Examination of Comparative Manual Removal Strategies for Non-Chemical Control of Invasive Non-Native *Phragmites australis subsp. australis*
Wymbolwood Beach Site, Tiny Township, Ontario

By Lynn Short, Professor, Horticulture, School of Applied Technology, Humber College

Introduction

European Common Reed or *Phragmites australis subsp. australis* is a non-native, invasive plant that has begun to spread in wetlands and ditches all around the Great Lakes. It has become an environmental, economic and safety concern.

Dense Phragmites at Research Site, April 30

Phragmites growing through a paved shoulder on Hwy 27

Phragmites can reproduce in several ways. It produces seeds that become airborne, drifting in the wind to other wet locations. It spreads by underground stems or rhizomes, that produce new shoots and roots approximately every 30 cm. It spreads by overland runners or stolons, that also produce roots and shoots approximately every 30 cm. Cut stems can also produce roots and shoots if they fall on moist soil. Once established, the clones spread rapidly and dominate the area. These areas provide poor habitat for native animals.

This plant threatens biodiversity in wetlands and coastal areas. It is a perennial plant that, once established, outcompetes native plant species for nutrients and water. Phragmites is allelopathic, inhibiting the growth of other species around it. Its rhizomes extend very deep into the soil to successfully access ground water, even during dry periods.

The Pest Management Regulatory Agency of Health Canada registers pesticides for use in Canada. The Ministry of the Environment and Climate Change is responsible for regulating the sale, use, transportation, storage and disposal of pesticides in Ontario under the

Pesticides Act. In Ontario, the use of herbicides to control Phragmites is only permitted where the plant is growing on dry land. It is not permitted to use herbicides near or over water, which is often where Phragmites is found to be growing.

On rare occasions, an Emergency Use Registration can be obtained to treat Phragmites in wet conditions. In June 2016, the Ministry of Natural Resources and Forestry received approval from Health Canada's Pest Management Regulatory Agency for an Emergency Use Registration of glyphosate to treat Phragmites within shoreline and wetland habitats at Rondeau Provincial Park and at specific sites in the Long Point region as part of a pilot project. Implementation of the pilot project is scheduled to occur between September 1 and October 31, 2016. This is a very special case.

Since most of the time, herbicides cannot be used, alternate strategies for controlling this plant are required. This led to the development of the manual control method that is currently in use at my family cottage property. The infestation of Phragmites on my property on Wymbolwood Beach, Georgian Bay began fifteen years ago. The Lake level was dropping and plants had begun to colonize the sandy beach. I knew very little about the plant and initially allowed it to grow there. As I watched it take over the beach, I realized that it was becoming a problem. After several different approaches attempting to control the plant failed, I developed the technique of using a spade to cut the stalks below the soil surface to remove them. I tried not to disturb the surrounding soil and native vegetation. This proved to be the most effective control. This method is now being used along the beachfront properties of Wymbolwood Beach with great success. Colleagues encouraged me to conduct research to determine the best schedule for removal of Phragmites stalks using this spading technique.

<u>Procedure</u>

A site was selected in Tiny Township at Wymbolwood Beach on the private property of Joanne Lelovic and Richard Weldon. The owners generously agreed to allow the research to occur on their property. The property has an unusual shape. It is triangular with the wide base of the triangle at the beach side. The property at the two extreme corners of the triangle are often not in use. There is a dune at the beach edge with shrub willows present and Phragmites behind the willows. This site was selected on the basis that Phragmites was the dominant species present and there had not been any control methods applied to the site. The Phragmites had been growing undisturbed for at least ten years. The test site measured approximately 12.5 metres by 8 metres in size.

Lynn Short at the Research Site in August

To prepare the site for the research project initially, the owners gave permission for the property management company to prepare the site. Peter Ford of Wysechoice Property Services directed the removal and disposal of last year's standing stalks. The stalks were very strong and had to be cut using a brush cutting saw. Once the stalks were removed from the site, the remaining thatch on the ground was raked away from the site using hard rakes by volunteers. This plant debris was raked to the edges of the site and packed in bags for the Township to pick up.

Clearing last year's growth to prepare the site

A composite soil sample was taken from the site for analysis. The soil sample was analyzed at Agrifood Laboratories in Guelph.

The site was then divided into four test sections, side by side, measuring 2.5m by 8m. Tall wooden stakes were used to mark the corners of each section. Diagonals were calculated to ensure that the sections were square. Strings were used to define the boundaries of

each section. The test sections were identified as: Section 1 - the control that would remain undisturbed except for data collecting; Section 2 - the section where all the stalks would be cut 5cm below the soil surface using a sharpened spade in July; Section 3 - the section where all the stalks would be cut 5cm below the soil surface using a sharpened spade in July and again in August; and Section 4 - the section where all the stalks would be cut 5cm below the soil surface using a sharpened spade in June, again in July and again in August.

Within each test section, four plots, each measuring 1 metre by 1 metre and labelled A, B, C, and D, were staked out for data collection throughout the summer. Short wooden stakes placed at the corners and strings around the perimeter were used to define the boundaries of these test plots. Each entire test section was treated according to our plan but only the four test plots were counted and measured for data collection. It was felt that it would be important to remove the Phragmites using the same protocol in the zones surrounding the measured test plots within each test section to minimize the influence of the treatments in the adjacent test sections.

Before any removal of stalks was started, core samples measuring 10cm by 10cm by 25cm deep containing rhizomes were taken. These samples were cut out 10cm by 10cm using a pruning saw with a blade 25cm long. The core samples were levered out of the ground using a trenching shovel. The rhizomes were then rinsed to remove the sand. Five samples were taken from within each test section but outside the four test plots. Each sample was bagged separately and labelled. They were kept cool and transported to Rebecca Rooney's Laboratory in the Biology 2 Building at the University of Waterloo for analysis.

At the end of the summer, when the removal of stalks and data collection were complete, five samples were taken from each test section in the same manner but in different locations than the original samples that were taken at the beginning. These samples were also brought to the University of Waterloo for analysis.

Before each cutting of the stalks was begun, the number of stalks, the height of the stalks and the diameter of the stalks was recorded in all test plots at both sites.

Each square metre was divided into four quadrants using dead Phragmites stalks cut into 1 metre lengths. This made it easier to count the stalks. All stalks were counted in each test plot. To measure the heights, a metre stick or tape measure was used, depending on the height of the stalk. The measuring device was placed beside the stalk touching the soil surface and the leaves of the plant were extended straight up beside the measuring device to determine the height to the tip of the leaves. The diameter of the stalks was measured at 5 cm above the soil surface using calipers. If there were more than 100 stalks/m^2, the stalks in the south and north quadrants of each test plot were measured for height and diameter.


Test Plots divided into 4 quadrants


Volunteers measuring Phragmites stalks

Removal of the Phragmites stalks was done using a spade. In Test Sections 2, 3 & 4, on the scheduled dates, each individual stalk was cut at 5 centimetres below the soil surface using a sharpened spade. The spades were sharpened on a rotating grinding wheel to create a slight bevel on the front edge of the spade blade.

Spades used for Phragmites stalk removal

Sharpened spade with bevel edge

It is important to remember that the goal of this technique is to remove the Phragmites stalk but to avoid disturbing the surrounding soil or other plants in the area, if possible.

The spade blade is placed a few centimeters away from the base of the Phragmites stalk and held at approximately a 45° angle. The foot is placed on the footrest of the blade and the leg is used to thrust the blade of the spade into the soil to cut the stalk below the soil surface. The stalks can then be easily removed from the soil.

Sometimes the stalk is curved below the surface. In those instances, there will need to be adjustments in the angle or direction of approach in order to successfully cut the stalk. In situations where other plant species are present near the Phragmites stalks, it may be necessary to use just the corner of the blade rather than the entire width of the blade to remove an individual stalk. This minimizes the damage to the surrounding plants.

Using spade removal technique

Cutting and bagging the Phragmites stalks

The schedule of work done, stalk removal and data collection was as follows:

Date	Action Taken
June 6, 2016	Rake thatch from research site
June 10, 2016	Complete raking of thatch from research site
June 12, 2016	Measure and install stakes for test sections and $1m^2$ plots
June 17, 2016	Collect composite soil sample
June 24, 2016	Collect initial rhizome samples Data Collection for all 16 test plots in all Sections
June 26, 2016	Cut all stalks in Section 4
July 15, 2016	Data Collection for all 16 test plots in all Sections
July 22, 2016	Cut all stalks in Sections 2, 3 & 4
August 12, 2016	Data Collection for all 16 test plots in all Sections
August 19, 2016	Cut all stalks in Sections 3 & 4
September 2, 2016	Collect final rhizome samples Data Collection for all 16 test plots in all Sections

Results

Thatch Depth: The depth of the thatch layer was measured at six locations before the area was raked to remove the thatch.
The measurements of thatch depths were 7.2cm, 10.0cm, 7.9cm, 9.3cm, 8.0cm and 7.8cm. The average thatch depth was 8.4cm.

Soil Analysis: The soil texture results were 95% sand, 3% silt and 2% clay, making this soil texture to be classified as sand. The soil pH was 7.2 (very slightly alkaline) and the organic matter present was 3.5%.

Measurement Data Results

June 24, 2016

Test Section 1 - Control

Plot	A	B	C	D
Density (stalks/m^2)	133	119	104	84
Average Height (cm)	35.7	40.7	38.4	41.3
Average Diameter (cm)	0.44	0.41	0.51	0.45

Test Section 2 – Spade cut 5cm below soil surface in July

Plot	A	B	C	D
Density (stalks/m^2)	103	154	122	131
Average Height (cm)	35.6	43.3	33.8	36.1
Average Diameter (cm)	0.41	0.43	0.47	0.52

Test Section 3 – Spade cut 5cm below soil surface in July & August

Plot	A	B	C	D
Density (stalks/m^2)	120	117	71	125
Average Height (cm)	34.9	37.5	48.5	44.4
Average Diameter (cm)	0.46	0.46	0.64	0.47

Test Section 4 – Spade cut 5cm below soil surface in June, July & August

Plot	A	B	C	D
Density (stalks/m^2)	132	97	64	124
Average Height (cm)	47.9	47.5	50.7	31.1
Average Diameter (cm)	0.45	0.39	0.32	0.43

July 15, 2016

Test Section 1 - Control

Plot	A	B	C	D
Density (stalks/m^2)	148	198	163	150
Average Height (cm)	115.7	No data available	No data available	No data available
Average Diameter (cm)	0.39	No data available	No data available	No data available

Test Section 2 – Spade cut 5cm below soil surface in July

Plot	A	B	C	D
Density (stalks/m^2)	135	195	164	154
Average Height (cm)	115.1	153.2	No data available	No data available
Average Diameter (cm)	0.40	0.45	No data available	No data available

Test Section 3 – Spade cut 5cm below soil surface in July & August

Plot	A	B	C	D
Density (stalks/m^2)	146	136	103	163
Average Height (cm)	118.2	132.9	144.4	129.7
Average Diameter (cm)	0.41	0.42	0.50	0.49

Test Section 4 – Spade cut 5cm below soil surface in June, July & August

Plot	A	B	C	D
Density (stalks/m^2)	93	73	31	77
Average Height (cm)	33.7	36.1	37.3	41.0
Average Diameter (cm)	0.41	0.40	0.48	0.43

August 12, 2016

Test Section 1 - Control

Plot	A	B	C	D
Density (stalks/m^2)	138	175	179	148
Average Height (cm)	147.4	158.5	215.5	184.9
Average Diameter (cm)	0.39	0.40	0.47	0.48

Test Section 2 – Spade cut 5cm below soil surface in July

Plot	A	B	C	D
Density (stalks/m^2)	25	51	55	54
Average Height (cm)	28.0	14.6	19.0	17.9
Average Diameter (cm)	0.45	0.46	0.47	0.44

Test Section 3 – Spade cut 5cm below soil surface in July & August

Plot	A	B	C	D
Density (stalks/m^2)	43	64	43	44
Average Height (cm)	14.4	14.4	20.7	20.1
Average Diameter (cm)	0.42	0.40	0.50	0.49

Test Section 4 – Spade cut 5cm below soil surface in June, July & August

Plot	A	B	C	D
Density (stalks/m^2)	38	64	25	37
Average Height (cm)	44.7	42.7	42.7	33.5
Average Diameter (cm)	0.39	0.39	0.31	0.42

September 2, 2016

Test Section 1 - Control

Plot	A	B	C	D
Density (stalks/m^2)	145	183	155	143
Average Height (cm)	193.6	196.7	223.3	198.8
Average Diameter (cm)	0.44	0.38	0.5	0.5

Test Section 2 – Spade cut 5cm below soil surface in July

Plot	A	B	C	D
Density (stalks/m^2)	39	65	64	67
Average Height (cm)	83.1	95.4	110.9	104.9
Average Diameter (cm)	0.43	0.41	0.42	0.42

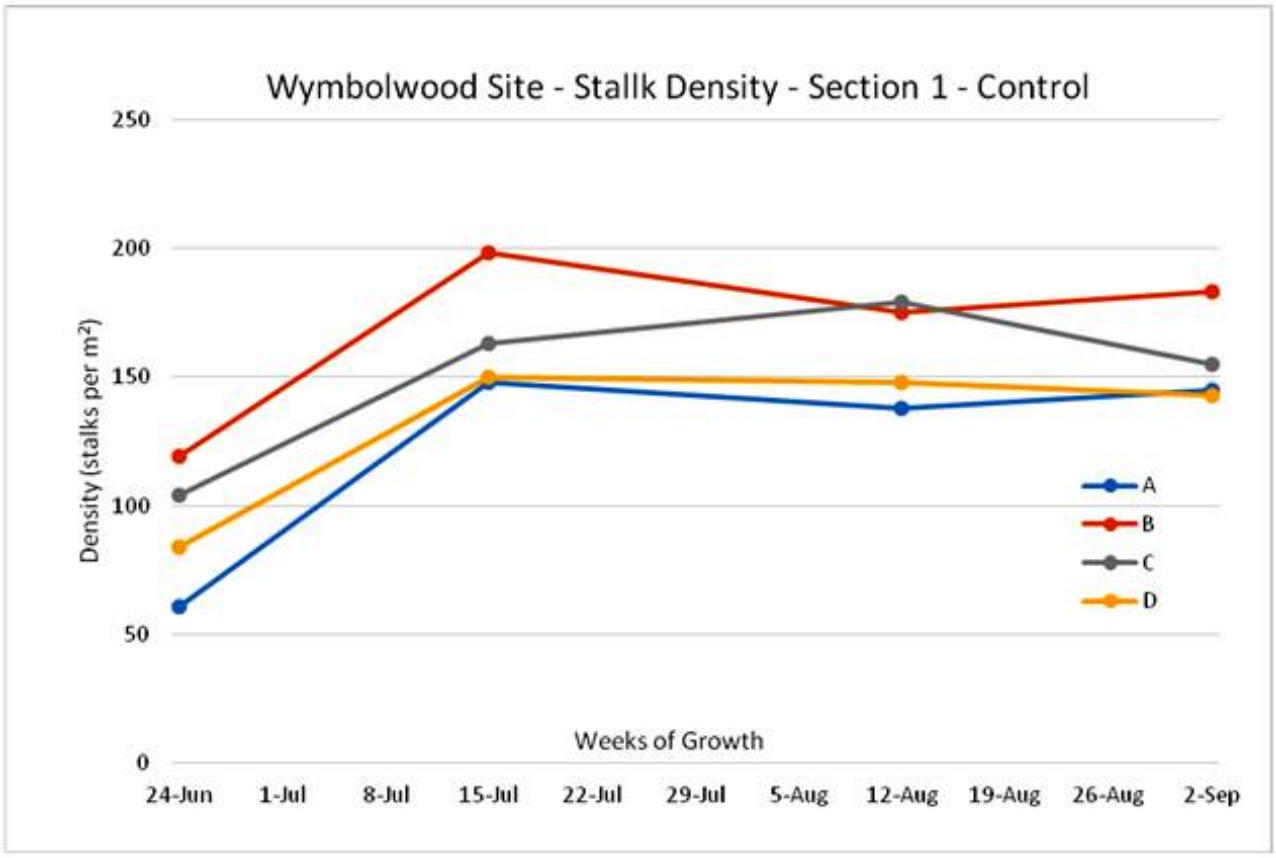
Test Section 3 – Spade cut 5cm below soil surface in July & August

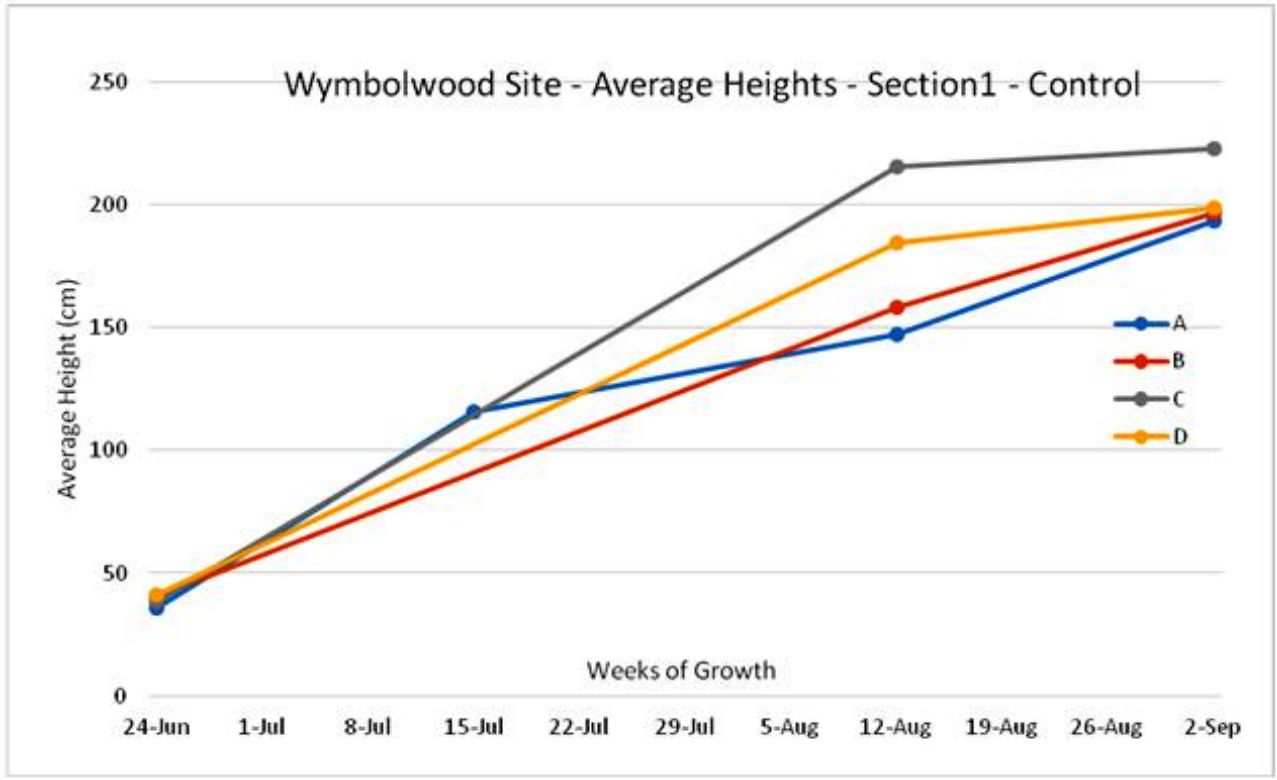
Plot	A	B	C	D
Density (stalks/m^2)	23	25	21	8
Average Height (cm)	15.8	15.15	16.4	11.6
Average Diameter (cm)	0.26	0.29	0.39	0.44

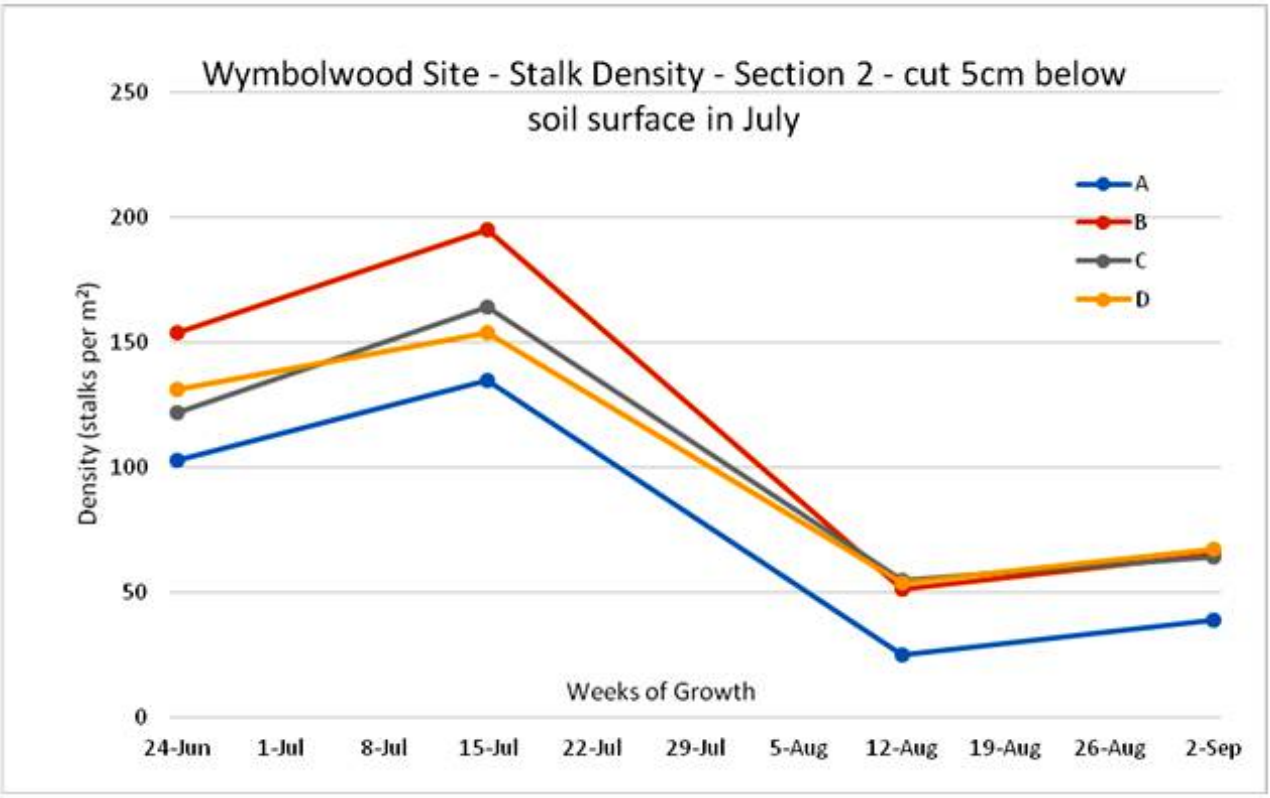
Test Section 4 – Spade cut 5cm below soil surface in June, July & August

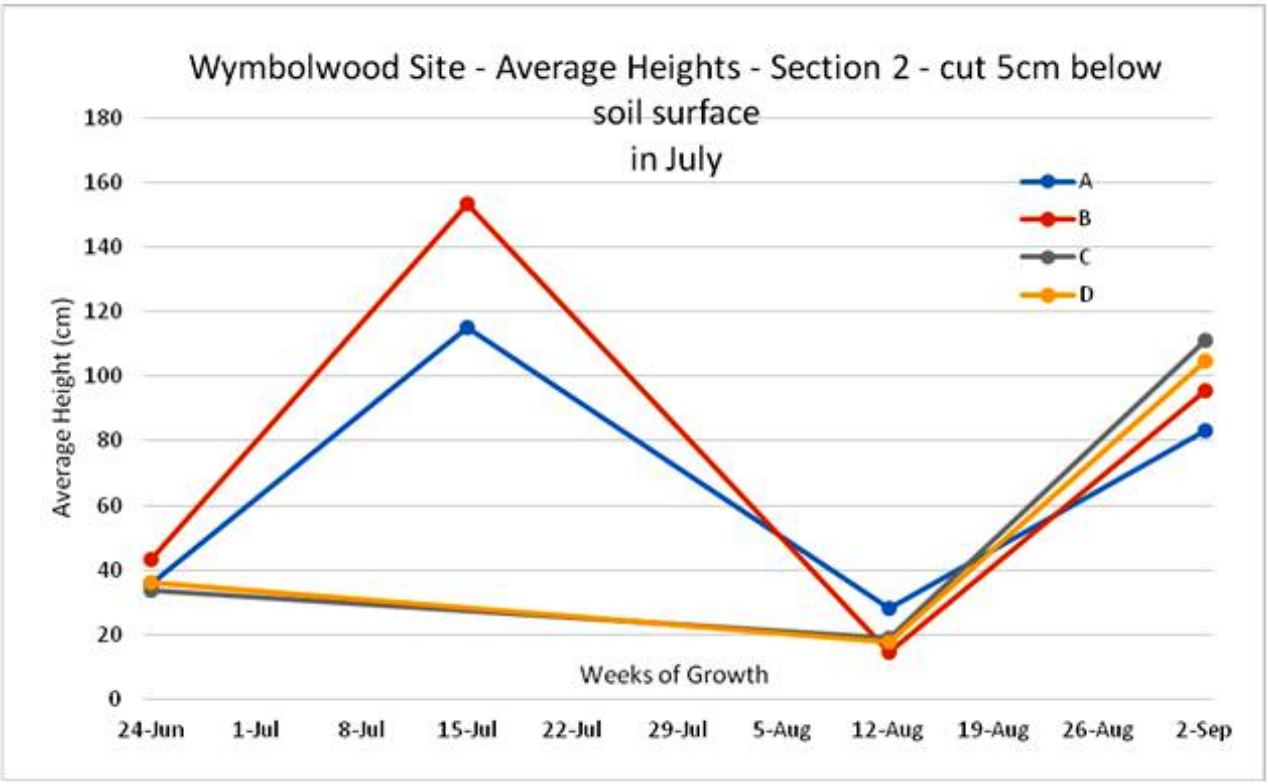
Plot	A	B	C	D
Density (stalks/m^2)	18	33	12	20
Average Height (cm)	19.3	20.3	28.4	18.2
Average Diameter (cm)	0.38	0.29	0.3	0.25

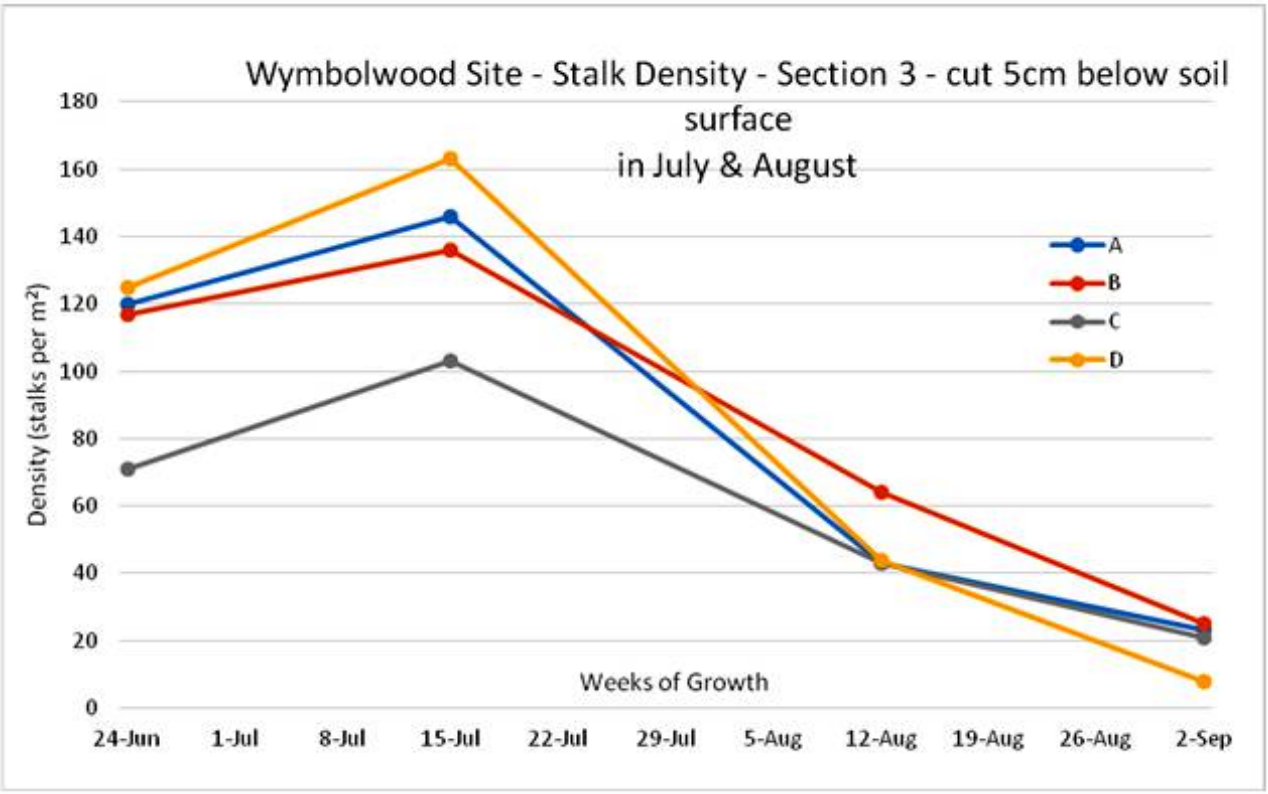
Following are Graphs of Stalk Density per m^2 and Average Stalk Heights for Research Site

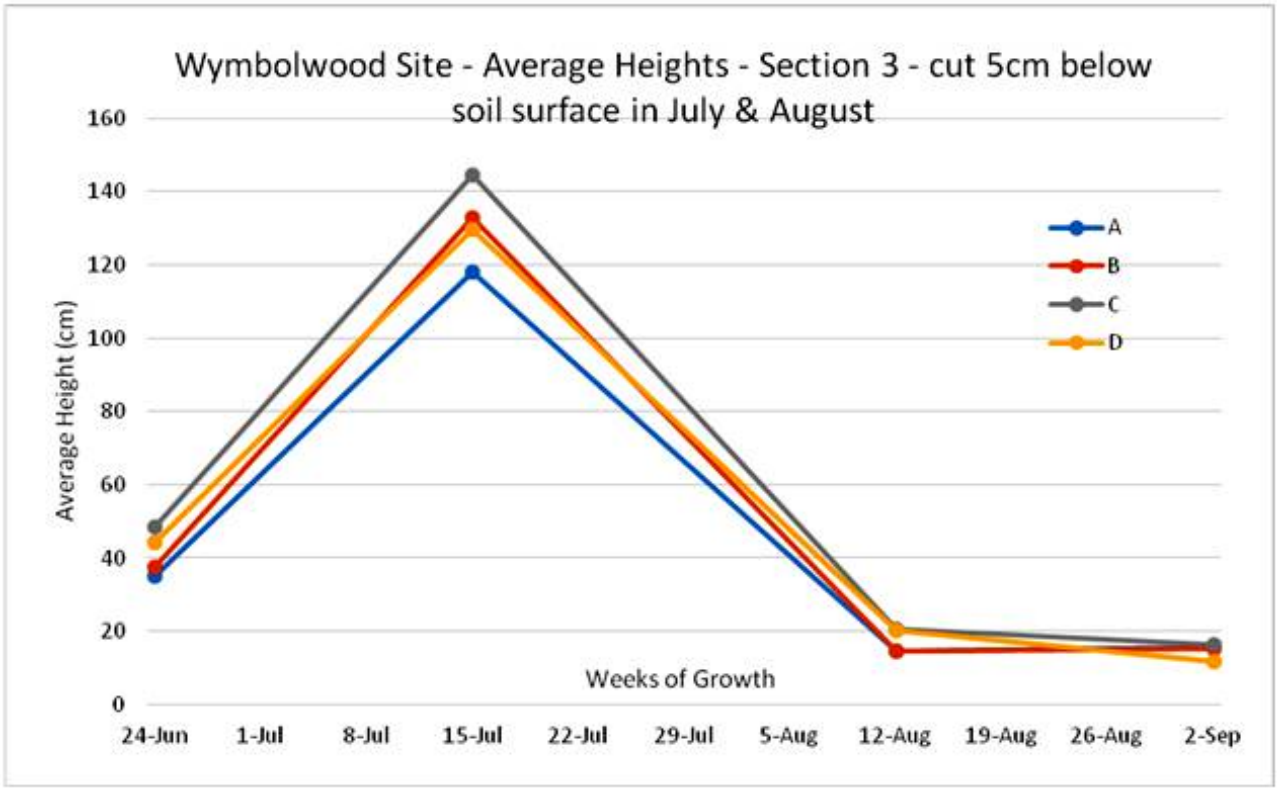

Wymbolwood Site - Stallk Density - Section 1 - Control
250
200
150
100
50
0
Density (stalks per m²)
Weeks of Growth
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
A
B
C
D

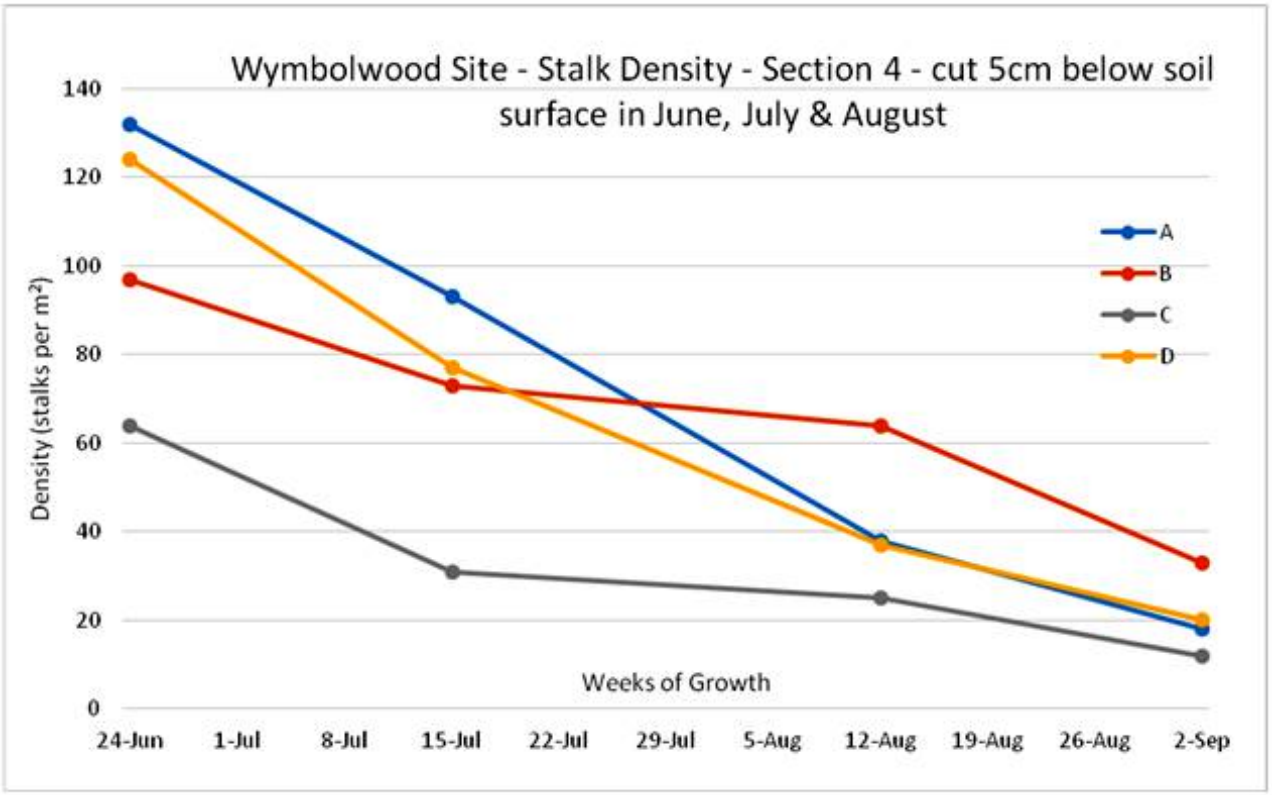

Wymbolwood Site - Average Heights - Section1 - Control
250
200
150
100
50
0
Average Height (cm)
Weeks of Growth
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
A
B
C
D

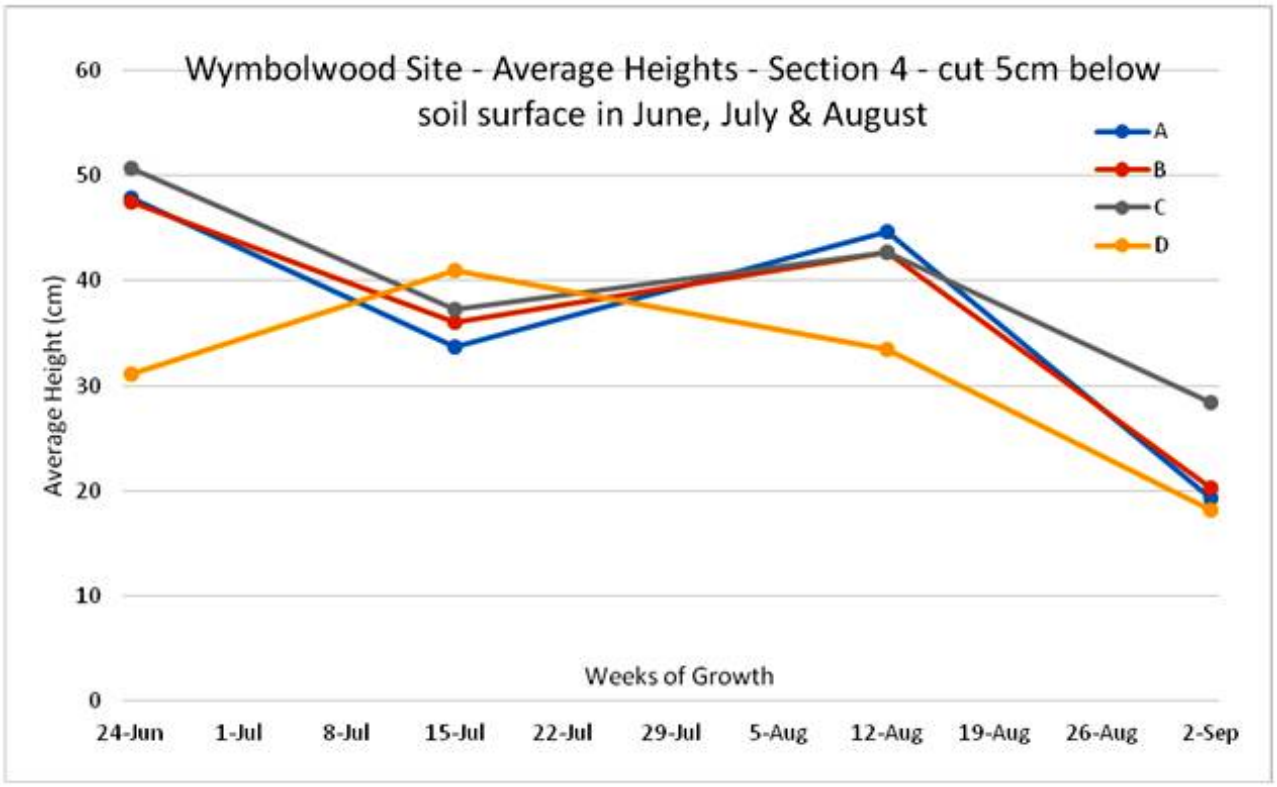

Wymbolwood Site - Stalk Density - Section 2 - cut 5cm below soil surface in July
Density (stalks per m²)
250
200
150
100
50
0
A
B
C
D
Weeks of Growth
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep


Wymbolwood Site - Average Heights - Section 2 - cut 5cm below soil surface in July
Average Height (cm)
180
160
140
120
100
80
60
40
20
0
A
B
C
D
Weeks of Growth
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep


Wymbolwood Site - Stalk Density - Section 3 - cut 5cm below soil surface
in July & August
Density (stalks per m²)
180
160
140
120
100
80
60
40
20
0
Weeks of Growth
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
A
B
C
D


Wymbolwood Site - Average Heights - Section 3 - cut 5cm below soil surface in July & August
Average Height (cm)
160
140
120
100
80
60
40
20
0
Weeks of Growth
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
A
B
C
D


Wymbolwood Site - Stalk Density - Section 4 - cut 5cm below soil surface in June, July & August
Density (stalks per m²)
140
120
100
80
60
40
20
0
Weeks of Growth
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
A
B
C
D


Wymbolwood Site - Average Heights - Section 4 - cut 5cm below soil surface in June, July & August
Average Height (cm)
60
50
40
30
20
10
0
Weeks of Growth
24-Jun
1-Jul
8-Jul
15-Jul
22-Jul
29-Jul
5-Aug
12-Aug
19-Aug
26-Aug
2-Sep
A
B
C
D

Overview of Research Site (September 2, 2016)
Section 4 in foreground, Section 1 in far background

Final results of a Section 4 test plot

Observations:

The summer of 2016 was a very hot and dry summer. During the first month, the research site at times had standing water about 5 cm deep over half of the area. By mid-summer, there was no longer any standing water but the soil stayed moist throughout the summer.

Removing the Phragmites stalks was very difficult at times because the underground rhizomes were so thick beneath the surface. This made inserting the spade into the soil somewhat challenging at times. Particularly, the July removal was very challenging because so many sections had to be cleared and it was extremely hot. For that removal, there were 10 volunteers working with me. We kept well hydrated and were able to complete the removal in three and a half hours. We filled 18 leaf bags with cut stalks that day!

Exposed Rhizomes at the edge of the beach
(not within Research Site)

Rhizome with small shoot attached
(removed from Section 3)

In Section 1, no plants were cut or disturbed during the entire study. This is the Control section. The test plots in this section attained their maximum density by mid-July and remained consistent until the end of the study. The height of the stalks attained the near maximum by mid-July and then got slightly taller by the beginning of September which was the end of our study. Almost all stalks were flowering by that time. The diameter of the stalks remained consistent throughout the summer.

September 2, 2016 Tall Phragmites
(Control Section 1)

Phragmites Flowerheads
(September 2, 2016)

In Section 2, all Phragmites stalks were cut 5cm below the soil surface using a sharpened spade in July and then allowed to grow for the rest of the summer. The density of the stalks growing back was reduced to less than half of the original density before cutting and, although it increased somewhat by the end of the summer, the numbers remained less than half of the original density seen in mid-July. The height was drastically reduced after cutting and grew slowly but the stalks did not reach the heights attained before cutting. No flowers were observed by the beginning of September. The diameter of stalks was unaffected after cutting compared to the original stalks before cutting.

In Section 3, all Phragmites stalks were cut 5cm below the soil surface using a sharpened spade in July and again in August. The density of the stalks dropped to about half of the original density after the first cut and then by half again after the second cut. There was a dramatic drop in the height of the regrowth after both cuts. No flowers were produced by the beginning of September. The diameter of the stalks did not change substantially compared to the original stalks before cutting. A very slight reduction was seen after the second cut.

In Section 4, all Phragmites stalks were cut 5cm below the soil surface using a sharpened spade in June, again in July and again in August. The density of the stalks growing back after each cut was reduced resulting in less than ¼ of the original density by the end of the study in early September. The height of the regrowth remained similar to the measured height in late June before the first cut until the third cut. The regrowth was very slow and the plants that grew were very short. The stalks did not flower by the beginning of September. The diameter of stalks was unaffected after cutting compared to the original stalks before cutting.

Last Day Data Collection – Section 4

Measuring Section 1 - Control

(September 2, 2016)

Observations of other plant species growing within the test plots revealed that, when the Phragmites was very dense, there was very little growth of other species. In Section 4, where the Phragmites had been removed the earliest, there were many different kinds of other plant species growing within the test plots. There was similar recovery in Section 3 where the Phragmites stalks had been removed twice. The growth was not as advanced but had a diverse group of plant species other than Phragmites. Sections 2 was also showing growth of other plant species mixed with the Phragmites stalks but they were not as plentiful or diverse as the ones in Sections 3 & 4 at the end of the study.

The regrowth of native beach ecosystem species in Sections 3 & 4 included Joe Pye Weed, Boneset, Blue Flag Iris, Wetland Bugleweed, Horsetail, small shrub willows and young Poplar saplings. Section 2, adjacent to the Control Section, had many seedlings of Herb Willow and some small poplar and shrub willows. The Control Section had some sparse plants of Bedstraw at the beginning of the season but that did not thrive.

Flowering Joe Pye Weed in Section 4

Bumblebee enjoying the flowers!

An interesting observation of the Phragmites stalks growing outside the research site was that they grew taller than the stalks in Section 1, the Control section. The Phragmites growing outside the research site experienced no disturbance over the spring and summer. Last year's standing stalks were not removed and no raking of the area to clear the thatch was done.

Notice the very tall Phragmites stalks in the far background

Conclusions

Removal of Phragmites stalks affects the growth of the stalks. The density of stalks/m^2 of the resulting regrowth is notably reduced whether the stalks are cut once, twice or three times in a season. This allows other plant species to become established among the Phragmites stalks. The height of the new stalks attained by the end of the summer is less than that which was attained by the middle of July prior to cutting and the stalks do not reach the stage of flowering. This reduces the ability of the plant to produce seeds. The diameter of the new stalks does not seem to be affected.

Based on the results of this research, it appears that the optimum cutting strategy for having the most effect on the growth of Phragmites, with the most improvement in other plant biodiversity, would be to cut the Phragmites stalks 5 cm below the surface of the soil using a sharpened spade three times during the summer, June, July and August. This strategy results in the most dramatic reduction in density of stalks/m^2 and the best improvement in the growth of other plant species in the location where the Phragmites has been removed. If there are time and staff constraints, then cutting below the soil surface twice using a sharpened spade in July and August would also result in a dramatic reduction in density. Cutting below the surface even once midsummer prevents flowering and also reduces the density.

Phragmites has been demonstrated to exhibit allelopathic qualities. It inhibits the growth of other plant species in its vicinity. The tall dense growth of Phragmites also blocks the sun and monopolizes the uptake of nutrients from the soil, making it difficult for other species to grow. Removal of Phragmites stalks, without disturbing the surrounding soil, allows for other plant species to germinate and grow in the cleared area. It was apparent that new plant growth occurred following the specific removal of the Phragmites stalks. It appears that the bank of seeds that is present in the soil responds well to the removal of the influence of the Phragmites.

It also appears that removing last year's standing dead stalks has some effect on the height of this year's growth but no effect on flowering. This may be a result of the phenomenon of "snorkeling" that this plant exhibits as a way of bringing oxygen to the rhizomes under the soil. Wet soil is typically very low in oxygen and the dead stalks and live stalks above the surface are able to transport oxygen down to the rhizomes and bring gases back up to the surface. If the dead stalks are removed, this appears to compromise the ability of the plant to transport oxygen to the rhizome, thereby affecting the growth of the plant.

A visit to the site at the beginning of October, one month after the end of the study, for additional photo documentation revealed observations that would continue to support the conclusions of this study. There was still no evidence of flowering in Sections 2, 3 & 4 at that time. These observations would continue to support the conclusion that the Phragmites should be removed either in July and August or in June, July and August to have the most effect on the growth of the plant. At a minimum, removal once midsummer also has an effect.

Section 2 (1 removal) - no flowers October 2, 2016

Section 3 (2 removals) - no flowers October 2, 2016

Section 4 (3 removals)– no flowers, October 2, 2016

Note: Sparse growth of Phragmites and other plant species present (Sections 2 & 3)
October 2, 2016

Next Steps

Phragmites cannot be completely controlled in one season. The rhizomes will continue to send up new shoots each season until using the energy that is stored underground in the rhizomes. By continually removing the stalks to prevent the plant from producing energy by the process of photosynthesis, the rhizomes will weaken and, hopefully, eventual wither and die. My past experience has shown that this process can take three to five years. This experiment should be repeated on the same site for at least the following season to determine the effectiveness of this year's work on the regrowth next spring and also to determine the effect of repeated cutting on the growth next season.

Another area of study might also be to document the regrowth of native and non-native species on the sites where Phragmites is being controlled as opposed to sites where it is not being controlled.

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