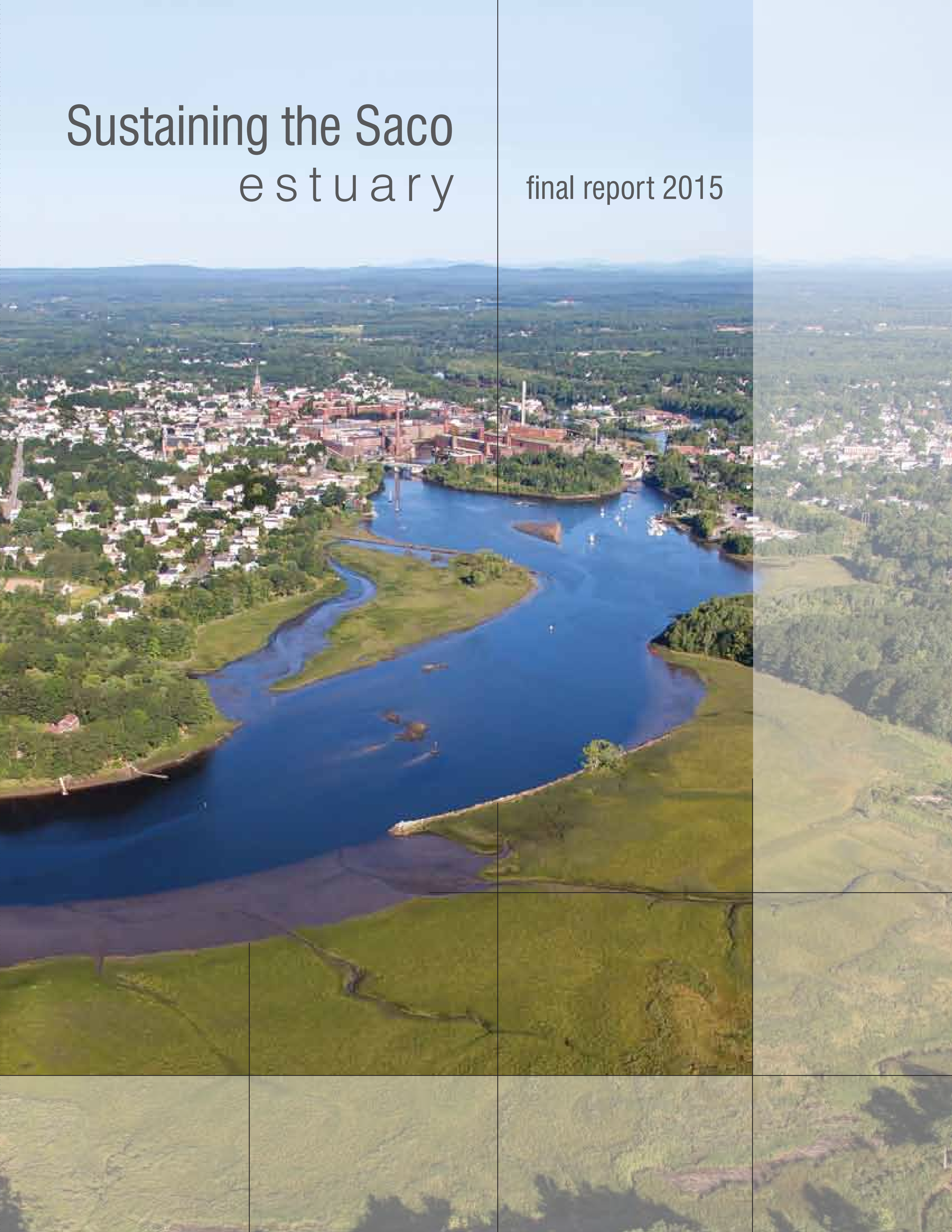
Sustaining the Saco estuary

final report 2015



Sustaining the Saco
estuary

final report 2015

Project Leaders

Christine B. Feurt, Ph.D.
University of New England and
Wells National Estuarine Research Reserve
Tel: (207) 602-2834
Email: cfeurt@une.edu

Pamela A. Morgan, Ph.D.
University of New England
Tel: (207) 602-2227
Email: pmorgan@une.edu

Project Team

University of New England
Mark Adams, Ph.D.
Anna Bass, Ph.D.
Carrie Byron, Ph.D.
Michael Daley, Ph.D.
Michael Esty
Noah Perlut, Ph.D.
Michele Steen-Adams, Ph.D.
James Sulikowski, Ph.D.
Stephan I. Zeeman, Ph.D.

Wells National Estuarine Research Reserve
Jacob Aman
Michele Dionne, Ph.D.
Jeremy Miller
Kristin Wilson, Ph.D.

This research is part of Maine's Sustainability Solutions Initiative, a program of the Senator George J. Mitchell Center, which is supported by National Science Foundation award EPS-0904155 to Maine EPSCoR at the University of Maine.

Report Editing and Design: Waterview Consulting

CONTENTS

CHAPTER 3

PLANTS OF THE SACO ESTUARY

TIDAL MARSHES

BY PAM MORGAN

INTRODUCTION

Tidal marshes are wetlands composed primarily of grasses, sedges and rushes that occupy the intertidal zone—the area between low and high tide. The Saco Estuary contains more than 350 acres of tidal marshes that vary from salt marshes near the mouth of the river, to brackish marshes, to tidal freshwater marshes in the estuary's upper reaches near Cataract Dam.

Why should we care about tidal marshes?

Tidal marshes, some of the most productive habitats in the world, provide a home for a wide variety of plants and animals, including fish and birds. These habitats provide a diverse range of benefits—from aesthetics to fish habitat to water filtration. Many fish species use the surface of the marsh as a place to forage and escape from predators. In fact, tidal marshes are widely known as nursery grounds for important fish species. The fish and invertebrates of the marshes also provide an important source of food for resident and migratory birds, such as great blue herons and snowy egrets. People also value tidal marshes because they help clean coastal waters by extracting pollutants from water entering the estuary. Tidal marshes also serve as important buffer areas between developed coastal areas and the sea, absorbing the energy of incoming waves. In addition, marshes are valued highly for their beauty, which residents and visitors alike appreciate from the shore and from the water, making them an important recreational resource. One of the main reasons that scientists from the University of New England (UNE) and the Wells National Estuarine Research Reserve (NERR) have studied the Saco River tidal marshes is that very little was known about them. With this study, we now have a better understanding of the values these marshes provide and can monitor their health into the future.

What issues should we be concerned about?

In many estuaries, tidal marshes are degrading and even disappearing due to a number of human-caused threats (Gedan et al. 2011). These threats include increased coastal development and associated pollutants (especially nitrogen), climate change and associated sea level rise, increased flooding events and invasive species. *Phragmites australis*, also known as the common reed, is one invasive species of particular concern in the Saco Estuary's tidal marshes (Figure 1). This plant can quickly take over a marsh, choking out native plant species and decreasing its value as fish and bird habitat. Its dead stems have been known to catch fire, threatening nearby homes and businesses (Saltonstall 2005). Although the common reed provides some benefits to an estuary, its negative impacts have led scientists and land managers to develop a variety of methods to prevent its further spread (Saltonstall 2005).

FIGURE 1 The invasive common reed, *Phragmites australis.*

STUDY OBJECTIVES—PLANTS

Our objectives for the plant study were to answer these questions related to the tidal marshes:

1. What plants grow in the tidal marshes, and how do the plants change as one moves down the river?
2. How diverse are the plant communities in the marshes?
3. What rare and threatened plant species grow in the tidal marshes?
4. How extensive is the invasive common reed, *Phragmites australis*, in the estuary's marshes, and what should we do about it?
5. Does the extent of shoreline development affect the diversity of plants in the marshes?

RESEARCH DESIGN AND METHODS

We chose 16 marsh sites to study, located from the mouth of the river up to Cataract Dam (Figure 2). We chose these sites to capture the range of salinity in the estuary. Marshes were also selected based on the extent of shoreline development behind each site in order to study the possible impacts of shoreline development on marsh plant diversity. Using a geographic information system (GIS), we mapped the land cover/land use in a 100-meter area around each marsh site, so that we could quantify the amount of development adjacent to each marsh study site (see Chapter 7, Land Use and Land Cover Along the Saco River Estuary's Shoreline).

FIGURE 2 Tidal marsh study sites along the Saco Estuary.

FIGURE 3 UNE students sampling tidal marsh plants.

At each site we sampled plants using established methods for tidal marshes (Neckles and Dionne 2000) and determined percent cover of each plant species in one-square-meter quadrats along transects (Roman et al. 2001) (Figure 3). We also measured the salinity of the soil porewater at 15 to 20 centimeters deep in each quadrat using soil sippers and a handheld refractometer. This instrument measures how salty the water is where the plant roots are growing. Ten marshes were sampled in 2010, five more in 2012, and one more in 2013. In addition in 2010, 2011, and 2013, we sampled porewater salinity once each month (June, July, and August) at five sampling points in each marsh, again according to established methods (Neckles and Dionne 2000).

Mapping of *Phragmites australis* patches was done primarily by kayak. We used a handheld GPS with sub-meter accuracy (Trimble GEOXT-6000) while walking the perimeter of each patch we found. The density and height of stems was determined in the field, and plants in each patch were identified to determine whether they were the invasive form of *Phragmites* (there is a less common, native form of *Phragmites australis* as well) (Swearingen and Saltonstall 2010).

RESULTS AND DISCUSSION

What plants grow in the marshes?

We discovered that these marshes contain a diversity of plant species, changing as one moves from the river mouth up to the dam. The species of plants growing in the marshes depends to a large degree on marsh soil salinity, which is influenced by the incoming tides, freshwater inputs to the marshes from upstream, and local surface and groundwater inputs. Figure 4 shows the most common plants at each site and the soil porewater salinity when sampled in July. Figure 5 shows soil porewater salinities recorded in summer sampling from 2010 to 2013.

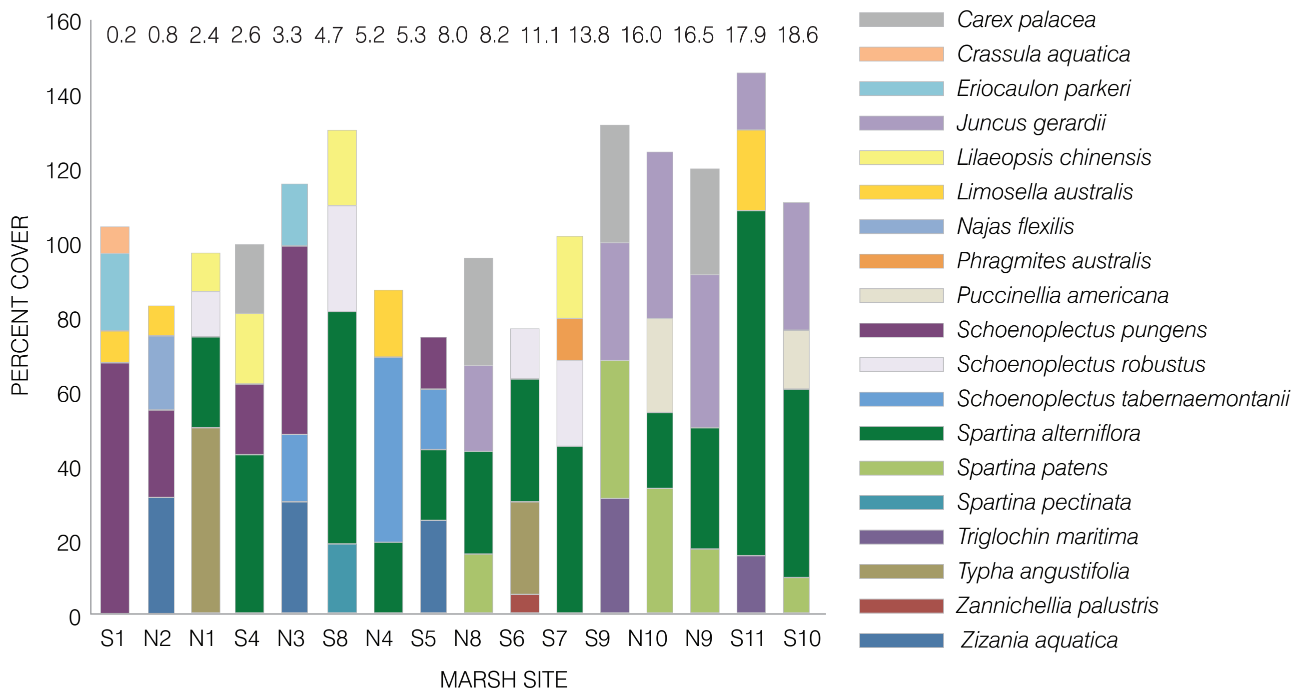


FIGURE 4 The most common plants found at each tidal marsh study site. Colored bars show the mean percent cover of each common species at a site. Numbers across the top of each bar are the soil porewater salinities (ppt) at sites in July, when plant sampling was conducted.

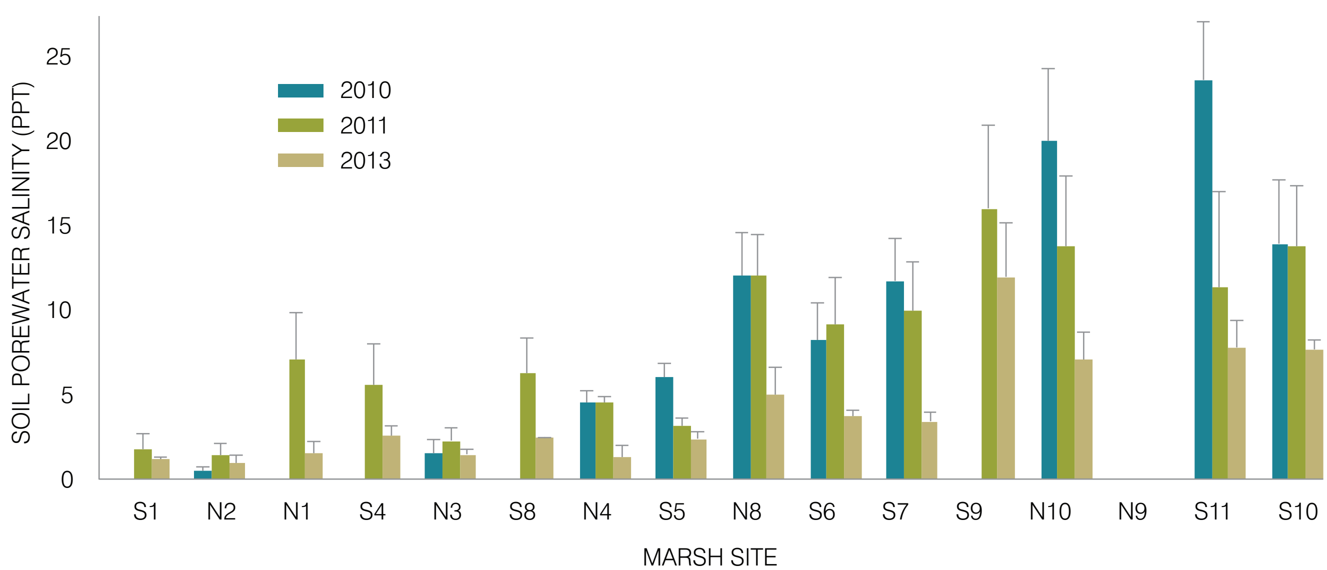


FIGURE 5 Soil porewater salinities at marsh sampling sites. Bars show means (± 1 standard error) of monthly averages for June, July, and August.

How diverse are the plant communities in the tidal marshes?

One way we can measure biodiversity is by counting the number of different species in a habitat. This is called species richness, denoted by the letter "S." Another way to quantify species diversity is by calculating a diversity index, such as the Shannon-Wiener Index (H).

We estimated plant species diversity at each tidal marsh study site (Table 1) and found that, for the most part, the farther upstream a site was located, the greater the number of plant species it had (Pearson correlation coefficient $r=0.57$). However, plant diversity as estimated by the Shannon-Wiener index did not show this correlation as strongly ($r=0.33$). The number of species at a site is usually related to the size of the area sampled, so we would expect larger marshes to have

TABLE 1 Plant diversity at tidal marsh sites as measured by the number of species (S) and the Shannon-Wiener Index (H). Salinities are means (±1 standard error) of July porewater measurements taken from plant sampling quadrats at each site.

Site	S	H	Salinity (ppt)	Marsh area (m^2)	Distance from site to river mouth (m)
S1	15	1.683	0.2±0.1	34,646	7,000
N2	20	2.144	0.8±0.2	7,536	6,904
N3	30	2.574	3.3±0.3	77,331	6,309
S5	22	2.512	5.3±0.4	34,812	4,799
N4	35	2.582	5.2±0.3	31,447	4,644
S4	24	2.552	2.6±0.3	7,781	4,490
N1	23	1.879	2.4±0.5	6,851	3,865
S8	20	2.336	4.7±0.7	2,045	3,621
S6	13	1.812	8.2±0.9	12,423	3,192
N8	17	2.218	8.0±0.6	50,718	2,572
S7	16	2.135	11.1±0.8	2,819	2,343
S9	15	2.375	13.8±1.0	27,727	1,579
N10	18	2.149	15.9±0.9	29,513	1,202
S10	14	1.833	18.6±2.9	5,840	1,015
S11	10	1.543	17.9±1.2	1,829	562
N9	13	1.952	16.5±1.1	14,859	478

more species. We observed this trend at our study sites, but it was not a particularly strong relationship (r=0.4 for both S and H).

It is noteworthy that the Saco River's tidal marshes display the classic gradient from salt marshes to brackish marshes to tidal freshwater marshes over a relatively short distance. The distance from the mouth of the river to the Cataract Dam at the head of tide is less than 5 miles (8 kilometers).

Are there rare and threatened plant species in the marshes?

We knew from the Maine Natural Areas Program that rare plants had been observed in the Saco Estuary, and so we looked for those plants at our study sites. Rare plants are defined by the State of Maine as species that are found in few places or species that may require unique or rare habitats to survive. We found 10 rare plant species, and many of these plants appeared to be thriving in the tidal marshes (Table 2).

How extensive is the invasive common reed, *Phragmites australis*?

In summer 2013, we located 33 patches of the invasive *Phragmites australis* in the estuary's marshes (Figure 6). The majority of these patches were small in area, less than 100 square meters, and some included very few stems (Figure 7). There was

TABLE 2 Rare plants found in Saco Estuary tidal marshes.

Species name	Common name	State rank	State status
Agalinis maritime	Saltmarsh false-foxglove	Uncommon S3	Special concern
Bidens hyperborean	Northern beggar-ticks	Uncommon S3	Special concern
Crassula aquatic	Pygmy-weed	Rare to uncommon S2S3	Special concern
Eriocaulon parkeri	Parker's pipewort	Uncommon S3	Special concern
Lilaeopsis chinensis	Eastern grasswort	Rare S2	Threatened
Limosella australis	Atlantic mudwort	Uncommon S3	Special concern
Sagittaria calycina (now known as *S. montevidensis*)	Spongy-leaved arrowhead	Uncommon S3	Special concern
Sagittaria rigida	Sessile-fruited arrowhead	Rare S2	Threatened
Samolus valerandi	Seaside brookweed	Uncommon S3	Special concern
Zannichellia palustris	Horned-pondweed	Rare S2	Special concern

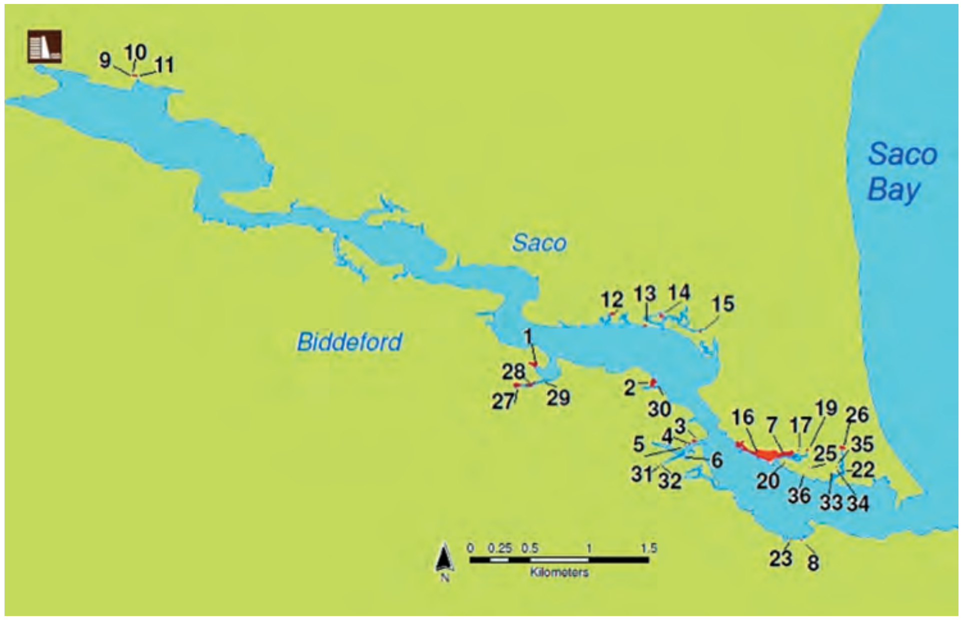


FIGURE 6 *Phragmites australis* patches in the Saco Estuary, mapped in 2013.

one very large patch near the mouth of the river that local residents have tried to keep in check by mowing and weed-whacking part of it each year. There were also several mid-sized patches that appeared to be spreading quickly, growing into the marshes and choking out native plants.

We tested the seed viability of 13 of the patches and found that plants in five of these patches produced seeds that would sprout and grow, although germination rates were low (0.4–1.3%). This means that *Phragmites* in the Saco Estuary can spread either by seed or by the fragmentation of underground stems, called rhizomes. The results of our drifter study to discover where most of these seeds or rhizome fragments might travel suggest that they primarily move downstream, and often travel up tidal creeks, where they could get caught and germinate.

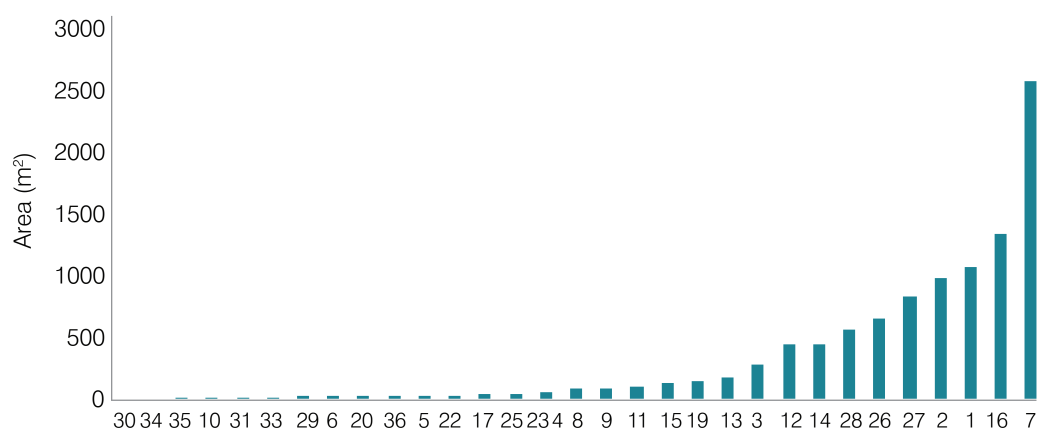


FIGURE 7 Size of *Phragmites australis* patches in the Saco Estuary. Note that patch 16 has been mowed, so its actual size is much larger.

What does this mean for the future of the Saco Estuary?

The good news is that the amount of *Phragmites australis* in the estuary is currently relatively small, but the concern is that this invasive plant is spreading. Existing patches appear to be increasing in area, small patches are appearing, and viable seeds are being produced. If we want the marshes to continue to support a diversity of native plants and healthy populations of invertebrates and fish, and to maintain the current views of the river from the shoreline, a management plan is needed.

Is development along the river's shoreline affecting the tidal marshes?

The State of Maine's Shoreland Zoning Act (Title 38 MRSA Sections 435-449) requires that Maine's municipalities adopt ordinances to regulate land use activities within 250 feet of the shoreline. Research in other estuaries has documented that shoreline development can affect tidal marshes in adverse ways, resulting in loss of marsh plant species biodiversity and an increase in invasive *Phragmites australis* (Gedan et al. 2011). Increased development can also lead to greater inputs of nitrogen pollutants to tidal marshes, which can cause changes in marsh plant communities and even the degradation of the marsh itself, as marsh soils decompose and erode away (Deegan et al. 2012). Of course, compared to areas farther south, Maine's coast is still relatively undeveloped. However, development pressure is a fact of life along the shorelines of southern Maine, so understanding the impacts of this development on our coastal habitats is important.

Understanding whether shoreline development affects marsh plant diversity is challenging because there other factors that affect diversity, such as soil porewater salinity and the size of the marsh, as discussed previously. However, when we look at the relationship between the extent of development adjacent to our marsh study sites and plant diversity, we do see a relationship. In Figure 8, the marsh sites (represented by triangles) are separated from each other on the graph according to the degree of similarity of their plant communities. Added to this are other factors that help explain the variation in plant communities at the sites. The extent of development adjacent to each marsh is an important factor. At this point, we cannot say that the extent of development is *causing* these differences in the plant communities, but we did find a relationship between the percent of highly developed land in the buffer areas around the marsh sites (i.e., 80% or more of the surface area is impervious) and marsh plant diversity as measured by the Shannon-Wiener Index (Pearson correlation coefficient $r=0.56$) and also the number of species per site (S) ($r=0.51$) (Figure 9). (See Chapter 7 for more information on land cover categories). Note that in this analysis, we looked at the land cover within 100 meters around each marsh study site, excluding marsh and mudflat habitat.

We also found a weak correlation between the amount of the buffer that was highly developed and the amount of available nitrate in the soil (measured at 10 study sites in June through August 2011, $r=0.37$). Researchers studying other tidal marshes in New England have found that coastal development contributes excess nitrogen to tidal marshes, leading to changes in the ecology of those marshes

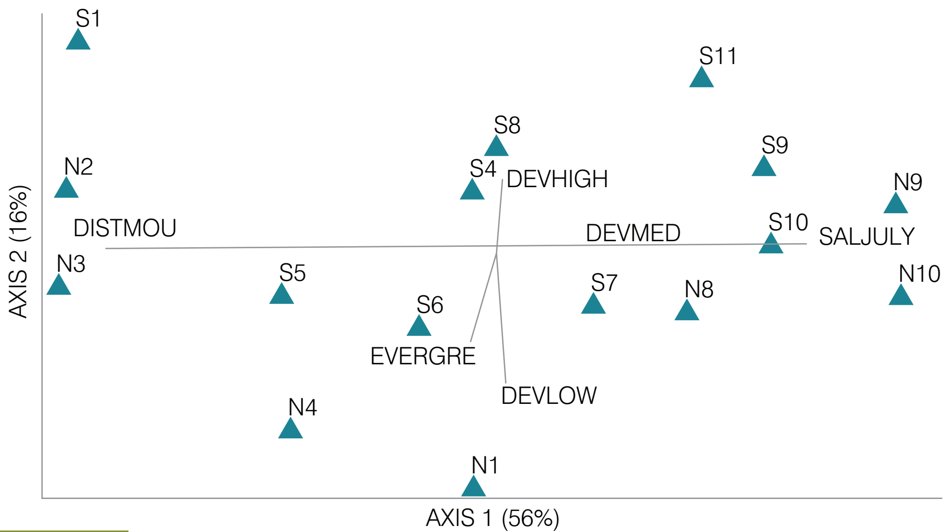


FIGURE 8 NMS ordination diagram showing the separation of the 16 marsh study sites (triangles) according to their plant communities. Also shown are the six most influential abiotic variables (intensity of development along the adjacent shoreline (DEV_HIGH, DEV_MED and DEV_LOW), proportion of evergreen cover, distance of sites to the mouth of the river, and soil porewater salinity in July).

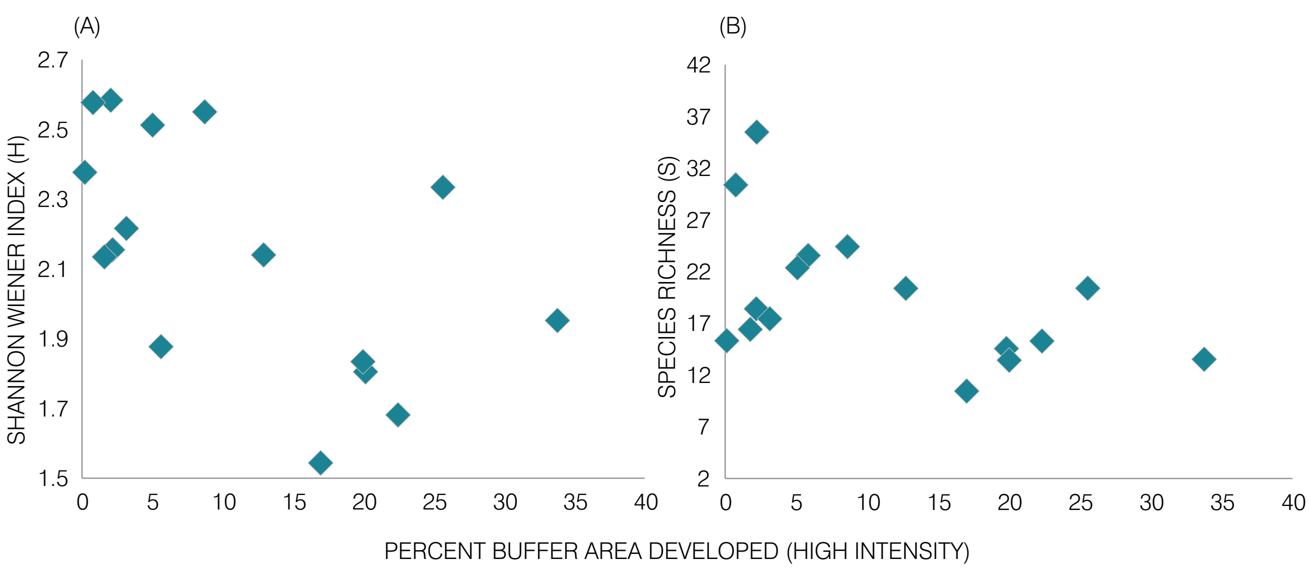


FIGURE 9 The proportion of high-intensity development in the 100-m buffer around tidal marshes related to marsh plant diversity as measured by (A) the Shannon-Wiener Index and (B) species richness.

(Silliman and Bertness 2004, Fitch et al. 2009). Although the marsh soil nitrate levels were relatively low and there is no cause for concern at this time, we should continue to monitor the possible effects of shoreline development and nitrogen inputs on the Saco Estuary. The results from this study provide a baseline dataset for this monitoring.

CONCLUSIONS

We made the following conclusions from our research on the plant communities in the Saco Estuary's tidal marshes:

- The tidal marshes contain a rich diversity of plant species growing in saltwater, brackish, and tidal freshwater marshes.
- Plant community diversity in the marshes is influenced by a number of factors, including salinity, distance to the river mouth, and the intensity of development in the adjacent shoreline.
- At least 10 rare plants grow in the marshes. Eight of these are Species of Concern and two are Threatened in the State of Maine.
- The invasive common reed, *Phragmites australis,* is found in both large- and small-sized patches in the marshes. A management plan for this species is needed to prevent it from spreading further.

ACKNOWLEDGEMENTS

Thanks to the many students who assisted on this project: Will Almeida, Danielle Behn, Chloe Crettien, Sarah Cowles, Chris Dracoules, Cory French, David Hague, Katie Hill, Gale Loescher, Shane Murphy, Brittany Parsons, Matt Simon, Michelle Slater, and Rachel Tamulonis. Thanks also to Biddeford and Saco landowners who allowed us access to the marshes across their property.

LITERATURE CITED

Deegan, L.A., D.S. Johnson, R.S. Warren, B.J. Peterson, J.W. Fleeger, S. Fagherazzi, and W.M. Wollheim. 2012. Coastal eutrophication as a driver of salt marsh loss. *Nature* 490: 388–394.

Fitch, R., T. Theodose, and M. Dionne. 2009. Relationships among upland development, nitrogen, and plant community composition in a Maine salt marsh. *Wetlands* 29(4): 1179–1188.

Gedan, K.B., A.H. Altieri, and M.D. Bertness. 2011. Uncertain future of New England salt marshes. *Marine Ecology Progress* Series 434: 229–237.

Neckles, H. A. and M. Dionne, Editors. 2000. *Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine.* Wells National Estuarine Research Reserve Technical Report. Wells, ME.

Roman C.T., M-J James-Pirri, and J.F. Heltshe. 2001. *Monitoring salt marsh vegetation.* Wellfleet, MA: Cape Cod National Seashore. Available from: http://www.nature.nps.gov/im/monitor/protocoldb.cfm.

Saltonstall, K. 2005. *Fact Sheet: Giant Reed. Weeds Gone Wild: Alien Plant Invaders of Natural Areas.* Plant Conservation Alliance. Available from: http://www.nps.gov/plants/alien/.

Silliman, B.R. and M.D. Bertness. 2004. Shoreline development drives invasion of *Phragmites australis* and the loss of plant diversity on New England salt marshes. *Conservation Biology* 18(5): 1424–1434.

Swearingen, J. and K. Saltonstall. 2010. Phragmites *Field Guide: Distinguishing Native and Exotic Forms of Common Reed (*Phragmites australis*) in the United States. Weeds Gone Wild: Alien Plant Invaders of Natural Areas.* Plant Conservation Alliance. Available from: http://www.nps.gov/plants/alien/pubs/index.htm.