Phragmites Mapping and Evaluation of Management Options

Friends of Scarborough Marsh

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1 Introduction

The goal of this report is to provide the Friends of Scarborough Marsh (FOSM) with mapping of the current extent of invasive Phragmites (*Phragmites australis*) in the Scarborough Marsh, to evaluate potential causes for the individual patches, and to recommend habitat improvement strategies and priorities for treatment. This final report includes a brief report summarizing our methods and results, stand evaluation, the mapped Phragmites stands prioritized for treatment, and treatment recommendations.

2 Site Description

Scarborough Marsh (the Marsh) consists of approximately 3,070 acres, including subtidal river, and intertidal mud flats and salt marsh vegetation. Almost all of the salt marsh acreage of Scarborough Marsh is owned by the Maine Department of Inland Fisheries and Wildlife (IFW). The Marsh is the largest contiguous salt marsh in the state and has been identified as a high-quality estuary and salt marsh by numerous State and Federal agencies (IFW, U.S. Fish and Wildlife Services, National Marine Fisheries Services).

The study area is defined as all of Scarborough Marsh to the head of tide, as depicted using the 2015 Highest Annual Tide Line (HAT) layer from Maine Geological Survey (2018; Figure 1).

3 Methods

3.1 Phragmites mapping

3.1.1 Photointerpretation

All discernable Phragmites stands were mapped from aerial imagery. The most recent publicly available aerials for the Scarborough Marsh are from Maine's Geolibrary (2018a) Data Catalogue. These are georeferenced, true color, 3-inch orthophotos flown in spring, 2017. Based on these images, the minimum map unit used was 4000 square feet (approximately 0.1 acre). In many cases, Phragmites stands smaller than 4000 square feet were easily discernable and were mapped accordingly. Stands that were too small to delineate or too diffuse to identify during photo interpretation, are shown with a single point on the maps. This effort resulted in 111 mapped polygon stands and 54 small and/or diffuse mapped points.

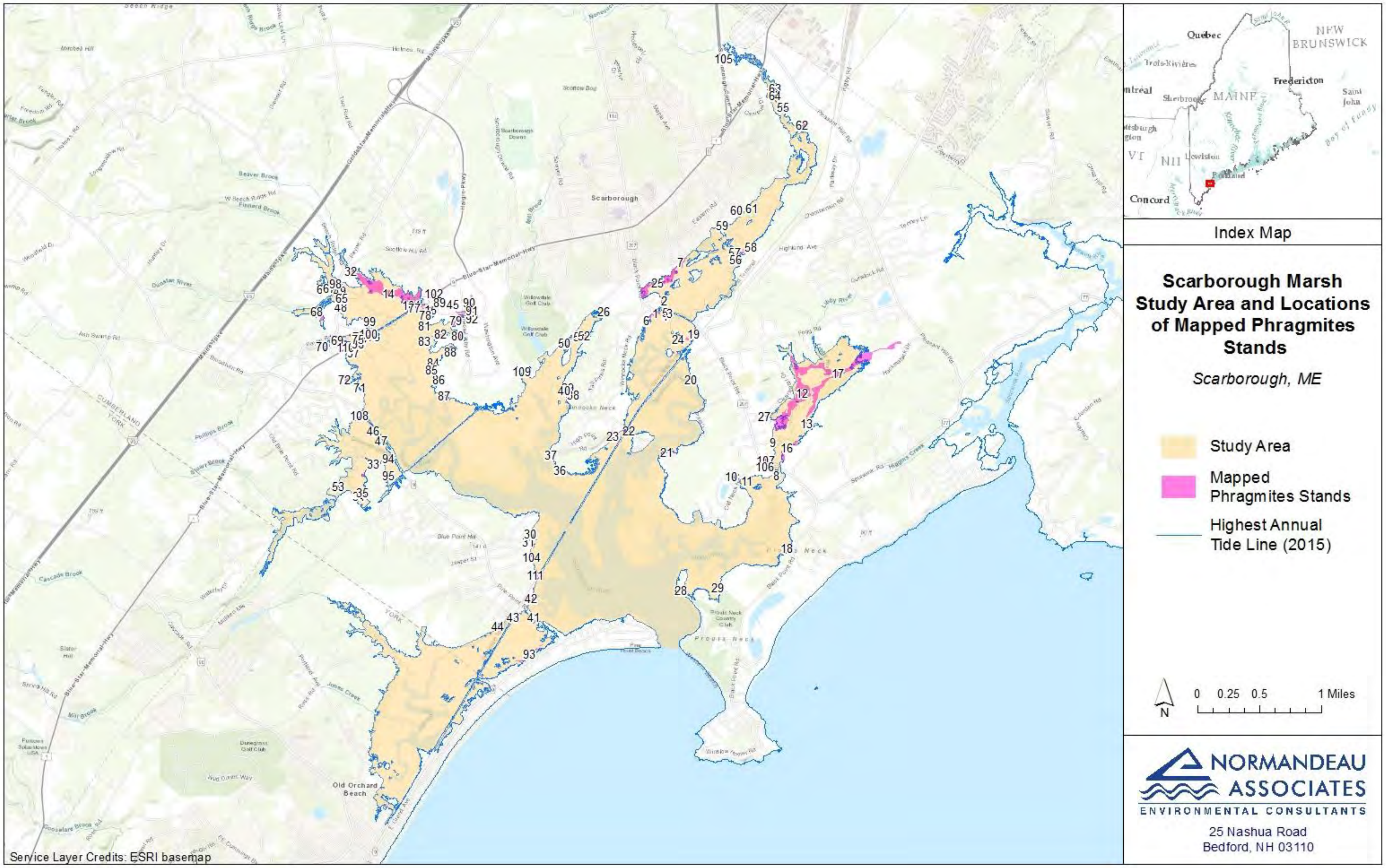

Figure 1. Scarborough Marsh study area and locations of Phragmites stands. For more detail, see Appendix A

3.1.2 Ground verification

To assess the accuracy of aerial interpretation, 18 photointerpreted stands (11%) were ground verified by wetland biologists familiar with Phragmites and other marsh vegetation. This verification involved a combination of site visits and visual assessments of stand presence, using binoculars and spotting scopes for areas that were not along public access roads or trails. Based on this verification, the aerial interpretation mapping was refined and completed.

3.1.3 Preliminary rankings

During the mapping and ground verification phases, Normandeau evaluated the potential factors that could be contributing to individual Phragmites stands' establishment and persistence. The three primary factors can be broadly categorized as low surface water salinities, elevated marsh surfaces relative to the tidal regime, and elevated nutrients from either upland surface water or groundwater sources. While the ecology of an individual site is undoubtedly more complex, evidence of one or more of these factors can be indicative of a potential stressor on the marsh, which could promote the establishment of Phragmites. Evidence of these factors on an individual Phragmites stand include position within the marsh, proximity to a tidal creek, proximity to upland, adjacent land use, other plant species present, depth to groundwater, previous studies on the marsh that can shed light on stand age and persistence, and earlier treatments.

Each mapped Phragmites stand was assessed for characteristics likely to affect the stand's potential to persist and expand. Five main characteristics were considered: number of tidal restrictions, distance from tidal creek, distance to uplands, adjacent land use, and size of stand. Each characteristic was then given a rank from 1 to 5, where 1 signified that the characteristic likely has a high probability of influence on the Phragmites stand. The five characteristics are described in more detail below.

3.1.3.1 Tidal Restrictions

This characteristic is based on the position of the stand within the marsh, and broadly defines the degree of restriction of tides from culverts, barriers and other manmade features. It is an indirect measure of both salinity and tide range. Ranks are based on the number of restrictions, largely drawing from *Stream Crossing Survey of the Scarborough Marsh Watershed* (Pinette 2017).

Rank (based on number of restrictions between the Phragmites stand and the mouth of Scarborough Marsh):

1. = 4 or more restrictions
2. = 3 restrictions
3. = 2 restrictions
4. = 1 restriction
5. = No restrictions

3.1.3.2 Distance from Tidal Creek

This characteristic estimates the linear distance of a stand from a mapped tidal creek. The NHD Flowline layer obtained from USGS (2018a) was used to identify tidal creeks greater than 3.3 feet in width. In ArcGIS Advanced, the 'Near' function was used to calculate the nearest distance of a mapped stand from a tidal creek at least one meter in width. These measurements were spot checked with aerial imagery for accuracy, unmapped creeks were added, and areas where the shortest distance to a tidal creek included an upland crossing were adjusted. Rankings were distributed based on a frequency distribution of measured values (0 feet to 952.4 ft).

Rank (based on distance of stand from nearest tidal creek):

1. = Greater than 400 feet
2. = Greater than 200 to 400 feet
3. = Greater than 100 to 200 feet
4. = Greater than 20 feet to 100 feet
5. = 0 to 20 feet

3.1.3.3 Distance to Uplands

This characteristic measures the relative position of and linear distance of the closest edge of a Phragmites stand to the 2015 HAT. It was calculated with the 'Near' function in ArcGIS Advanced and spot checked for accuracy, particularly for stands occurring above the highest annual line. For stands falling entirely or partially above the highest annual tide line, the proportion of the stand that were above and below the highest annual tide line were estimated.

Rank (based on stand proximity and relative position to the upland edge):

1. = 75 percent or more of stand is above HAT
2. = Less than 75 percent of the stand lies above HAT and stand is less than 25 feet below HAT
3. = Stand is 25 to less than 50 feet below HAT
4. = Stand is 50 feet to less than 100 feet below HAT
5. = Stand is 100 feet or more below the HAT

3.1.3.4 Adjacent Land Use

This characteristic considers adjacent upland land use within a 250-foot radius of the mapped stand. Development within the adjacent shoreline has been shown to increase the rate of spread of Phragmites (Sillman and Bertness 2004). This buffer distance was chosen based on its equivalency to the protected shoreland zone. One to three uses were listed, and grouped into three main categories: Developed, Mixed, and Undeveloped. The dominant (>50%) land use(s) were considered.

Rank (based on dominance of land use):

1. = Developed lands where dominant use included:
    a. Commercial
    b. Roadway
    c. Golf course
    d. Combination of roadway and commercial
    e. Combination of roadway and residential
2. = Developed lands where dominant use included:
    a. Residential (includes open fields/hay fields /pastures
    b. Agriculture (ROW crops)
    c. Railroads
    d. Combination of agriculture and commercial
    e. Combination of residential and roadway
3. = Mixed (combination of developed and undeveloped lands, with a prevalence of developed) including:
    a. Combination of commercial and forested
    b. Combination of residential and forested
    c. Combination of residential and shrub
4. = Mixed (combination of developed and undeveloped lands, with a prevalence of undeveloped) including:
    a. Combination of forested and commercial
    b. Combination of forested and residential
    c. Combination of forested and roadway
5. = Undeveloped lands where dominant use included:
    a. Forested
    b. Shrub
    c. Herbaceous

3.1.3.5 Size of Phragmites Stand

This factor assumes larger stands are more difficult to treat, and more resilient to treatment. Rankings were based on a frequency distribution of measured values (0.01 acres to 26.67 acres).

Rank (based on stand size)

1. = Stand is greater than 3 acres in size
2. = Stand is greater than 0.5 acres but less than or equal to 3 acres in size
3. = Stand is greater than 0.2 acres but less than or equal to 0.5 acres in size
4. = Stand is greater than 0.1 acres but less than or equal to 0.2 acres in size

5. = Stand is 0.1 acre or less in size

3.2 Representative Stands

3.2.1 Site Selection

Site selection of representative stands for field assessment was based on the rankings developed and other logistical considerations. A variety of ranks for each of the five categories was targeted, along with accessibility, stand features, and location within the Marsh (Table 1).

Table 1. Phragmites Stands Selected for Assessment sorted by Area.

ID	Size (Acres)	Relative Rank					Distance from Nearest Phragmites	Area
		Number of Tidal Restriction	Distance from Tidal Creeks	Distance from Upland	Land Use	Size		
-2*	0.43	3	5	2	5	3	73.09	Nonesuch River
-1*	0.15	3	5	3	4	4	73.09	Nonesuch River
14	26.67	2	5	2	5	1	71.58	Dunstan River
28	0.26	5	1	2	3	3	1405.42	Libby River
79	2.95	3	5	2	1	2	62.81	Dunstan River
96	0.04	3	5	2	1	5	44.06	Dunstan River
97	0.03	3	2	2	1	5	78.17	Dunstan River
98	0.01	1	4	2	1	5	63.15	Dunstan River
100	0.53	2	2	2	2	2	79.16	Dunstan River
101	0.47	3	1	2	1	3	33.64	Dunstan River
103	0.02	4	5	2	4	5	55.85	Mill Brook
104	0.69	4	5	2	4	2	19.37	Scarborough River
105	1.31	1	3	1	4	2	1733.62	Nonesuch River
106	0.03	4	2	2	2	5	100.05	Libby River
107	0.46	4	4	2	2	3	100.05	Libby River
108	0.19	2	1	1	1	4	826.47	Dunstan River
109	0.03	4	4	2	4	5	55.85	Mill Brook
111	0.30	4	5	2	5	3	19.37	Scarborough River

Notes:

*Stands -1 and -2 were mapped as Phragmites during aerial mapping, but were determined to be cattail during ground verification. They were removed from the data set.

3.2.2 Field Evaluations

The selected representative stands included a minimum of 10% of the mapped Phragmites stands. Fieldwork included an evaluation of the photointerpreted boundary and documentation of the plant species within and adjacent to the representative stands. Portions of the perimeter of each representative stand was ground delineated using a Trimble Geo-Positioning Systems (GPS) to determine the accuracy of the aerial photointerpretation. During the site visits, stands of Phragmites that were too small or too diffuse (mixed in with other vegetation) to be detected on the aerials were also noted. These stands were not delineated, but their approximate locations were depicted on the map. Stand characteristics recorded during the evaluation include approximate height of Phragmites, other plant species present within the stand and adjacent to it, substrates and depth to groundwater. Photographs of the representative stands are provided in Appendix B.

In addition to delineating stand boundaries, general locations of both mapped stands (polygons) and small stands (points) were verified when possible. Of the 111 mapped stands, locations for 94 stands were verified (85%), and 16 are based solely on aerial imagery. These 16 stands are thus likely to be accurate based on aerial signatures, but could also be cattail or other species obscured by treeline vegetation. Fifty-four small stands were noted in the field, and/or referenced from a map produced by Maine Audubon (1999). Of the 54 points, the general location of 48 were verified in the field (89%; Listed in Appendix C).

Field verification of stands revealed general consistency with mapped locations (Figure 2), but also identified some shortfalls of using aerial imagery signatures to map plant species, as discussed in section 3.2.3.

3.2.3 Mapping Adjustments

Based on data obtained from the field evaluations, the ranking metrics and stand polygons were revised as needed. Typical adjustments included carving out cattail (*Typha* spp.) from aerial interpreted stands (Figure 3), which are difficult to distinguish from Phragmites in the imagery, and adjusting the rankings based on any changes to stand boundaries. Other adjustments included adding areas of Phragmites that were obscured by trees or other overstory vegetation, mostly along treeline, and adding points of small and/or diffuse Phragmites stands (Figure 4). Mapping prior to field verification included 113 stands and 136.4 acres of Phragmites within the Marsh. Mapping post field verification included 111 stands totaling 133.5 acres and 54 diffuse/small stands.

Figure 2. Phragmites stands (106, 107) showing accuracy of aerial mapping.

Figure 3. Phragmites stands (104) showing aerial cattail misidentification (the boundary of stand 111 was not GPS located).

Figure 4. Phragmites stands (103 and 15) showing diffuse boundary.

4 Results

4.1 Field Evaluation

Of the 111 stands delineated through aerial interpretation, 17 were reviewed in the field (Figure 5). An additional 54 stands were marked by points to show locations of very small and/or diffuse stands not visible in the aerial imagery. The full listing of attribute data associated with all stands is provided in Appendix C.

Vegetation within and directly proximate to the Phragmites stands varied across the Marsh, presumably influenced by salinity and water levels. Phragmites, although dominant throughout most of the stands, was accompanied by a mix of species, predominantly along the outer margins. In the upper reaches of the Marsh (stands 19, 79, 106, 114, 115, and 122) common species within the stands included: narrow-leaved cattail (*Typha angustifolia*), creeping bent grass (*Agrostis stolinifera*), New York aster (*Aster novae-belgii),* seaside goldenrod (*Solidago semperviren*), and bindweed (*Convolvulus sepium*). Stands closer to the bay also included: spike grass (*Distichlis spicata*), and glasswort (*Salicornia depressa*). Poison ivy (*Toxicodendron radicans*) was noted in higher concentrations in stands along roads, rails, and side slopes.

Common marsh species occurring adjacent to the Phragmites stands in the upper reaches of the Marsh included salt hay (*Spartina patens*), salt marsh bulrush (*Bolboschoenus robustus*), and New York aster. Spike grass, seaside goldenrod, smooth cordgrass (*Spartina alterniflora*) and black grass (*Juncus geradii*) were more common closer to the Bay, while cattail was found adjacent to most stands in all areas of the Marsh.

Figure 5. Field Evaluated Phragmites stands.

Table 2. Summary of Stand Features Identified in Ground Verification

Stand ID	Hours From Low Tide[a]	Depth to Groundwater (in)[b]	Distance to Tidal Creek (ft)	Phragmites Average height (ft)[c]	Phragmites Average % Cover	Dominant Adjacent Vegetation
14	-3:02	Not Collected	150 - 450	12	Up to 100	*Typha, Bolboschoenus*
96	+5:10	4	Adjacent/ 100	11	100	*Symphyotrichum novae- belgii, Solidago sempervirens, Spartina pectinata*
97	+4:30	Surface	>500	8	50-90	*Typha angustifolia, Spartina patens*
98	-4:08	Surface	Adjacent	11	100	*Rosa virginiana, Agrostis stolonifera*
100	-5:22	Surface	300 - 500	11	95	*Symphyotrichum novae-belgii, Agrostis stolonifera, Spartina patens*
101*	+1:32	Variable (0 to 14)	>500	10	80 -100	*Spartina patens, Juncus gerardii, Solidago sempervirens, Symphyotrichum novae-belgii*
103	+3:47	16	Adjacent	7	75	*Spartina patens, Distichlis spicata, Solidago sempervirens*
104	+1:30	5	Adjacent	11	100	*Agrostis stolonifera, Bolboschoenus robustus, Spartina alterniflora*
105	+5:22	Not collected	Adjacent	12	100	*Typha latifolia,*
106	-5:56	Surface	>300	5	80	*Spartina alterniflora, Spartina patens, Distichlis spicata, Salicornia depressa*
107	-5:16	Surface	300	5	95	*Spartina patens*
108	+3:30	Surface	>400	14	100	*Typha angustifolia, Spartina patens, Spartina alterniflora*
109	+3:07	6	Adjacent	10	90	*Solidago sempervirens, Symphyotrichum novae-belgii, Spartina patens, Distichlis spicata*
111	+2:39	Surface	200	12	100	*Typha latifolia, Bolboschoenus robustus, Symphyotrichum novae-belgii*

Note: Stand 14 and 55 are contiguous; encompasses the north side of Dunstan Marsh.

Stand 105 not accessible due to fencing; observations made from adjacent roadway slope.

Stands 14, 96, 97, 98, 100, 104, 108, and 111 were evaluated on 27 September 2018.

Stands 101, 103, 105, 106, 107, and 109 were evaluated on 28 September 2018.

*Stand 101 was on multiple elevation gradients

[a] Low tide on 27 September 2018 was 0700 and 1922; low tide on 28 September 2018 was 0738 and 2004; both in reference to Portland Harbor

[b] Depth to groundwater measured by auger hole.

[c] Average height for stands 19, 67, and 98 are estimated values due to access/competing vegetation.

4.2 Establishing Treatment Priorities

A goal of this project is to determine which Phragmites stands would be most suitable for management or eradication by identifying those stands with characteristics most conducive to treatment. The prioritization is based on the ranks assigned to the five characteristics (tidal restrictions, distance from tidal creek, distance to uplands, adjacent land use, and size of stand). A score of 5 was assumed to represent a more treatable condition for each characteristic. A score of 1 was assumed to be more difficult to treat, therefore a lower priority. The rankings were assessed via three calculations: frequency of highest ranks for each stand (Freq5 in Table 3), frequency of ranks 4 or 5 (Freq4-5), and the sum of the ranks for each stand. (SumRanks). Freq5 is a frequency count of ranks equal to 5 from the five measured characteristics. Freq4_5 is the frequency of ranks equal to 4 or 5 in each of the five categories listed above. SumRanks is the sum of all ranks for the five characteristics. Only one stand, Stand 83) has a Freq5 value of 4, meaning 4 of the 5 characteristics had a rank of 5); four stands have a Freq5 value of 3; and 20 stands have a Freq5 value of 2. The SumRanks field better accounts for stands that have many rank values of 3 and 4. For example, a Phragmites stand with a rank equal to 4 for all five categories would have a SumRank value of 20. The Freq4_5 field appeared to best represent the higher scores of both Freq5 and SumRanks, and thus was used to assign highest priority for treatment of Phragmites stands. Using this field, 23 stands were identified as high priority for treatment (Table 3; Figure 6). A full list of rankings is provided in Appendix C.

This priority ranking makes the assumption that the stands most likely to successfully respond to treatment are those that are the least tidally restricted, closest to the tidal creek, furthest from the upland, with little adjacent development, and small in size. These treatment priorities align with current literature review for Phragmites management completed by Hazelton (2018) and Quirion *et al.* (2017). Hazelton writes, "Restoration efforts are best spent on high quality sites (e.g., less disturbed, lower anthropogenic nutrient loads, more native vegetation in landscape), as they are most likely to recover to a native state." He and others have documented that large stands are less receptive to treatment than small stands, so priority should be given to smaller stands (<0.25 acres) that are at risk for expanding (Hazelton 2018).

Quirion *et al.* also discuss the importance of targeting small stands for treatment, documenting an 83 percent probability of eradicating patches under 0.36 m^2 (<0.0001 acres) and 26 percent probability at 45 m^2 (0.01 acres). Large patches of Phragmites from the Adirondacks (3000 m^2 or about 0.75 acres) had only a two percent probability of eradication after treatment over a seven-year timeframe (Quirion *et al.* 2017).

Table 3. Preliminary List of Stands Identified as High Priority for Treatment

ID	Relative Ranks					Frequency of Rank 5	Sum of Ranks	Frequency of 4 and 5 Ranks	Priority
	Number of Tidal Restriction	Distance from Tidal Creeks	Distance from Upland	Land Use	Size				
104	4	5	4	4	5	2	22	5	High
61	3	5	5	5	5	4	23	4	High
52	4	5	3	5	5	3	22	4	High
103	4	5	2	4	5	2	20	4	High
109	4	4	2	4	5	1	19	4	High
83	3	3	5	5	5	3	21	3	High
53	2	5	3	5	5	3	20	3	High
78	3	1	5	5	5	3	19	3	High
30	4	5	2	3	5	2	19	3	High
51	4	3	2	5	5	2	19	3	High
56	3	5	2	5	4	2	19	3	High
11	5	5	2	2	4	2	18	3	High
20	5	4	2	2	5	2	18	3	High
34	2	2	5	5	4	2	18	3	High
35	2	2	4	5	5	2	18	3	High
8	5	4	2	1	5	2	17	3	High
21	5	4	1	5	2	2	17	3	High
50	4	1	2	5	5	2	17	3	High
54	2	4	1	5	5	2	17	3	High
40	4	3	2	5	4	1	18	3	High
37	4	2	2	5	4	1	17	3	High
42	5	2	2	4	4	1	17	3	High
87	3	4	1	5	4	1	17	3	High

Research has also shown that smaller patches of Phragmites have a greater rate of increase than larger patches (Hazelton 2018, Quirion *et al.* 2017). Phragmites is believed to spread rapidly by seed dispersal more so than transplanted vegetative shoots or plant parts (Belzile *et al.* 2009). Populations expand rapidly with increased genetic diversity, and only become large, clonal masses after competition between genetic variants has progressed for years. Genetic diversity decreases with stand age, where larger, established clones will shade out new seedlings, and thus expansion of these stands is much slower (Belzile *et al.* 2009, Hazelton 2018). Treatment of smaller Phragmites stands would thus not only increase the likelihood of removal, but would limit expansion and establishment of new stands in surrounding areas (Quirion *et al.* 2017).

5 Management Recommendations

Phragmites is notoriously resilient and eradication can require years of treatment and monitoring. FOSM will want to focus on those areas with a potential for long-term success, and to define success carefully. Eradication may not be a realistic or cost-effective goal, but habitat modification to enhance a stand for wildlife use, or to reduce its rate of expansion may be appropriate. Normandeau worked with FOSM to define the goals of the control program, and to select treatments that are likely to be effective.

5.1 Stand Rank Assessment

Based on conversations with FOSM, Phragmites treatment should target areas with reasonable access (assessed by distance from Maine Geolibrary's E911 Roads layer (2018b)), have high ecological benefit (corresponding to saltmarsh sparrow habitat and stands near/within the 3.3 foot marsh migration estimates from Maine Department of Agriculture, Conservation and Forestry (2018), and that are likely to be receptive to treatment based on the priorities and literature reviewed above. Stands likely to be receptive to treatment, based on size and proximity to other stands, should also considered.

5.1.1.1 Prioritized Rankings

Based on these goals and priorities, four characteristics were added to the ranking criteria to establish a final list of stands prioritized for treatment: saltmarsh sparrow habitat, stand access, marsh migration potential and distance to other Phragmites stands.

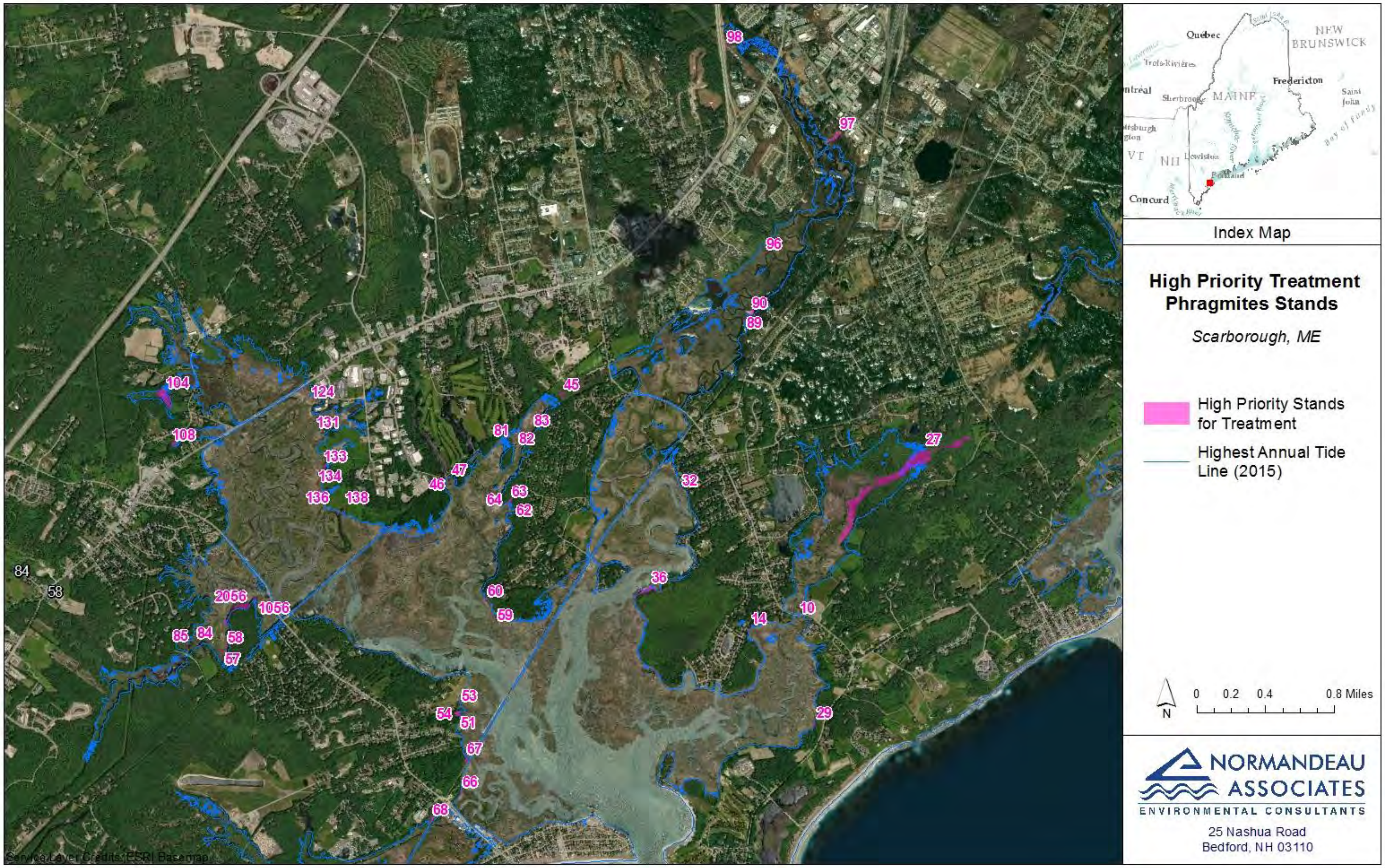

Figure 6. Mapped Phragmites stands by treatment priority.

5.1.1.2 Saltmarsh Sparrow Habitat

This characteristic is based on the position of the stand in relation to areas within Scarborough Marsh that were mapped as high productivity saltmarsh sparrow (*Ammospiza caudacuta*) habitat (K. Ruskin, unpubl data, hereafter "saltmarsh sparrow habitat"). Saltmarsh sparrows are considered at risk of extinction due to climate change (Bayard and Elphick 2011). Phragmites stands upgradient or within saltmarsh sparrow habitat may limit the availability of refugia as sea-level rise degrades existing habitat. Ranks are based on distance to the saltmarsh sparrow habitat and relative position in the landscape.

Rank (based on stand distance from 1 or more mapped saltmarsh sparrow habitat areas):

1. = Stand is ≥ 1000 feet downgradient from the nearest saltmarsh sparrow habitat or separated by a tidal restriction
2. = Stand is <1000 feet downgradient from the nearest saltmarsh sparrow habitat
3. = Stand is ≥ 1000 feet upgradient from the nearest saltmarsh sparrow habitat
4. = Stand is <1000 feet upgradient from the nearest saltmarsh sparrow habitat
5. = Stand overlaps 1 or more habitat areas

5.1.1.3 Stand Access

This characteristic measures the linear distance from the closest edge of a Phragmites stand to the 2017 Maine E911 Roads layer. It was calculated with the 'Near' function in ArcGIS Advanced. All Phragmites stands are within one-quarter mile of mapped E911 roads. Ranks were determined based on frequency distribution of the data.

Rank (based on stand proximity and relative position to E911 roads):

1. = Stand is 500 feet or more from an E911 Road
2. = Stand is 200 to less than 500 feet from an E911 Road
3. = Stand is 60 feet to less than 200 feet from an E911 Road
4. = Stand is 30 feet to less than 60 feet from an E911 Road
5. = Stand is less than 30 feet from an E911 Road

5.1.1.4 Marsh Migration Potential

This characteristic depicts the position of the stand in relation to a 3.3-foot vertical marsh migration potential. Ranks are based on the percentage of a stand that overlaps with the marsh migration zone. This metric favors treatment of stands on the east side of the marsh, where a greater area of marsh migration potential exists; the western side of the marsh has steeper slopes that limit marsh migration potential, which in turn limits treatment based on this metric.

Rank (based on overlap with marsh migration 3.3-foot marsh migration layer):

1. = No overlap with marsh migration zone
2. = <25% of stand falls within marsh migration zone
3. = ≥25% and <75% falls within marsh migration zone
4. = ≥75% and <90% falls within marsh migration zone

2\. 5. = ≥90% falls within marsh migration zone

5.1.1.5 Distance to Other Phragmites Stands

Stands in close proximity (<100 feet (Bazile et al. 2009)) to other Phragmites populations are likely to expand and possibly combine over time. Using the near function in ArcGIS advanced, distance was calculated to the nearest mapped stand to help assess which areas might benefit from treatment of multiple stands.

Rank (based on Phragmites stand distance to adjacent stands). Unlike distance from tidal creek, this is not a 'within marsh' distance, but rather the linear distance between features. This method more accurately reflects the ability of seeds to disperse by wind.

1\. = Stand is less than 100 feet from adjacent Phragmites stand

5\. = Stand is equal to or greater than 100 feet from an adjacent Phragmites stand

5.2 Stand Rank Selection

The above four metrics were used in combination with the preliminary metrics described in section 3.1.3 to develop a final list of stands that should be prioritized for treatment. Stands with at least three criteria with a rank greater than or equal to 4 and a total of all ranks of at least 25 were identified as priority stands, based on natural breaks in the distribution of these parameters. The 54 small or diffuse stands were not included in this analysis, as the points lacked the necessary precision for analysis on all parameters, but could generally be considered valuable eradication targets because of their small size.

Priority Phragmites treatment areas include 42 stands distributed widely throughout the marsh (Table 4). Of the four new metrics, the most common factors influencing stand selection were adjacent land use and size. Only one stand ranked 4 or 5 for the presence of saltmarsh sparrow habitat, likely a result of infrequency of co-occurrence of Phragmites and saltmarsh sparrows.

Table 4. Final Phragmites Treatment Priorities, sorted by Number of 4 and 5 Ranks.

Id	Relative Ranks									Number of 4 and 5 Ranks	Sum of Ranks	Recommended Treatment*
	Distance From Tidal Creeks	Distance from Upland	Land Use	Size	Tidal Restrictions	Saltmarsh Sparrow	Marsh Migration	Road Access	Distance from other Stands			
103	5	2	4	5	4	3	2	4	1	6	30	H
109	4	2	4	5	4	3	2	5	1	6	30	H
104	5	4	4	5	4	1	1	2	5	5	31	H
11	2	2	2	4	5	3	3	4	5	5	30	B
51	3	2	5	5	4	3	4	2	5	4	33	H
52	5	3	5	5	4	3	1	1	5	4	32	H
8	4	2	1	5	5	1	3	5	5	4	31	H
18	3	2	4	3	5	4	3	2	5	4	31	H
21	4	1	5	2	5	3	5	1	5	4	31	H
61	5	5	5	5	3	1	1	1	5	4	31	H
37	2	2	5	4	4	1	5	2	5	4	30	H
70	5	1	5	3	2	1	5	3	5	4	30	H
30	5	2	3	5	4	1	3	1	5	4	29	M
38	2	1	4	4	4	3	4	2	5	4	29	H
50	1	2	5	5	4	3	2	2	5	4	29	M
20	2	2	2	5	5	3	2	2	5	4	28	H
26	1	1	5	2	4	3	5	2	5	4	28	H
36	1	2	5	4	4	1	5	1	5	4	28	H
87	4	1	5	4	3	1	4	1	5	4	28	H
106	2	2	2	5	4	1	2	5	5	4	28	H
111	5	2	5	3	4	1	1	5	1	4	27	H
39	2	1	5	3	4	3	5	1	1	4	25	H
83	3	5	5	5	3	1	1	1	1	4	25	H
43	4	1	4	3	3	1	5	2	5	3	28	H
28	1	2	3	3	5	1	2	5	5	3	27	H
34	2	5	5	4	2	1	1	2	5	3	27	H
41	4	2	1	3	5	1	2	4	5	3	27	H
42	2	2	4	4	5	1	2	2	5	3	27	H
25	5	2	2	1	3	1	2	5	5	3	26	B
31	3	1	5	2	4	1	4	1	5	3	26	H
35	2	3	5	5	2	1	1	2	5	3	26	H
56	4	2	5	4	3	1	1	1	5	3	26	H
84	3	2	5	4	3	1	2	1	5	3	26	H
86	1	2	5	5	3	1	3	1	5	3	26	H

Id	Relative Ranks									Number of 4 and 5 Ranks	Sum of Ranks	Recommended Treatment*
	Distance From Tidal Creeks	Distance from Upland	Land Use	Size	Tidal Restrictions	Saltmarsh Sparrow	Marsh Migration	Road Access	Distance from other Stands			
93	1	2	2	2	4	5	2	3	5	3	26	H
94	3	2	5	4	2	1	2	2	5	3	26	H
105	3	1	4	4	1	1	4	3	5	3	26	H
16	4	2	2	2	4	1	3	2	5	3	25	M
27	1	1	2	3	4	1	5	3	5	3	25	H
29	3	2	1	4	5	1	3	1	5	3	25	H
107	3	2	2	3	4	1	2	3	5	3	25	H
110	2	1	1	4	2	1	5	4	5	3	25	H

* H=Herbicide, B=Burn, M=Mowing

5.3 Treatment Options

A number of treatment options are commonly used singly or in combination for the removal and/or control of Phragmites in tidal ecosystems. The most commonly utilized treatments include mowing/cutting, burning, herbicide application, and tidal flushing/flooding. Each of these methods are discussed in more detail below.

5.3.1 Mowing/Cutting

Mowing/cutting is a method used to control the spread of Phragmites. Timing of treatment is aimed at when the effects would cause the most stress to the plant, typically late summer after the plant has exerted energy into making plumes. This method requires several successive years to show success, and incorrect timing can actually stimulate growth and increase plant density (Hazelton 2018, Tiner 1995). Although not successful in eradicating Phragmites, mowing/cutting is often performed to reduce fire hazard potential in high-risk areas. Repeated mowing at short, regular intervals has shown success in reducing regrowth (Howell 2017) and success is enhanced when timed before seasonal flooding or when cut underwater (Hazelton 2018, Howell 2017). Covering cut stems with plastic for the duration of the growing season has also shown success (Hazelton 2018, Tiner 1995). These methods are similar to ‘spading’, where Phragmites stems are cut one to two inches below the soil surface between mid-July and mid-August, or twice during the growing season. This method starves the underground rhizomes and weakens the stand over time (Howell 2017, Short 2018). Mowing equipment can cause soil compaction, requiring pressure-sensitive gear that can be cost prohibitive (Tiner 1995) and may still affect the marsh surface. As an example, ruts from mowing in 2012 are still visible in 2018 aerial images of Phragmites stands in the Dunstan Marsh area near Route 1.

Additionally, mowing or cutting requires disposal of cut material to prevent further build-up of the peat. In order to prevent regrowth from cut stems, Mowed debris should be removed from site and buried at least 0.7 m below the soil surface and preferably 1m or more (Howell 2017).

5.3.2 Burning

Burning, when timed and conducted properly, can be an effective method of controlling Phragmites. Only a root burn will reduce the growth of an established stand, and should be performed in mid- to late summer when the plant is transporting nutrients into its roots. Burns that occur in winter and/or spring can stimulate growth. Burns should be repeated for several successive years for best results (Tiner 1995).

5.3.3 Herbicide

Treatment with either a glyphosate-based product or imazapyr have shown reasonable success in eradicating Phragmites, if applied at the right time of year and for multiple seasons (Hazelton 2018, Howell 2017). Timing of application should be late summer (August/September) after the plant has flowered and when its energy is diverted back into its roots. Some product labels recommend a second foliar treatment three weeks after the initial spray, before the end of the growing season. One study found that spraying prior to seed set reduced the need for follow up treatment during the next growing season (Howell 2017). Herbicides do present a risk to native vegetation and groundwater, which in turn could affect other organisms in aqueous environments. Imazapyr has shown greater success in reducing Phragmites after treatment than glyphosate-based products, but also shows a lower recovery rate of native vegetation (Hazelton 2018, Howell 2017). A wicking glove is one option for avoiding non-target effects, and cut-stem injection presents a second option. Herbicide treatment is often followed by native plantings, ideally one year or more after treatment, to allow the herbicide time to translocate through the Phragmites root systems and to prevent further spread when disrupting rhizomes for planting. However, studies on seed banks under large clonal Phragmites stands have shown great diversity of native plants and may diminish the need for any follow up planting if herbicide treatment has effectively killed the Phragmites (Hazelton 2018).

Herbicide treatment may be the most wide-spread option for controlling Phragmites, but results are often not looked at over more than a few years. Research over a multi-year study period showed herbicide use as most evident after the first treatment year, with subsequent years having a diminishing effect. This particularly applied to large, clonal stands (Hazelton 2018).

5.3.4 Tidal Flushing/Flooding

Altering the water regime and/or restoring tidal flow is another option for Phragmites treatment on a landscape scale. If flooding is a viable option, inundation for at least four months during the growing season will have the best results. If flooding is not a realistic option, restoring tidal flow may be more suitable. In many instances, Phragmites has proliferated in an area because of culverting or restricting tidal flow in the first place. By upgrading existing culverts to larger size or box culverts, installing self-regulating tide gates, or implementing other means to remove tidal exchange restrictions, Phragmites stands will decline with sufficiently high salinity (typically greater than 20 ppt, Lissner and Schierup 1997), and typically experience dieback within four years (Tiner 1995,). However, due to its deep rhizomes, well established stands of Phragmites have been shown to persist in salinities up to 45 ppt (Chambers et al 2003). In Ipswich, Massachusetts, restoration of tidal flushing was shown to result in landscape scale declines in phragmites, but it was ineffective at targeted removal (Buchsbaum et al 2006).

Tidal restoration has been implemented in five locations in Scarborough Marsh. The Seavey Landing Project was a 25-acre tidal site that had been negatively impacted by man-made ditches. To restore ditched areas, seven ditch plugs were installed and 15 pools were constructed to recreate deeper pools that existed prior to ditching. Restoration efforts at Seavey Landing were completed in 2002 (Cooperative Conservation 2017).

The second effort was aimed at restoring tidal flushing to Cascade Brook, one of five prominent tributaries within the Marsh, consisting of 100 acres of salt marsh. Cascade Brook was constricted by two underwater berms and an unused water control structure, and suffered degradation from flooding that led to piling of spoil material and peat piles and invasion by Phragmites into disturbed areas. Tidal flushing/flooding was restored by lowering the water control structure and partially removing the underwater berms. This work also involved restoring the marsh elevation and Phragmites control, and was completed in 2004 (Cooperative Conservation 2017).

Tidal restoration was incorporated into a third restoration effort, which focused on approximately 381 acres of the Mill Brook salt marsh. This area was restricted by man-made ditches, which limited tidal flow and consequently lowered the natural water table and destroyed pool habitat. Additionally, freshwater runoff from the development of surrounding upland areas led to proliferation of Phragmites. Restoration of tidal flow was accomplished through use of 25 ditch plugs, creation of one ditch and two breaches in man-made berms, and ditch maintenance in three locations. Phragmites treatment was also performed. These efforts were completed in 2005 (Cooperative Conservation 2017).

The fourth restoration targeted tidal restriction of 114 acres of the Libby River from an undersized culvert on Black Point Road (Route 207). The culvert reduced natural tidal flow by one-third. In conjunction with limited tidal flow, surrounding development and associated freshwater runoff led to the spread of Phragmites in approximately 30 acres of this section of the Marsh. This restoration phase involved installation of two new large culverts to return flow and salinity at Black Point Road (USFWS 2006). Portions of the Phragmites-infested areas on the west side of the Libby River Marsh were treated with herbicide in 2008.

A fifth tidal restoration project focused on a 247-acre subwatershed of the Marsh, the Nonesuch River. Similar to other restoration areas, the Nonesuch River experienced tidal restriction from old hayroads and man-made drainage ditches. In addition to changes in hydrology, these restrictions are thought to play a role in the establishment of Phragmites within sections of the River. Tidal restoration efforts involved breaching old hayroads and plugging ditches. Phragmites treatment was also conducted. (USFWS 2007).

5.3.5 Ongoing Research

New science and technology are emerging to control invasive plant species, at the forefront of which are biocontrols, fungal pathogens, and gene silencing. Howell's review of recent literature (2017) documents two stem feeding moths that prefer the invasive Phragmites to the native lineage. His review and others have also noted fungal pathogens as a potential management avenue (Hazelton 2018, Howell 2017). Furthermore, the USGS (2018b) have experimented with a gene silencing approach that limits the ability of Phragmites growth and reproduction. Locally, sugar is being tested as a means of increasing soil bacteria activity and increasing soil acidity (Burdick and Adamowicz in Hazelton 2018). With the attention invasive species are getting from scientists, land managers and citizens, a better solution to Phragmites management could be available in the near future. This would be especially beneficial in attempts to manage large, well-established stands in the Marsh that are currently very challenging to control.

5.3.6 Other Treatment Approaches

Additional options to control Phragmites, and manage land use should also be considered by FOSM to reduce the introduction and spread of Phragmites.

5.3.6.1 Outreach

By educating and involving citizens FOSM can obtain a more complete account of Phragmites stands in the Marsh, and how the boundaries of these stands change over time.

5.3.6.2 Reducing fill and fertilizer use

Reducing nearby fill and fertilizer use can also have a positive impact on preventing both the spread and establishment of Phragmites. Unclean fill can be contain seeds of invasive species, potentially adding not only Phragmites, but knotweed, loosestrife, and other plant species that can quickly degrade native marsh habitat. Fertilizer use from adjacent golf courses, farms and residential lawns can provide nutrients to give establishing Phragmites stands a competitive advantage. By limiting the amount of fertilizer applied to these areas, the potential runoff can be substantially decreased.

5.3.6.3 Increase Riparian Buffers

Increasing natural riparian buffers can be an efficient solution in reducing nutrient loads to marshes. By planting along the marsh edge, native plants are able to trap many of the excess nutrients that would otherwise runoff from developed areas during a rain storm or other precipitation event. A minimum planting buffer between a riparian area and nutrient source of

49 to 164 feet is recommended by Hawes and Smith of the Yale School of Forestry and Environmental Studies (2005).

5.3.6.4 Restoring marsh elevations

The Scarborough Marsh watershed has experienced substantial development pressure from surrounding areas over the past century. Development of nearby land has altered some of the natural elevations, often changing the composition of plant and pool structure in the Marsh. By removing fill and regrading areas to a more natural elevation, tidal waters can begin to flow into areas they had previously been, decreasing the suitability for Phragmites. This treatment option was performed in the second restoration phase, which restored tidal flushing to Cascade Brook. Removal of 5,000 cubic yards of spoil material on the Marsh surface and in tidal creeks as well as removal of peat piles was completed in 2004 (Cooperative Conservation 2017).

5.4 Treatment Recommendations

Based on the characteristics of stands prioritized for treatment, recommendations for the type of treatment were developed for each of the high-priority stands (Table 4; Figure 7, and Appendix C). Typically smaller stands and those along the upland edge of the marsh were recommended for herbicide. Stands located along tidal creeks or near other bodies of water were recommended to be burned to limit transport of herbicide. Large stands where elimination is not practicable but other factors resulted in high priority for treatment were recommended for periodic (infrequent) mowing as a temporary method to slow the expansion. It is likely that new technologies for treatment will be available for large stands in upcoming years.

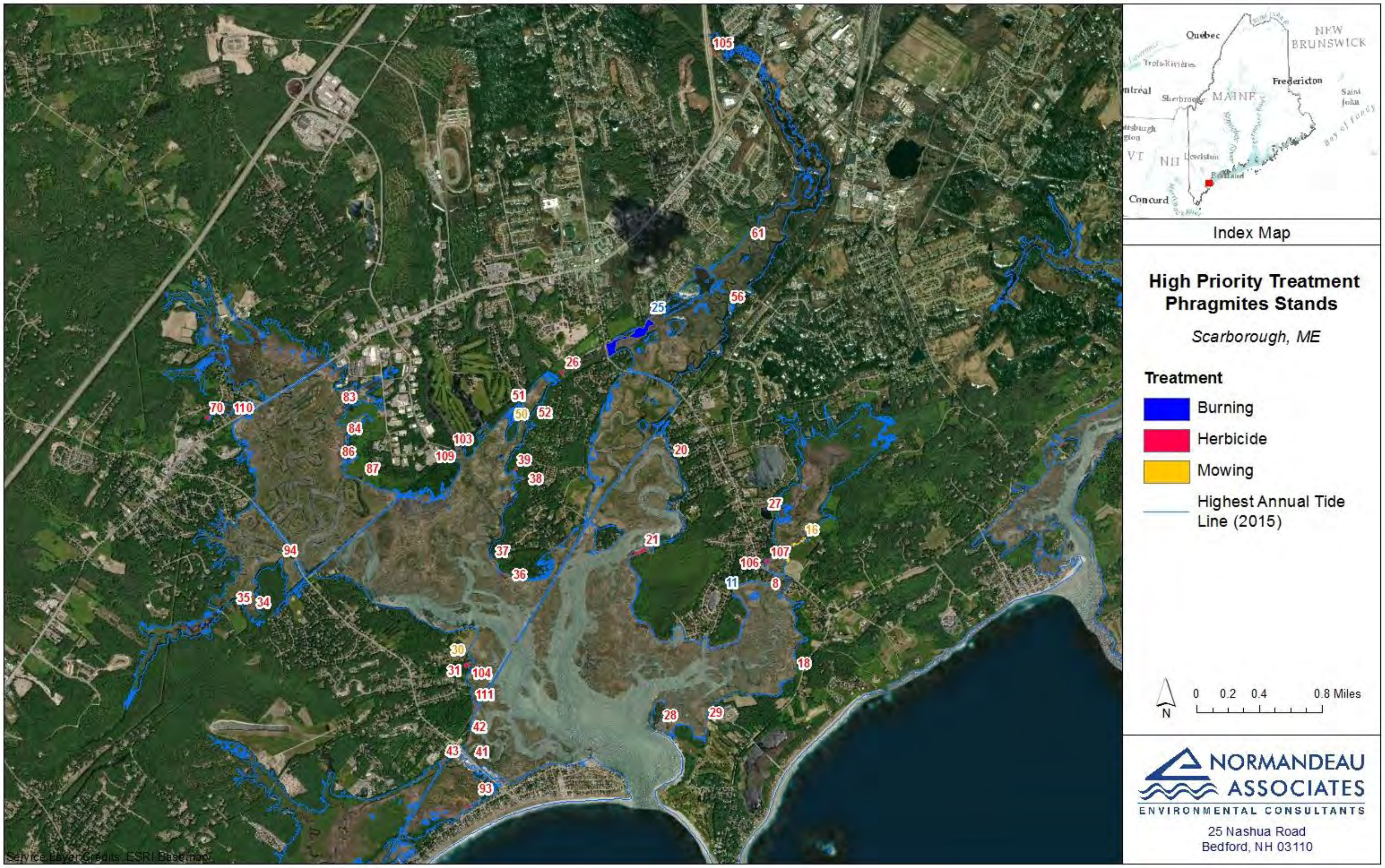

Figure 7. Mapped Phragmites stands by recommended treatment type.

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7 Appendices

Appendix A. Large Scale Map of Phragmites Stands


Index Map
Scarborough Marsh Phragmites Stands
Scarborough, ME
Small/Diffuse Phragmites Stands
Native Phragmites Stands
Phragmites stands
Highest Annual Tide Line (2015)
N
0 0.25 0.5 1 Miles
25 Nashua Road
Bedford, NH 03110

Appendix B. Photos of Field Evaluated Stands


Photo 1. Stand ID 14


Photo 2. Stand ID 14


Photo 3. Stand ID 14 Along Route 1


Photo 4. Stand ID 14 Along Route 1


Photo 5. Stand ID 96 and surrounding landscape


Photo 6. Stand ID 96


Photo 7. Stand ID 96 and surrounding landscape


Photo 8. Stand ID 96

Photo 9. Stand ID 97

Photo 11. Stand ID 97

Photo 10. Stand ID 97 and surrounding landscape

Photo 12. Stand ID 97 and surrounding landscape

Photo 13. Stand ID 98

Photo 14. Stand ID 98 and surrounding landscape

Photo 15. Stand ID 98

Photo 16. Stand ID 98 surrounding landscape


Photo 17. Stand ID 100 and surrounding landscape


Photo 18. Stand ID 100 and surrounding landscape


Photo 19. Stand ID 100 and surrounding landscape


Photo 20. Stand ID 100 and surrounding landscape

Photo 21. Stand ID 101 and surrounding landscape

Photo 23. Stand ID 101 and diffuse vegetation

Photo 22. Stand ID 101

Photo 24. Stand ID 101 and surrounding landscape


Photo 25. Stand ID 103 (right) and 47 (left)


Photo 27. Stand ID 103 surrounding landscape


Photo 26. Stand ID 103


Photo 28. Stand ID 103 surrounding landscape

Photo 29. Stand ID 104

Photo 30. Stand ID 104 and surrounding landscape

Photo 31. Stand ID 104 and surrounding landscape

Photo 32. Stand ID 104 and surrounding landscape


Photo 33. Stand ID 106


Photo 35. Stand ID 106


Photo 34. Stand ID 106 surrounding landscape


Photo 36. Stand ID 106 surrounding landscape

Photo 37. Stand ID 107 and surrounding landscape

Photo 38. Stand ID 107 and surrounding landscape

Photo 39. Stand ID 107 disturbed area

Photo 40. Stand ID 107 disturbed area


Photo 41. Stand ID 108


Photo 42. Stand ID 108 and surrounding landscape


Photo 43. Stand ID 108


Photo 44. Stand ID 108 and surrounding landscape

Appendix C. Full Attribute Table for Phragmites Stands

Id	Shape *	FieldVer	Visit	Tide_Restr	Dist_Tidal	Dist_Uplan	AdjLandUse	Acres	Dist_Phrag	E911_Distance	TRestr_Rnk	TidCrk_Rnk	DisUp_Rnk	AdjLU_Rnk	Size_Rnk	Access_Rnk	MMig_Rnk	SMSP_Rnk	Phrag_Rnk	Freq5	Freq4/5	SumRanks	Priority	Treatment
1	Polygon	Y	0	1	209	0.0	Developed (residential, roadway)	0.80	34.086442	21.83242	4	2	2	2	2	5	2	1	1	1	2	21	N	NA
2	Polygon	Y	0	2	171	57.0	Developed (roadway, residential)	0.01	36.226021	143.506	3	3	4	1	5	3	1	1	1	2	3	22	N	NA
3	Polygon	Y	0	1	108.18	2.8	Developed (roadway)	0.02	71.167855	23.95144	4	3	2	1	5	5	1	1	1	2	4	23	N	NA
4	Polygon	Y	0	1	187	21.7	Developed (roadway)	0.31	14.319557	43.96018	4	3	2	1	3	4	1	1	1	1	2	20	N	NA
5	Polygon	Y	0	1	261	4.6	Developed (roadway)	0.04	14.319557	32.30039	4	2	2	1	5	4	1	1	1	1	3	21	N	NA
6	Polygon	Y	0	1	246.86	0.0	Developed (residential)	0.55	34.086442	188.9131	4	2	2	2	2	3	3	1	1	1	2	20	N	NA
7	Polygon	Y	0	2	40.29	8.5	Mix (residential, forested)	0.99	100.83485	153.8607	3	4	2	3	2	3	1	1	5	1	2	24	N	NA
8	Polygon	Y	0	0	26.46	0.0	Developed (roadway)	0.02	404.59948	21.97502	5	4	2	1	5	5	3	1	5	3	4	31	Y	H
9	Polygon	Y	0	1	103.8	0.0	Developed (residential)	0.33	366.53002	85.43788	4	3	2	2	3	3	2	1	5	2	2	25	N	NA
10	Polygon	Y	0	1	550	0.0	Developed (residential)	0.63	225.89339	123.6017	4	1	1	2	2	3	3	3	5	0	2	24	N	NA
11	Polygon	Y	0	0	289	0.0	Developed (residential)	0.14	225.89339	30.87982	5	2	2	2	4	4	3	3	5	2	5	30	Y	B
12	Polygon	Y	0	1	0	0.0	Mix (forested, residential)	33.28	39.536106	191.7988	4	5	2	4	1	3	2	1	1	2	4	23	N	NA
13	Polygon	N	0	1	0	9.6	Mix (residential, forested)	0.62	31.262112	874.4003	4	5	2	3	2	1	1	1	1	2	2	20	N	NA
14	Polygon	Y	1	3	92	0.0	Undeveloped (forested)	26.79	71.5763	31.42446	2	4	2	5	1	4	2	1	1	2	4	22	N	NA
15	Polygon	Y	0	2	90	0.0	Developed (commercial)	0.81	93.320471	32.82362	3	4	2	1	2	4	2	1	1	0	1	20	N	NA
16	Polygon	Y	0	1	37.62	0.0	Developed (residential)	2.73	366.53002	360.9955	4	4	2	2	2	2	3	1	5	1	3	25	Y	M
17	Polygon	Y	0	1	0	0.0	Mix (forested, residential)	21.51	31.262112	294.7594	4	5	2	4	1	2	3	1	1	1	4	23	N	NA
18	Polygon	Y	0	0	120.23	0.0	Mix (forested, residential)	0.25	3226.9272	219.3447	5	3	2	4	3	2	3	4	5	3	4	31	Y	H
19	Polygon	Y	0	1	173	0.0	Developed (residential, roadway)	1.04	109.56684	125.0567	4	3	2	2	2	3	2	1	5	1	2	24	N	NA
20	Polygon	Y	0	0	275.38	0.0	Developed (residential)	0.09	1554.4511	206.4859	5	2	2	2	5	2	2	3	5	4	4	28	Y	H
21	Polygon	Y	0	0	54	0.0	Undeveloped (forested)	1.35	1779.5406	707.2	5	4	1	5	2	1	5	3	5	4	4	31	Y	H
22	Polygon	Y	0	1	1012	0.0	Developed (roadway, residential)	0.37	25.996432	14.7469	4	1	2	1	3	5	2	1	1	1	2	20	N	NA
23	Polygon	N	0	1	568	0.0	Developed (residential)	0.42	180.89234	356.1266	4	1	2	2	3	2	3	1	5	0	1	23	N	NA
24	Polygon	Y	0	1	25.5	23.2	Developed (railroad)	0.25	109.56684	599.589	4	4	2	2	3	1	1	1	5	1	2	23	N	NA
25	Polygon	Y	0	2	0	0.0	Developed (residential)	8.43	100.83485	28.22737	3	5	2	2	1	5	2	1	5	1	3	26	Y	B
26	Polygon	Y	0	1	695	0.0	Undeveloped (shrub, forested)	0.50	1258.8911	302.1819	4	1	1	5	2	2	5	3	5	2	4	28	Y	H
27	Polygon	Y	0	1	512.57	0.0	Developed (residential)	0.43	122.09875	82.56648	4	1	1	2	3	3	5	1	5	1	3	25	Y	H
28	Polygon	Y	0	0	463	0.0	Mix (residential, forested)	0.29	1405.4237	24.88756	5	1	2	3	3	5	2	1	5	2	3	27	Y	H
29	Polygon	Y	0	0	110.16	0.0	Developed (golf course)	0.16	1405.4237	1200.127	5	3	2	1	4	1	3	1	5	1	3	25	Y	H
30	Polygon	N	0	1	5.25	0.0	Mix (residential, forested)	0.01	227.90439	652.4867	4	5	2	3	5	1	3	1	5	2	4	29	Y	M
31	Polygon	N	0	1	153	0.0	Undeveloped (forested)	0.54	227.90439	555.9082	4	3	1	5	2	1	4	1	5	2	3	26	Y	H
32	Polygon	Y	0	3	7.53	0.0	Developed (agriculture, commercial)	0.19	89.684718	146.6025	2	5	2	2	4	3	2	1	1	2	3	22	N	NA
33	Polygon	Y	0	3	92	0.0	Undeveloped (forested)	1.74	153.15	687.7241	2	4	2	5	2	1	2	1	5	0	2	24	N	NA
34	Polygon	Y	0	3	260	117.3	Undeveloped (forested)	0.11	153.80291	430.8244	2	2	5	5	4	2	1	1	5	1	3	27	Y	H
35	Polygon	Y	0	3	299	40.5	Undeveloped (forested)	0.07	153.80291	463.4343	2	2	3	5	5	2	1	1	5	2	3	26	Y	H
36	Polygon	Y	0	1	514	0.0	Undeveloped (forested)	0.14	382.32284	589.0768	4	1	2	5	4	1	5	1	5	3	4	28	Y	H
37	Polygon	Y	0	1	253	0.0	Undeveloped (forested)	0.13	382.32284	308.0775	4	2	2	5	4	2	5	1	5	4	4	30	Y	H
38	Polygon	N	0	1	344	0.0	Mix (forested, residential)	0.11	297.68887	241.45	4	2	1	4	4	2	4	3	5	4	4	29	Y	H
39	Polygon	N	0	1	231	0.0	Undeveloped (forested)	0.21	60.534063	594.2796	4	2	1	5	3	1	5	3	1	3	4	25	Y	H
40	Polygon	N	0	1	141	5.1	Undeveloped (forested)	0.10	60.534063	691.5992	4	3	2	5	4	1	1	3	1	3	4	24	N	NA

Id	Shape *	FieldVer	Visit	Tide_Restr	Dist_Tidal	Dist_Uplan	AdjLandUse	Acres	Dist_Phrag	E911_Distance	TRestr_Rnk	TidCrk_Rnk	DisUp_Rnk	AdjLU_Rnk	Size_Rnk	Access_Rnk	MMig_Rnk	SMSP_Rnk	Phrag_Rnk	Freq5	Freq4/5	SumRanks	Priority	Treatment
41	Polygon	Y	0	0	50.26	0.0	Developed (roadway, commercial)	0.20	492.82424	33.37005	5	4	2	1	3	4	2	1	5	3	3	27	Y	H
42	Polygon	Y	0	0	251.91	0.0	Mix (forested, commercial)	0.14	492.82424	339.0754	5	2	2	4	4	2	2	1	5	2	3	27	Y	H
43	Polygon	Y	0	2	46	0.0	Mix (forested, commercial)	0.30	319.59067	270.7937	3	4	1	4	3	2	5	1	5	2	3	28	Y	H
44	Polygon	Y	0	2	236	12.6	Mix (residential, forested)	0.43	319.59067	339.8993	3	2	2	3	3	2	1	1	5	0	2	22	N	NA
45	Polygon	Y	0	3	806	0.0	Developed (commercial)	0.39	62.805481	25.98982	2	1	1	1	3	5	4	1	1	2	2	19	N	NA
46	Polygon	Y	0	3	291	0.0	Developed (roadway)	0.15	433.45369	24.17472	2	2	2	1	4	5	2	1	5	1	2	24	N	NA
47	Polygon	Y	0	3	122	2.3	Developed (roadway)	0.04	433.45369	56.62329	2	3	2	1	5	4	1	1	5	1	3	24	N	NA
48	Polygon	Y	0	3	40.12	17.4	Developed (roadway)	0.04	52.315307	36.57919	2	4	2	1	5	4	1	1	1	2	3	21	N	NA
49	Polygon	Y	0	3	0	0.0	Developed (roadway, residential)	0.63	63.149477	22.42506	2	5	2	1	2	5	2	1	1	1	3	21	N	NA
50	Polygon	Y	0	1	517	0.0	Undeveloped (forested)	0.07	405.4622	254.8973	4	1	2	5	5	2	2	3	5	2	4	29	Y	M
51	Polygon	Y	0	1	196	0.0	Undeveloped (forested)	0.04	405.4622	339.6457	4	3	2	5	5	2	4	3	5	2	4	33	Y	H
52	Polygon	Y	0	1	19.78	28.7	Undeveloped (forested)	0.02	409.41449	573.1645	4	5	3	5	5	1	1	3	5	2	4	32	Y	H
53	Polygon	Y	0	3	0	49.4	Undeveloped (forested)	0.02	53.300866	537.8843	2	5	3	5	5	1	1	1	1	4	4	24	N	NA
54	Polygon	Y	0	3	56.05	0.0	Undeveloped (forested)	0.02	53.300866	582.8451	2	4	1	5	5	1	3	1	1	2	3	23	N	NA
55	Polygon	N	0	3	109	0.0	Mix (forested, commercial)	0.39	464.23368	609.4113	2	3	1	4	3	1	3	1	5	1	1	23	N	NA
56	Polygon	Y	0	2	41.5	9.4	Undeveloped (forested)	0.12	252.1489	978.8405	3	4	2	5	4	1	1	1	5	2	3	26	Y	H
57	Polygon	Y	0	2	99	7.7	Undeveloped (forested)	0.35	210.50943	995.7183	3	4	2	5	3	1	1	1	5	2	2	25	N	NA
58	Polygon	Y	0	2	115	22.5	Undeveloped (forested)	0.57	210.50943	783.5732	3	3	2	5	2	1	1	1	5	1	1	23	N	NA
59	Polygon	Y	0	2	107	0.0	Developed (residential)	0.33	745.12459	116.6641	3	3	1	2	3	3	5	1	5	1	2	26	N	NA
60	Polygon	Y	0	2	372.96	0.0	Mix (residential, shrub)	0.05	562.95193	82.39993	3	2	1	3	5	3	1	1	5	1	1	24	N	NA
61	Polygon	N	0	2	18.39	192.3	Undeveloped (shrub)	0.08	562.95193	726.4451	3	5	5	5	5	1	1	1	5	3	4	31	Y	H
62	Polygon	N	0	3	69	0.0	Undeveloped (forested)	0.96	977.54387	637.4318	2	4	1	5	2	1	2	1	5	1	2	23	N	NA
63	Polygon	N	0	3	66	0.0	Developed (commercial)	0.33	94.36816	625.1313	2	4	1	1	3	1	4	1	1	1	2	18	N	NA
64	Polygon	N	0	3	161.11	0.0	Developed (commercial)	0.17	94.36816	665.5824	2	3	1	1	4	1	3	1	1	1	1	17	N	NA
65	Polygon	Y	0	3	1.97	7.5	Developed (roadway, residential)	0.10	52.315307	30.62836	2	5	2	1	4	4	1	1	1	2	3	21	N	NA
66	Polygon	N	0	4	234.74	0.0	Developed (residential)	0.09	66.656509	187.1798	1	2	2	2	5	3	3	1	1	0	1	20	N	NA
67	Polygon	Y	0	4	315.54	0.0	Developed (residential)	0.02	66.656509	203.5512	1	2	1	2	5	2	4	1	1	1	2	19	N	NA
68	Polygon	Y	0	4	0	0.0	Undeveloped (forested)	2.83	797.67927	413.587	1	5	2	5	2	2	2	1	5	1	2	25	N	NA
69	Polygon	Y	0	3	0	0.0	Developed (residential)	2.83	244.94901	53.71275	2	5	2	2	2	4	2	1	5	2	2	25	N	NA
70	Polygon	N	0	3	0	0.0	Undeveloped (forested)	0.39	290.46675	136.5881	2	5	1	5	3	3	5	1	5	3	4	30	Y	H
71	Polygon	N	0	2	453	0.0	Undeveloped (forested)	0.45	441.56069	742.6792	3	1	2	5	3	1	3	1	5	1	1	24	N	NA
72	Polygon	N	0	2	478	0.0	Mix (forested, commercial)	0.43	441.56069	533.0133	3	1	1	4	3	1	4	1	5	1	2	23	N	NA
73	Polygon	Y	0	2	98	66.6	Developed (roadway)	0.37	46.600662	113.5265	3	4	4	1	3	3	1	1	1	1	2	21	N	NA
74	Polygon	Y	0	2	150	0.0	Developed (roadway)	0.19	46.600662	38.35038	3	3	2	1	4	4	2	1	1	2	2	21	N	NA
75	Polygon	Y	0	3	1.58	4.1	Developed (roadway)	0.05	27.07642	37.07102	2	5	2	1	5	4	1	1	1	2	3	22	N	NA
76	Polygon	Y	0	3	20.66	4.2	Developed (roadway)	0.14	27.07642	41.48371	2	4	2	1	4	4	1	1	1	2	3	20	N	NA
77	Polygon	Y	0	2	562	5.8	Developed (roadway)	0.11	33.642704	35.1813	3	1	2	1	4	4	1	1	1	1	2	18	N	NA
78	Polygon	Y	0	2	592	141.6	Undeveloped (forested)	0.03	57.72647	455.5576	3	1	5	5	5	2	1	1	1	0	4	24	N	NA
79	Polygon	Y	0	2	327	0.0	Developed (roadway, commercial)	2.95	62.805481	32.50141	3	2	2	1	2	4	2	1	1	1	2	18	N	NA
80	Polygon	Y	0	2	543	0.0	Developed (roadway, commercial)	1.69	334.3739	21.58368	3	1	2	1	2	5	2	1	5	0	1	22	N	NA

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81	Polygon	Y	0	2	282	0.0	Mix (commercial, forested)	0.35	57.72647	376.944	3	2	2	3	3	2	2	1	1	1	1	19	N	NA
82	Polygon	Y	0	2	162.61	0.0	Undeveloped (forested, herbaceous)	0.29	95.269309	695.3021	3	3	2	5	3	1	2	1	1	2	2	21	N	NA
83	Polygon	Y	0	2	142.13	127.6	Undeveloped (forested)	0.05	95.269309	996.6192	3	3	5	5	5	1	1	1	1	3	4	25	Y	H
84	Polygon	Y	0	2	142	0.0	Undeveloped (forested, shrub)	0.17	130.60408	1201.489	3	3	2	5	4	1	2	1	5	1	3	26	Y	H
85	Polygon	Y	0	2	391.17	12.6	Undeveloped (forested, herbaceous)	0.11	130.60408	1158.541	3	2	2	5	4	1	1	1	5	0	2	24	N	NA
86	Polygon	Y	0	2	580	0.0	Undeveloped (shrub, herbaceous)	0.09	488.62155	786.6316	3	1	2	5	5	1	3	1	5	1	3	26	Y	H
87	Polygon	Y	0	2	27.49	0.0	Undeveloped (herbaceous)	0.18	497.36374	676.0699	3	4	1	5	4	1	4	1	5	3	4	28	Y	H
88	Polygon	Y	0	2	788	7.2	Undeveloped (shrub)	0.18	422.6668	535.7711	3	1	2	5	4	1	1	1	5	1	2	23	N	NA
89	Polygon	Y	0	3	1017	0.0	Developed (commercial)	0.07	151.32866	76.9023	2	1	1	1	5	3	5	1	5	1	2	24	N	NA
90	Polygon	Y	0	3	1286	0.0	Developed (commercial)	1.16	96.846105	213.7073	2	1	1	1	2	2	5	1	1	0	1	16	N	NA
91	Polygon	Y	0	3	1349	0.0	Mix (commercial, forested)	0.10	92.667928	222.3446	2	1	1	3	4	2	3	1	1	0	1	18	N	NA
92	Polygon	Y	0	3	943	0.0	Developed (roadway, commercial)	1.10	63.525646	30.80433	2	1	1	1	2	4	3	1	1	0	1	16	N	NA
93	Polygon	Y	0	1	561.97	0.0	Developed (residential)	1.25	1357.76	120.4319	4	1	2	2	2	3	2	5	5	2	3	26	Y	H
94	Polygon	Y	0	3	123.16	0.0	Undeveloped (forested)	0.14	153.15	411.4751	2	3	2	5	4	2	2	1	5	2	3	26	Y	H
95	Polygon	Y	0	3	153.03	0.0	Undeveloped (forested)	0.28	492.14	192.7932	2	3	2	5	3	3	1	1	5	2	2	25	N	NA
96	Polygon	Y	1	2	9.71	0.0	Developed (roadway)	0.07	68.903395	38.63524	3	5	2	1	5	4	2	1	1	2	4	24	N	NA
97	Polygon	Y	1	2	267.72	0.0	Developed (roadway, residential)	0.08	68.903395	37.3997	3	2	2	1	5	4	3	1	1	2	3	22	N	NA
98	Polygon	Y	1	4	0	8.0	Developed (roadway)	0.01	81.27265	28.77559	1	5	2	1	5	5	1	1	1	2	3	22	N	NA
99	Polygon	Y	1	3	354.47	22.1	Developed (residential)	0.30	79.600725	147.595	2	2	2	2	3	3	1	1	1	1	1	17	N	NA
100	Polygon	Y	1	3	453.61	0.0	Developed (roadway)	0.13	79.600725	34.4037	2	1	2	1	4	4	3	1	1	1	2	19	N	NA
101	Polygon	Y	1	2	731	0.0	Developed (roadway, commercial)	0.97	14.675408	36.9529	3	1	2	1	2	4	2	1	1	1	1	17	N	NA
102	Polygon	Y	0	2	973.07	0.0	Developed (roadway, commercial)	0.07	122.43	29.54898	3	1	1	1	5	5	3	1	5	1	2	25	N	NA
103	Polygon	Y	1	1	0	0.0	Mix (forested, golf course, bike path)	0.03	33.442168	38.29951	4	5	2	4	5	4	2	3	1	3	6	30	Y	H
104	Polygon	Y	1	1	0	50.2	Mix (forested, residential)	0.02	442.81829	391.1159	4	5	4	4	5	2	1	1	5	4	5	31	Y	H
105	Polygon	Y	1	4	161.5	0.0	Mix (forested, roadway)	0.18	1773.624	97.45395	1	3	1	4	4	3	4	1	5	3	3	26	Y	H
106	Polygon	Y	1	1	311.78	0.0	Developed (residential, roadway)	0.06	139.71073	28.92422	4	2	2	2	5	5	2	1	5	2	4	28	Y	H
107	Polygon	Y	1	1	119.4	0.0	Developed (residential, forested)	0.46	133.50323	177.2778	4	3	2	2	3	3	2	1	5	1	3	25	Y	H
108	Polygon	Y	1	3	401	0.0	Developed (commercial, roadway, forested)	0.12	826.47452	33.36611	2	1	1	1	4	4	3	1	5	1	2	22	N	NA
109	Polygon	Y	1	1	57.41	0.0	Mix (forested, golf course, bike path)	0.00	33.442168	28.24594	4	4	2	4	5	5	2	3	1	3	6	30	Y	H
110	Polygon	Y	0	3	248	0.0	Developed (roadway, residential)	0.13	146.16	30.29821	2	2	1	1	4	4	5	1	5	1	3	25	Y	H
111	Polygon	Y	1	1	16	0.0	Undeveloped (forested)	0.30	19.370368	0	4	5	2	5	3	5	1	1	1	2	4	27	Y	H