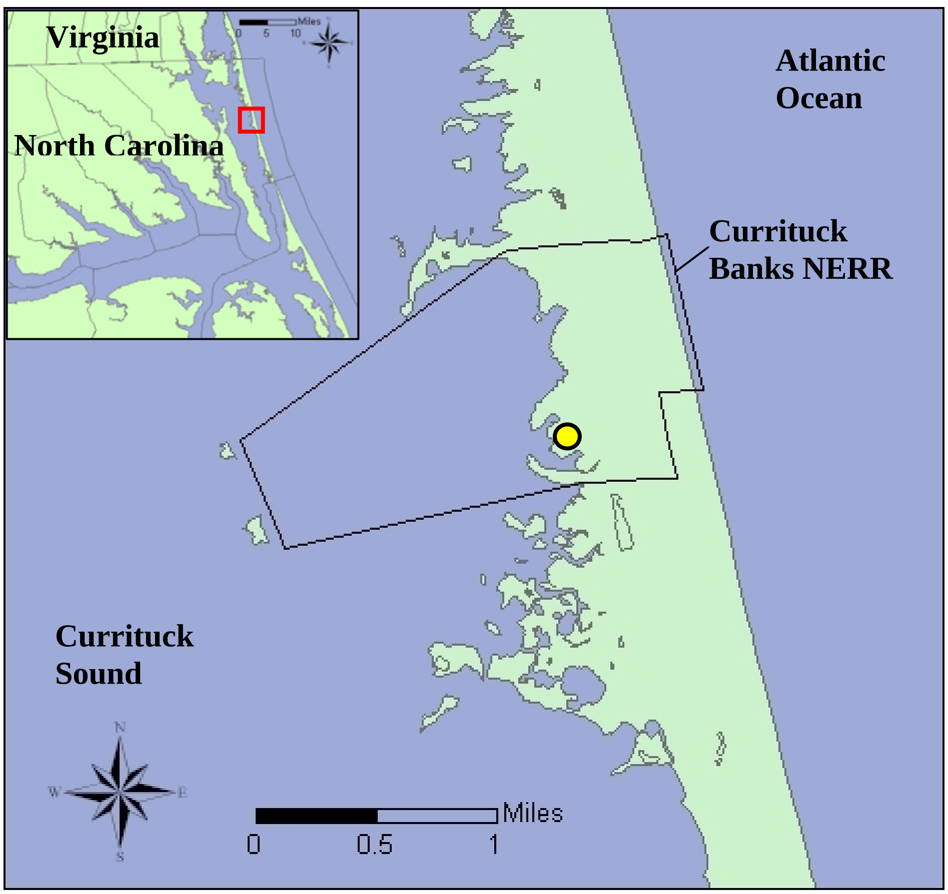

Figure 1: Map showing location of Currituck Banks (insert) and location of *Phragmites australis* stand within Currituck Banks NERR.

Common native grasses found in this marsh environment include black needlerush (*Juncus roemerianus*), big cordgrass (*Spartina cynosuroides),* saltmeadow cordgrass (*Spartina patens*), sawgrass (*Cladium jamaicense*) and cattail (*Typha latifolia)*. Because of the size, location and potential for this stand to spread, the NCCR made an effort to eradicate this stand. After consultation with the U.S. Fish and Wildlife Service, it was decided the best option for removing this stand would be an herbicide application.

The US Fish and Wildlife Service requested the NCCR try a newly registered herbicide Habitat® to treat the *Phragmites* stand. Habitat® inhibits a plant specific enzyme that causes the plant to stop growing and slowly die as its food and energy reserves are exhausted. This enzyme is not found in humans, other mammals, birds, fish or aquatic invertebrates. With the exception of its effect on plants, Habitat® is considered to be practically nontoxic by the U.S. EPA.

The stewardship and research sectors devised a plan to monitor the effectiveness of the removal effort and the potential return of native marsh species. The goals of this plan were:

1. Treat the 1.7 acres *Phragmites australis* stand within the Currituck Banks NERR marsh with Habitat®.
2. Conduct pre and post herbicide application vegetation monitoring within the study area to quantify herbicide effectiveness and ability of native plants to recolonize.
3. Assess the pre and post herbicide application salinity and nutrient (NH_4^+, NO_3^-, PO_4^{-3}) concentrations in the root zone groundwater within the study area.

Methods

Study Area

As part of a previous study, the 1.7acre *Phragmites* stand at Currituck Banks was aged through the use of historical aerial photography. GIS was used to draw polygons around the extent of the *Phragmites* stand as it expanded since the early 1980s. The age based polygons are shown in Figure 2. These age based “rings” were used as the basis for stratifying the sampling plots. Previous studies have shown that *Phragmites* can alter the marsh biogeochemistry. Because of this, the areas where *Phragmites* has been in Currituck Banks the longest may be less suitable for native species compared to the newly invaded areas. Thus, we stratified the sample plots to include representative areas within each ring. We also incorporated two control groupings, a “near phrag” group which represents the area of native marsh adjacent to the exterior extent of the *Phragmites* monoculture including the transition zone, and a “Natural” group representing areas in the marsh not adjacent to the *Phragmites* containing only native species.. Within each group three replicate sample plots were chosen at random. The sampling plot locations are shown in Figure 2. Sample site locations were marked using a Trimble GPS, and PVC poles.

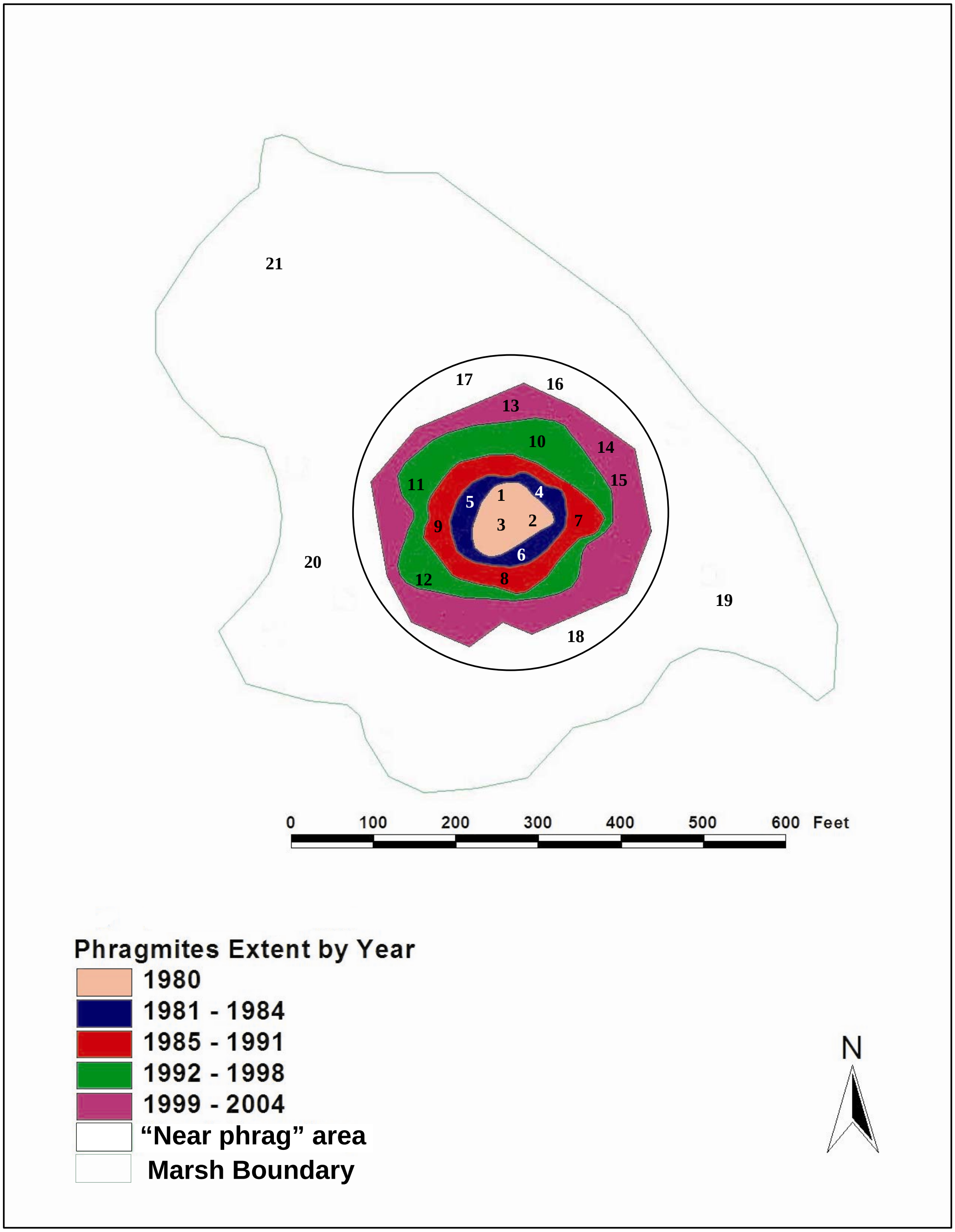

Figure 2: *Phragmites* age rings and sampling site (1-21) locations.

Vegetation Survey Methods

At each sample plot, stem counts for all species present were quantified within a 0.5 m^2 quadrat. A meter stick was used to measure the height of the five tallest individuals for the three most dominant species. Photos of each plot were taken during each sampling trip. Data was entered into a field journal and later transferred to an excel spreadsheet.

Sediment Organic Matter Content

A 2.5in diameter by 24 in deep core sample was obtained by hand into clear acrylic core liners from each sampling plot. The bottom of the root zone was measured for each sampling plot using a meter stick. Samples for sediment organic matter content were obtained from these cores. The samples were obtained from just below the root zone to quantify the organic matter of the marsh sediment. Samples were stored frozen until analysis. Upon thawing, percent carbon (C) and percent nitrogen (N) samples were homogenized using mortar and pestle, dried for 24 hrs at 70 °C, fumed in an HCL atmosphere to remove precipitated carbonate, and stored in a desiccator until analysis. Percent C and N samples were analyzed using a Perkin Elmer model 2400 series II CHN analyzer (Perkin-Elmer, Norwalk, CT, USA).

Groundwater Methods

At each sampling plot a well was installed to provide root zone groundwater samples. The well was constructed of PVC. Each well extended down to 18cm, which was the bottom of the root zone based on core samples (described above). The below ground portions of the wells were constructed of well pipe allowing water to enter while barring most dirt and debris. Groundwater samples were obtained from the wells by suction using plastic tubing and a 50 ml syringe. Groundwater samples were analyzed for salinity using a refractometer on site. Samples for nutrient analysis (NH_4^+, NO_3^-, and PO_4^{-3}) were stored on ice, filtered through a GF/F filter (0.7 µm pore size) within 8 hrs of collections and stored frozen until analysis. Nutrient analyses were performed on a high sensitivity autoanalyzer (Lachat Quick Chem. IV; Lachat Instruments, Milwaukee, WI, USA).

Removal Methods

Reserve staff and volunteers removed approximately two acres of old growth *Phragmites* stalks still standing since last year's growing season using basic lawn equipment and an all-terrain mower over a three-day period in April 2007. Equipment was provided by The Nature Conservancy. A path from the upland was cut into the center of the *Phragmites* area. Mowing proceeded out from there in concentrically bigger rings until all the existing *Phragmites* was removed.

Herbicide was applied using a Marsh Master provided by the U.S. Fish and Wildlife Service in May 2007 to new growth *Phragmites* stalks. This machine is designed to traverse marsh habitats with minimal disturbance. A 50:50 V/V mixture of Habitat and water was used to treat the area. After this initial spraying follow up spot spraying was conducted using a back-mounted manually operated pressurized sprayer using the same 50:50 mixture.

Monitoring Timeline

The above activities were conducted based on the following timeline.

Table 1: Sampling and activity timeline

	Date							
Activity	8-2006	10-2006	4-2007	5-2007	6-2007	7-2007	10-2007	4-2008
Plot Delineation - Well Installation	X							
Vegetation Survey		X			X	X	X	X
Mowing			X					
Organic Matter		X						
Habitat Spraying				X				
Groundwater Salinity		X	X		X	X	X	X
Groundwater Nutrients		X	X	X			X	X

Results and Discussion

Logistical

Using hand operated mowing equipment was extremely difficult and time consuming. Access to the remote site from the land was very challenging and getting the mowing equipment to the location was problematic. Accessing the marsh with the frequency needed for this project left visible trails in the vegetation and depressions in the sediment. This disturbance was still present during the final vegetation survey. Such long lived disturbance could open the marsh up to further colonization by invasive species and provide easy access to the marsh for the large herbivores (feral pigs and horses) that reside within Currituck Banks. Future marsh studies in the region would be greatly aided by using a Marsh Master. The Marsh Master allowed easier access to the site, more efficient herbicide application, and left minimal disturbance. However, it was only available for use by NCCR staff in late spring/early summer, which is not the ideal spraying time for maximum effectiveness.

Organic matter results

The organic matter content of the marsh was of interest as *Phragmites* has been shown to alter marsh sediment chemistry. The organic matter samples taken at the start of this project clearly showed that the *Phragmites* areas had higher amounts of carbon than areas without *Phragmites* (Figure 3). This is consistent with the high below ground biomass associated with *Phragmites*.

There was not a similar trend in sediment nitrogen content (Figure 3). It should be noted that these trends are based on a single sampling event and should be considered with caution.

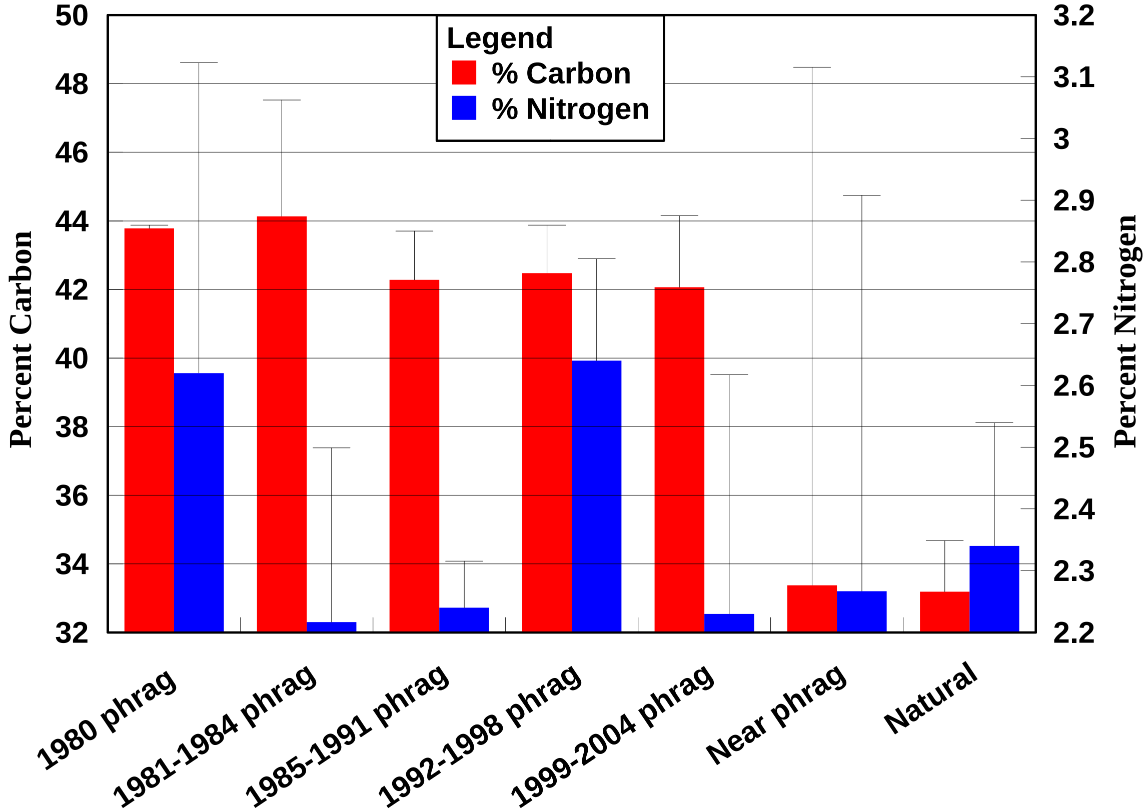

Figure 3: Initial mean percent carbon and nitrogen by sampling block. Error bars represent one standard deviation of the mean.

<u>Groundwater Data</u>

Figure 4 shows the average salinity values observed during the study. Overall, the salinity data within any one sampling date were very similar. Differences across sampling dates were much more apparent. Salinity values ranged from 0 - 10 ppt and averaged 3.9 +/- 1.7 ppt within the marsh. The data do not show any consistent trends in salinity based on sampling blocks or *Phragmites* removal. This does not mean that the *Phragmites* or its removal did not have any impact on the groundwater salinity values, only that other drivers in the area were more important. The amount of precipitation and water level of Currituck Sound are potential candidates. Two factors support this theory. One, the period before the 7-16-07 sampling date was extremely wet, and the concurrent salinity values from the wells were very low. Two, the period before the 4-16-08 sampling date was very dry and the concurrent salinity values from the wells were very high. The data do suggest that on the local scale, removing the *Phragmites* did not impact groundwater salinity levels. This can be seen by comparing the two sampling dates on either side of the *Phragmites* removal, 4-4-07 and 6-6-07. The salinity values for these two sampling dates were nearly identical.

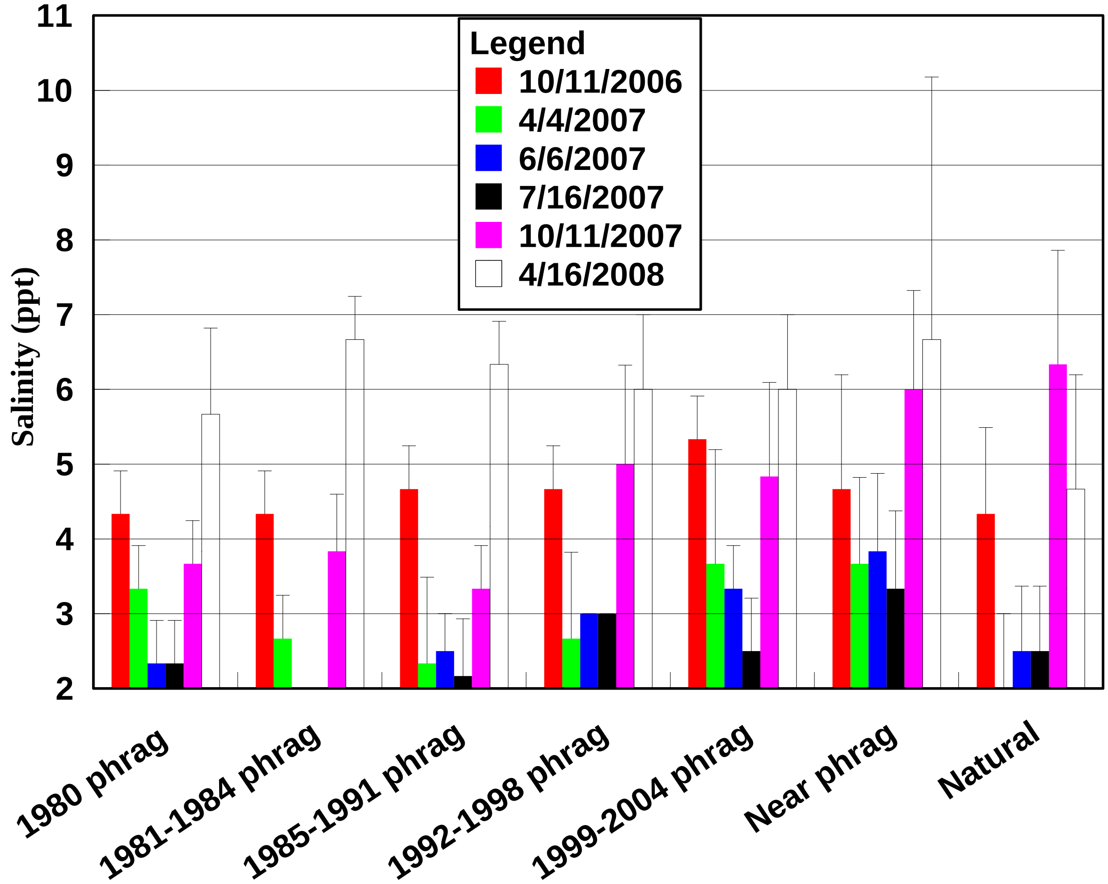

Figure 4: Mean salinity by sampling block and date. Error bars represent one standard deviation of the mean.

Figure 5 shows the averaged NO_3^- concentration from each sampling date by sampling block. Overall, the NO_3^- concentration within the groundwater ranged from 0 – 62.8 µg l^{-1} with an average of 13.3 +/- 9.8 µg l^{-1}. There was no apparent difference in the groundwater NO_3^- concentrations based on sampling block or *Phragmites* removal. Comparing the two blocks that should have the most disparity if *Phragmites* was a major driver of NO_3^- concentration (natural and 1980 phrag) showed very little difference in NO_3^- concentration across all sampling dates. In general, aside from three outliers (4-4-07: *1999-2004 phrag* and *near phrag*; 4-16-08: *near phrag*), the NO_3^- data from all wells tracked each other very closely.

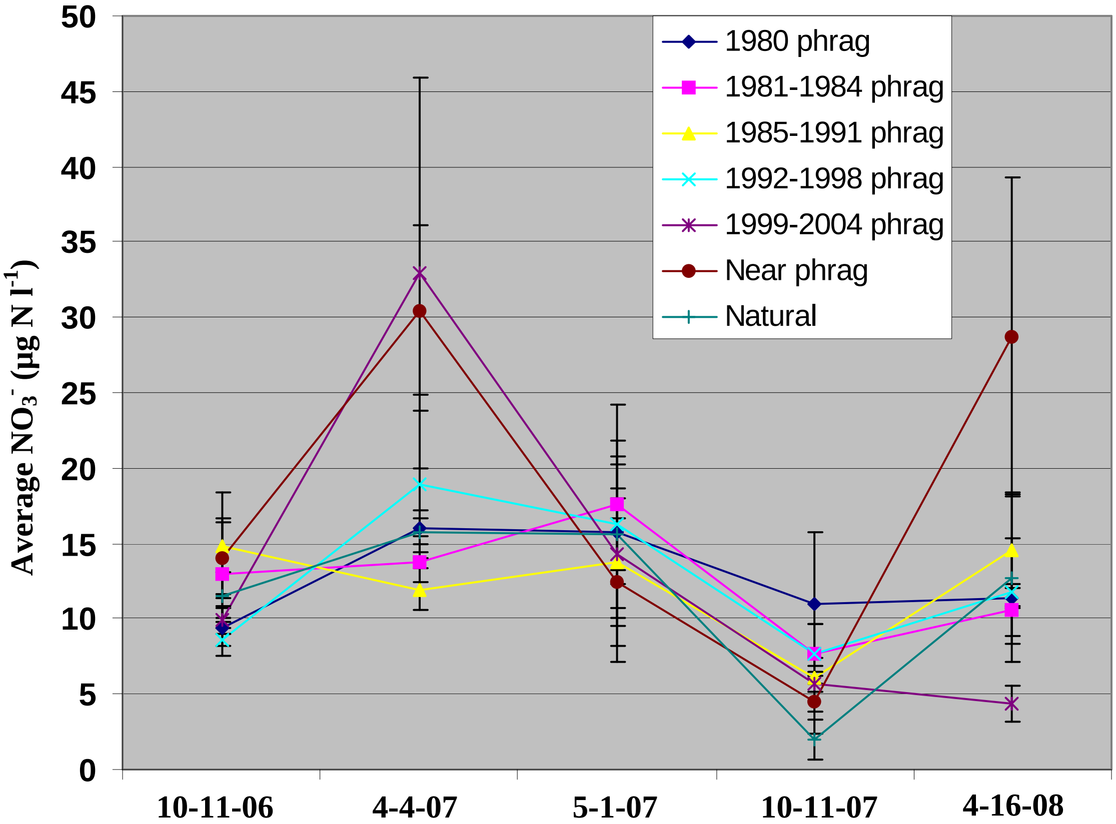

Figure 5: Mean NO_3^- concentration for each sampling block by date. Error bars represent one standard deviation of the mean.

Figure 6 shows the averaged NH_4^+ concentrations from each sampling date by sampling block. NH_4^+ was the predominate form of inorganic nitrogen within the marsh, often having concentrations 10x that of NO_3^- (Figures 5 & 6). The NH_4^+ data was also much more variable, ranging from 12.5 – 2620 µg l^{-1} with an overall average of 373 +/- 559 µg l^{-1}. The highest NH_4^+ concentrations were observed in the two oldest *Phragmites* areas (4-4-07: *1980 phrag* and *1981-1984 phrag*; 10-11-07: *1980 phrag*). Given the observed difference in sediment organic matter between the *Phragmites* areas and the non-*Phragmites* areas (Figure 3), differences in NH_4^+ would not be surprising as NH_4^+ is one of the major by-products of organic matter remineralization. To examine this, the NH_4^+ concentration was averaged by block across all sampling dates (Figure 7). From this plot it is clear that there is not a consistent relationship between *Phragmites* age and average groundwater NH_4^+ concentration. This pattern holds even if the post *Phragmites* removal data is not included in the average (data not shown). Thus, there is no apparent difference in the groundwater NH_4^+ concentration based on sampling block or *Phragmites* removal.

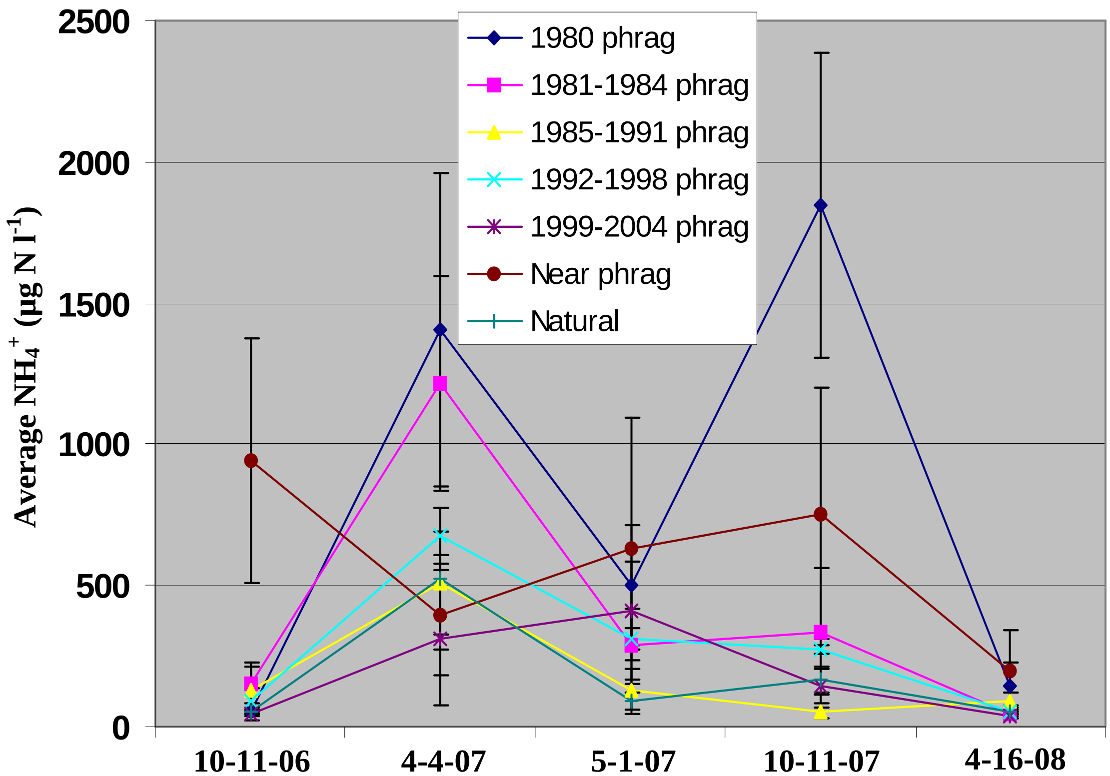

Figure 6: Mean NH_4^+ concentration for each sampling block by date. Error bars represent one standard deviation of the mean.

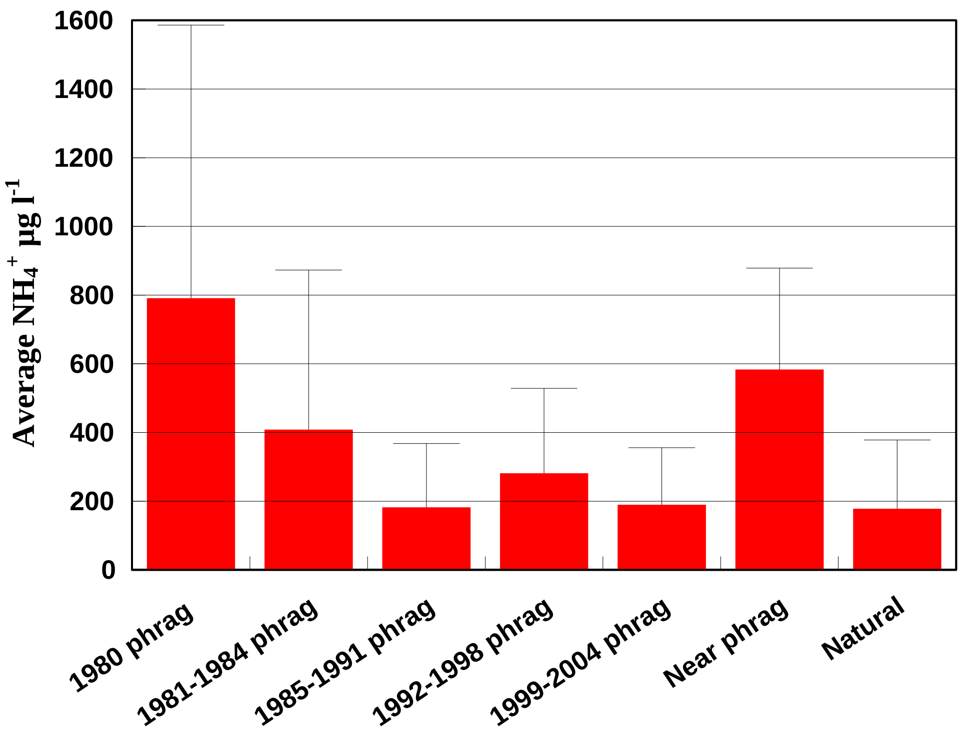

Figure 7: Mean NH_4^+ by sampling block for the study period. Error bars represent one standard deviation of the mean.

Figure 8 shows the averaged PO_4^{-3} concentrations from each sampling date by sampling block. Unlike the nitrogen data, there are some interesting trends in the PO_4^{-3} data. PO_4^{-3} concentrations dropped throughout the study period in all blocks. There was not a consistent pattern comparing *Phragmites* blocks with non- *Phragmites* blocks or between pre and post *Phragmites* removal. As with the salinity data, there is most likely a large scale driver at work here causing this pattern that masks any potential signal associated with the *Phragmites* and its removal. The decrease in PO_4^{-3} is an interesting finding but not one that can be answered with the data at hand. Despite not being able to identify the cause, the net effect for the sample site marsh is that less PO_4^{-3} is available to support autotrophy and over the course of this study period the marsh was likely a source of PO_4^{-3} to Currituck Sound.

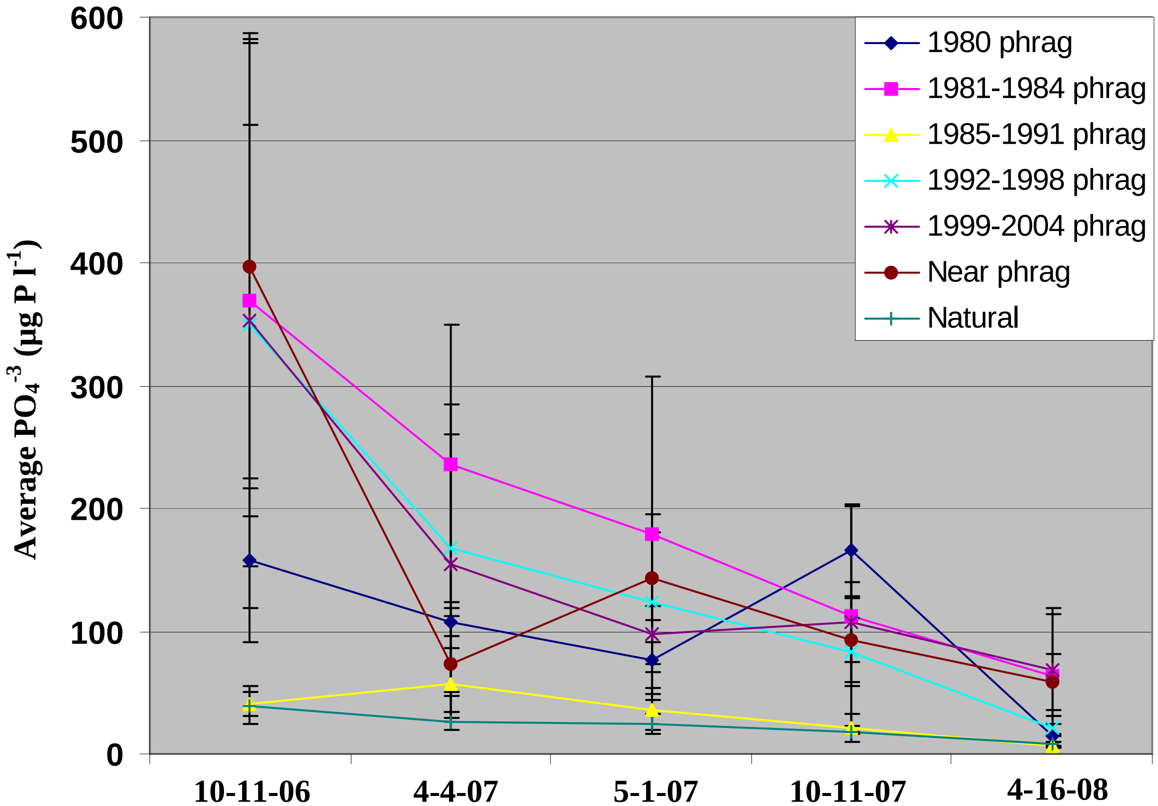

Figure 8: Mean PO_4^{-3} concentration for each sampling block by date. Error bars represent one standard deviation of the mean.

<u>Vegetation Surveys</u>

The vegetation data has been summarized in Figure 9. The plots show average percent cover for each block by *Phragmites* and non-*Phragmites* marsh species. For the purpose of this report non-phrag can be interpreted as native species. The error bars represent one standard error of the mean. Panel A shows the pre treatment vegetation assessment. There is a well defined bi-modal distribution with the *Phragmites* being most prevalent in the areas where it has been present the longest and not present in the natural areas. The native plant species show the opposite pattern with very few members in the oldest *Phragmites* areas and 100% coverage in the natural areas. The herbicide was applied in mid-May 2007. By October of that year, no live above ground *Phragmites* shoots were present within the study site. This gave the Reserve staff initial high hopes that the methods used in this study were going to provide effective control for the *Phragmites*. However, by April of the following year (panel E) the *Phragmites* had returned in every area that it had previously occupied. Furthermore, comparing the initial vegetation survey to the final one (panel E) showed that the *Phragmites* had not just come back in the original areas but was also more prevalent then before. In four of the six blocks (1980 phrag, 1981-1984 phrag, 1992-1998 phrag, and near phrag) where *Phragmites* was observed during the initial survey (panel A), it had increased its percent cover by April 2007 (panel E). Additionally, it was observed that the *Phragmites* had expanded into areas that it had not previously been (see panel E: *natural*). It is feasible that the disturbance caused by staff accessing the marsh to do the work provided avenues for this *Phragmites* expansion.

Conclusions

Habitat did not provide effective control of the *Phragmites* at Currituck Banks. This may be due to the timing involved with the conducted work (i.e. spraying is ideally done in late summer so that herbicide is transferred to the roots as the plants senesces). *Phragmites* presence and removal efforts did not have an impact on groundwater salinity and nitrogen levels. The study marsh groundwater PO_4^{-3} levels decreased throughout the study period. Given the amount of effort required and the observed effectiveness compared to the level of disturbance, *Phragmites* removal using the methods outlined in this project do not provide a viable management option for the NCCR.

Any future removal efforts will need to carefully consider the required cost against the potential benefits and chance of success. This project made it clear that the NCCR does not have the resources needed to tackle large scale removal projects on its own. Future removal efforts need to be conducted in partnership with other area land management agencies. This project also demonstrated that the NCCR was ideally suited to monitor and map *Phragmites*. This is where the Reserve will focus its efforts regarding *Phragmites* over the next few years. This activity will provide valuable data to future collaborative removal projects by providing target areas for removal efforts.

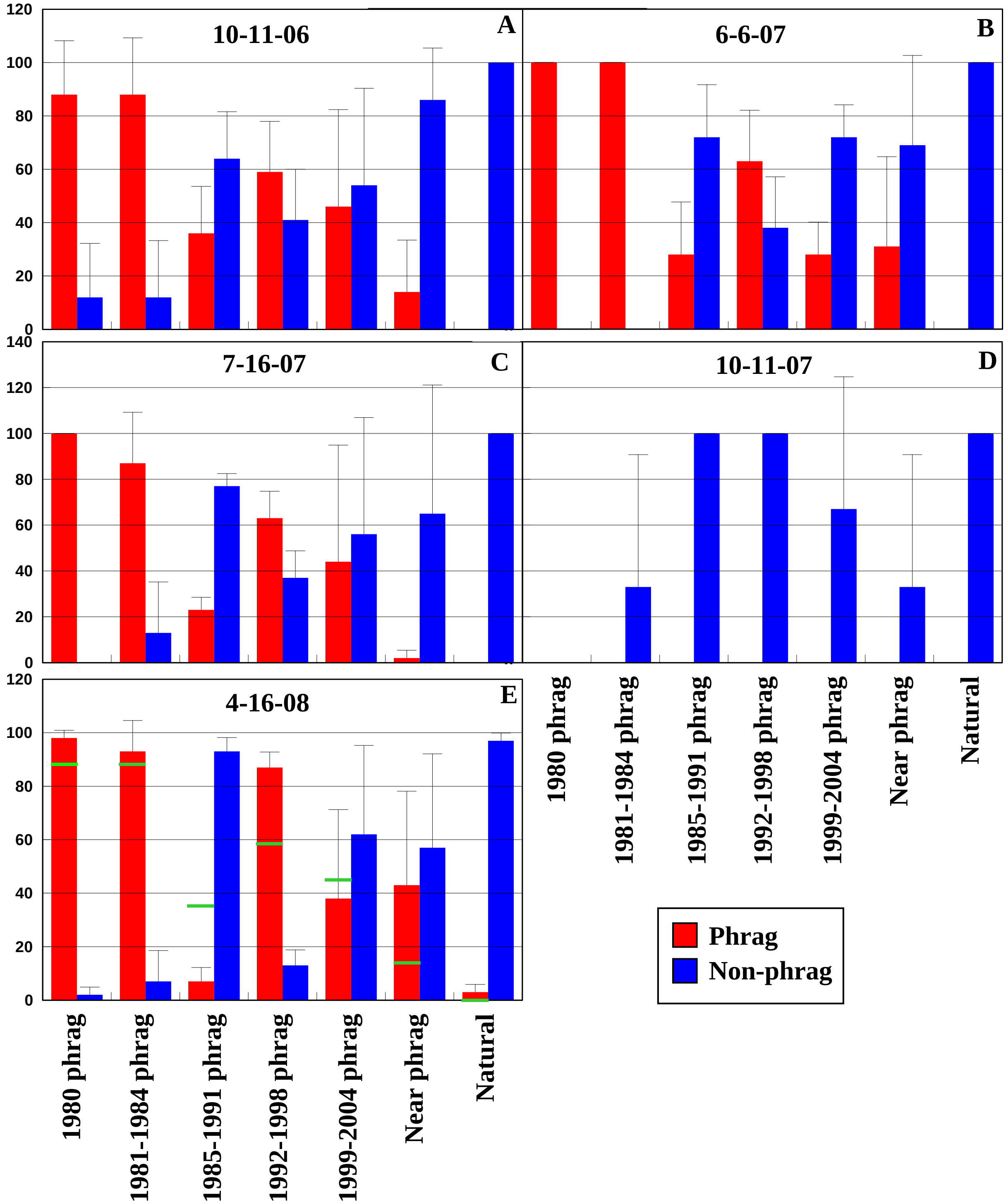

Figure 9: Mean percent cover for each sampling block by sampling date. Error bars represent one standard deviation of the mean. Spraying was conducted in May 2007. The green bars in panel E represent the *Phragmites* values from the pre-treatment survey (panel A). Comparing panel A and E clearly shows an increase in *Phragmites* percent cover despite the temporary decrease observed in panel D.