THE LAND USE HISTORY, FLORA, AND NATURAL COMMUNITIES OF THE ISLES OF SHOALS, RYE, NEW HAMPSHIRE AND KITTERY, MAINE

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THE LAND USE HISTORY, FLORA, AND NATURAL COMMUNITIES OF THE ISLES OF SHOALS, RYE, NEW HAMPSHIRE AND KITTERY, MAINE

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ABSTRACT. The vascular flora, natural communities, and natural community system on the Isles of Shoals in New Hampshire and Maine are described based on a combination of historical records dating back to 1614 and a comprehensive survey conducted in 2006. A total of 430 native or naturalized vascular plant taxa from 242 genera and 71 families have been documented on these nine maritime islands. The families best represented in the flora were Asteraceae (58 taxa), Poaceae (49 taxa), and Rosaceae (35 taxa); the largest genera were *Carex* (9 taxa), *Juncus* (8 taxa), *Persicaria* (7 taxa), and *Solidago* (7 taxa). Forty-two percent of the 430 plant taxa were non-native. Proportions among life forms were 86% herbs, 12% shrubs, and 2% trees. Plant richness for extant taxa totaled 333 and varied from 53 on White Island to 246 on Appledore. Fifteen plant taxa are rare in either New Hampshire or Maine. Fourteen natural communities, two human-disturbed cover types, and one natural community system were described from the nine islands. Eight of the 14 natural communities are extremely rare in New Hampshire; none of the communities are rare in Maine. Appledore, over twice the size of the next largest island, supported all 14 communities and both human-disturbed cover types. Seaveys, the second smallest island, supported just three communities. One natural community system was described, the maritime rocky shore, which characterizes all of the islands in the Isles of Shoals. Although not rare in Maine, this system in New Hampshire only occurs on these islands. Island size was significantly related to vascular plant richness and native plant richness but was somewhat less related to the richness of non-native plants.

Key Words: Isles of Shoals, maritime islands, New Hampshire, Maine, vascular flora, vascular plant richness, species-area relationship, rare plant taxa, non-native plants, natural communities, natural community system

The Isles of Shoals, an archipelago comprising nine islands and numerous smaller rocky ledges, lies in the Gulf of Maine ca. 9.5 km east from the nearest point on the mainland at Rye, New

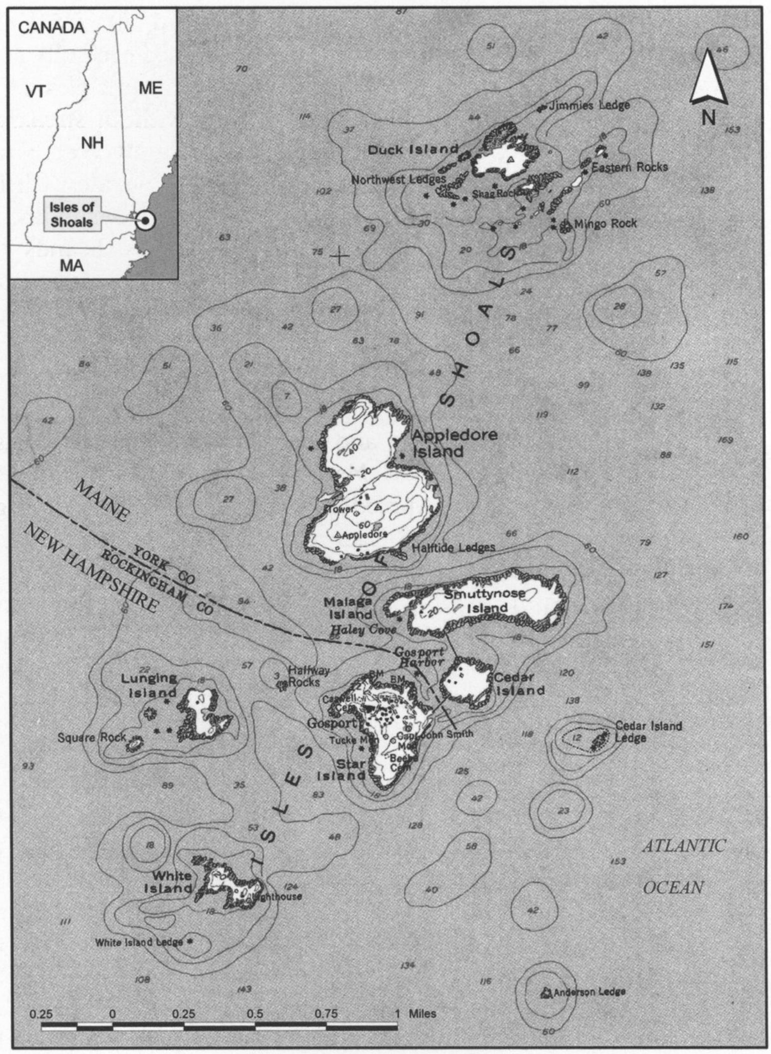

Figure 1. Location map of the Isles of Shoals, New Hampshire and Maine. Note: Seaveys Island, not named on the map, is the northwestern half of White Island.

Hampshire (Figure 1). These islands total 82.33 ha, ranging from 39.46 ha (Appledore) to 0.77 ha (Malaga). The "Shoals" are located within an area 5.0 km north-south from Jimmies Ledge to Anderson Ledge by 2.7 km east-west from Cedar Island Ledge to

Square Rock (43°00′28″ to 42°57′44″ latitude and 70°35′52″ to 70°37′52″ longitude). Water depths around the islands generally are between 18 and 30 m. The highest elevation above mean high water occurs on Appledore at 20 m. These islands are without streams, but small freshwater ponds occur on Appledore, Smuttynose, and Star. The nine islands were divided between the states (then provinces) of New Hampshire and Maine in the mid-1600s by their British grantees John Mason and Ferdinando Gorges. Islands in New Hampshire are Lunging, Seaveys, Star, and White. These are the only maritime islands in the state. Appledore, Cedar, Duck, Malaga, and Smuttynose lie in Maine.

Previous vascular plant studies on the Isles of Shoals have focused on Appledore (Boden 1977; Borror 1994; Clarke 1936; George 1980; Goldenberg 1976) and Star (Howard 1968; Nichols 2004; Steiger and Schultes 1940). Natural community descriptions have also been limited to Appledore (Boden 1977; Goldenberg 1976) and Star (Nichols 2004; Steiger and Schultes 1940). The goal of this study was to inventory the vascular flora and describe the natural communities of all nine islands, and to compile a comprehensive checklist of the Shoals' flora using current taxonomic and nomenclatural standards. The data collected in this study also allowed an examination of the effects of island size on plant diversity. Present-day vegetation patterns are examined with respect to land use history and the maritime position of the Shoals.

Geology. The Isles of Shoals are the remnant base of an ancient mountain that formed 300 to 400 million years ago. Rutledge (1997, p. 93) wrote "The high alpine peak was eroded down to a modest hill and then sheared off by the last ice flow hardly more than ten thousand years ago." Shortly after deglaciation and marine submergence of our present coastline (ca. 12,640 YBP), isostatic recovery of the crust in the Gulf of Maine left the Isles of Shoals temporarily connected to the mainland (McMaster 2005). Sea level minima occurred aproximately 11,400 YBP at 60 m below present levels (Bloom 1963). Presumably, most of the native flora on the Shoals arrived during this period. The Shoals were once again isolated around 7000 YBP (McMaster 2005).

Most of the glacially eroded bedrock on the Shoals is granite (Kingsbury 1976). Metamorphic rock embedded in the granite matrix is the oldest type of bedrock on the islands (Fowler-Billings 1977). Glacial scouring and "plucking" during the last ice age is responsible for the islands' whale-back shapes. Numerous smaller examples of whale-backs also occur, including the western end of White, the ledges southeast of Duck (i.e., Shag, Eastern, and Mingo), surfaces on the southern shore of Smuttynose and western shore of Appledore, and ledges on the northwest side of Star (Fowler-Billings 1977). The higher areas on the southern and eastern sides of Star and eastern promontory of White near the lighthouse "stand high because they are underlain by unusually large bodies of pegmatite [a coarse granite], which is especially resistant to erosion" (Fowler-Billings 1977, p. 7). Beneath the water, a pegmatite belt connects the highlands on these two islands. Waves from winter storms have also helped shape the current land forms, often approaching the Shoals from an easterly direction and contributing to the creation of steep cliffs along their eastern shores.

Trap dikes, characterized by fine-grained diabase rock, frequently cut across the light-colored granite matrix. Due to columnar jointing of the trap dikes, waves and other erosional forces remove column-like sections of dikes allowing for the creation of low areas of damp soil on many of the islands. The bouldery depression on the eastern end of Smuttynose results from the presence of two or three trap dikes. Emergent marsh plants characteristic of fresh and brackish water, together with upland herbs, can be found in this long, broad depression. Trap dikes on the Shoals are typically parallel and trend to the northeast, similar to their orientation on the mainland. In a few examples, trap dikes disappear beneath the water offshore from one island only to reemerge on another island (Fowler-Billings 1977).

Glacial till occurs in some of the depressions on Appledore (Kingsbury 1976), and likely in similar settings on some of the other larger islands. Island soils are typically thin with a high percentage of organic content from decayed vegetation and seabird guano (Fowler-Billings 1977). Exposed areas supporting large seabird nesting colonies are often dominated by bare bedrock. Soils one meter or more deep occur in some of the wetland depressions (Novak 1971).

Exposure and disturbance. Prevailing winds are westerly. They tend toward the northwest in the fall, winter, and spring, and toward the southwest during the summer. Kingsbury (1975) described the stormy and foggy nature of this area, often with sudden and considerable shifts in wind and temperature. Heavy winds associated with storms locally called nor'easters frequently attain gale force (34–63 kn; 39–72 mph). Nor'easters are most frequent and strongest from September to April but can strike any time of year. Storms originating in the tropics in late summer and autumn are rarer but can be more intense, with wind speeds exceeding hurricane force (more than 63 kn). Thunderstorms can also be accompanied by strong winds, particularly during the summer months (Kingsbury 1975).

Wave heights during storms depend on wind strength and, to a lesser degree, duration of storm, bottom depth, and current direction relative to wind direction (Kingsbury 1975). Sustained hurricane force winds hit the Shoals on average once every ten years (Boden 1977), generating storm surges and large waves that can hit rocky shores with incredible force. Large waves have broken the thick glass 25 m above sea level in the White Island lighthouse as well as the seawall between Cedar and Star (Kingsbury 1976). The granite blocks in the seawall each weigh several tons.

The distance of the soil line from mean high water, considering elevation differences along different stretches of shoreline, can indicate the degree of exposure to storm waves for any stretch of shoreline. Despite a high average elevation of at least 6 m along the southwest shore of Star, Kingsbury (1976) noted the soil line was set back 30 m or more from the high tide line. The soil line on less exposed areas on the island is considerably closer to the shore. Similar patterns can be found on other islands, for example along Appledore's exposed northern and eastern shores compared with its more protected western and southern shores.

Storm waves and wind can deposit considerable amounts of salt spray on island vegetation, causing leaf necrosis, accumulation of red pigment (beta-cyanin), and dieback of exposed shoots (Boden 1977; Waisel 1972). In exposed settings, plants have reduced reproductive success, are shorter, and show more discoloration (Rich 1976). Excessive concentration of salt in the soil suppresses plant growth by changing soil structure, inhibiting water uptake, creating nutrient imbalances, and causing the accumulation of elements toxic to plants (Boden 1977). Excessive salt concentrations can also lead to the acceleration of protein breakdown, reduced seed germination, leaf number, and shoot development, and the accumulation of chloride ions in leaves, reducing photosynthesis (Boden 1977).

Rate of salt deposition drops off rapidly over the first 500 m from the sea (Malloch 1972). Because of small island sizes, however, all of the natural communities on the Shoals are probably affected by salt spray. Many of the species in these communities likely have a degree of salt tolerance that provides them with a competitive advantage over less salt-tolerant taxa. For example, differences in leaf folding and orientation accounted for differences in salt tolerance in two subspecific taxa of *Festuca rubra*, a species of grass common on the Shoals (Humphreys et al. 1986). Salt spray also plays a role in characterizing mineral influxes to shoreline habitats (Boyce 1954; Clayton 1972; Salisbury 1952) and is likely a factor in nutrient cycling in the maritime rocky shore system on the Shoals. Systems are groups of natural communities drawn together on the landscape by a common suite of environmental conditions.

Both human and naturally induced fires are likely somewhat frequent on the thin dry soils on these islands. However, fires have not been frequent enough to support fire-restricted plant species or natural communities. In coastal heathlands on Martha's Vineyard (Massachusetts), the damaging effects of salt spray on vegetation after a fire are reduced; soil water is more available in burned areas because of reduced water competition and evapotranspiration rates (Griffiths et al. 2006).

In areas with moderate to high seabird nesting densities, elevated ammonia concentrations from large amounts of guano can inhibit plant growth, especially woody species, and alter plant community composition (Ellis et al. 2006; Hogg and Morton 1983). As seabird nesting densities increase, annual and biennial plant species increase, while perennials decrease (Ellis et al. 2006; Hogg and Morton 1983). In cormorant colonies, where nesting densities are greatest on the Shoals, plants may be absent altogether (Ellis et al. 2006). High nutrient concentrations from seabird nesting colonies are "a form of severe disturbance that maintains plant communities in early successional stages" (Ellis et al. 2006, p. 571). Seabird nesting colonies have been associated with rapid changes in plant species composition and structure (Ellis et al. 2006; Pike and Hodgdon 1962) and this dynamic pattern appears to occur on Seaveys (S. Fuller, NH Fish & Game, pers. comm.; D. Hayward and M. Hayward, Shoals Marine Laboratory, pers. comm.).

The surrounding ocean has a moderating effect on air temperatures. For example, average daily high temperatures are notably lower in summer and higher in winter compared to the mainland. Furthermore, spring and fall typically lag four weeks behind mainland seasons (Boden 1977). Average monthly temperatures peak between June and August (ca. 15 to 20°C) and reach an annual low in January and February (ca. −1.0 to −0.5°C; NOAA, unpubl. data). Annual rainfall is typically $\geq$ 100 cm (McGill 1977). For resident Shoalers, the importance of weather, cycles of nature, and phenomena in the sky have been well described by Celia Thaxter (1873, pp. 98–99):

> The weather becomes of the first importance to the dwellers on the rock; the changes of the sky and sea, the flitting of the coasters to and fro, the visits of the sea-fowl, sunrise and sunset, the changing moon, the northern lights, the constellations that wheel in splendor through the winter night,—all are noted with a love and careful scrutiny that is seldom given by people living in populous places. One grows accustomed to the aspect of the constellations, and they seem like the faces of old friends looking down out of the awful blackness; and when in summer the great Orion disappears, how it is missed out of the sky!

Botanical history. The Isles of Shoals have a notable history of botanical observations, especially on Appledore and Star Islands. A summary of the botanical history outlined in Boden (1977) and Howard (1968) is updated below.

1614 Captain John Smith described the islands as barren rocks densely overgrown with shrubs and sharp "whins" (blackberries?) and a few old, stunted cedars.

1623 Sir Christopher Levett, after visiting the islands, wrote "upon these islands I neither could see one good timber tree, nor so much ground as to make a garden" (Penrose 1957, p. 22).

1800 Rev. Jedediah Morse noted some plants on Appledore including huckleberry, bayberry, blackberry, raspberry, wild currant, gooseberry, elder, sumac, woodbine, poison ivy, wild cherry, shadbush, and a little wild apple tree. Mention was made of "whortle-berries, choak-plums, and a few cranberries" on both Appledore and Smuttynose.

1852 Nathaniel Hawthorne's diary told of one or two trees on Appledore.

1873 Celia Thaxter wrote of a small elm on Appledore about 20 years old, maple, poplar, birch, six kinds of ferns, herb-Robert, columbine, anemone, pimpernel, white violets, iris, wild rose, goldenrod, aster, polygala, ground-nut, helianthus, potentilla, henbane, sea lungwort, poisonous hemlock, and jimsonweed.

1873 Celia Thaxter (1873, p. 29) documented a population of oyster plant on Lunging where it "spreads at the top of the beach." This is the only record for this species [*Mertensia maritima*] in New Hampshire.

1875 Jenness (1884, p. 4) described the islands as ". . . wholly destitute of trees, and even of shrubs, except huckleberry and bayberry bushes, woodbines, wildroses, and such like, wherever in the crevices of the rocks the shallow roots have found a handful of soil."

1912 *Carex nigra*, a sedge rare in New Hampshire, was collected on Star by G. M. Allen.

1936 William Clarke (1936) collected 142 taxa in 44 families on Appledore. Seventy-nine of these taxa were found again by Boden (1977), several in the same places that Clarke found them.

1940 Rev. Theodore Steiger and Dr. Richard Schultes (1940) listed 127 taxa seen on Star in June. They estimated one-third of the plants were introduced from Europe. No specimens were collected.

1952 Dr. Reed Rollins and Dr. Richard A. Howard (unpubl. data) collected specimens on Star and Appledore. They noted the presence of *Myriophyllum* and *Potamogeton* in a pond (Crystal Lake or the reservoir marsh) on Appledore, but these have not been found since.

1965 Dr. Albion Hodgdon collected seven taxa on Star, among them a putative hybrid between *Juniperus horizontalis* and *J. virginiana* and the only record of *Symphyotrichum praealtum* from Star Island.

1967 Dr. Richard A. Howard, Dr. Reed Rollins, R. Howard, and Jack Gates collected 270 taxa, mostly from Star Island.

1976 Rich (1976) studied the physiognomic differences between the windward, leeward, and sheltered populations of wild rose on Appledore.

1976 Goldenberg (1976) described a small salt marsh on Appledore.

1977 Boden (1977) described and mapped plant associations and compiled an updated and comprehensive list of vascular plant taxa on Appledore.

1980 George (1980) documented 60 prominent plants on Appledore.
1989 Kelso and Harrington (1989) examined the pollen record on Appledore.
1994 Borror (1994) updated the Appledore vascular plant checklist compiled by Boden (1977).
2004 On Star Island, Nichols (2004) described seven natural communities and identified 214 vascular plant taxa.
2006 Ellis et al. (2006) studied transport of resources from marine to terrestrial habitats by nesting seabirds and its effects on vegetation composition and structure on the Shoals.

Land use history. A long history of human habitation, beginning early in the 17th century, has had a profound effect on the Shoals' flora and natural communities. Shortly after Champlain noted the Isles of Shoals on his 1605 voyage, the Shoals became well known to fishermen worldwide (Randall and Burke 1997). Seasonal occupation began in 1623 by fishermen taking advantage of the locally rich cod-fishing grounds (Kelso and Harrington 1989). Year-round residents and livestock were first reported between 1635 and 1640 (Jenness 1884; Kelso and Harrington 1989). By 1700, somewhere between 600 and 1200 people lived on the Shoals (Randall and Burke 1997).

In 1715 the township of Gosport on Star Island was created, with a variety of civic and religious establishments. Livestock were kept in common pasture land on the southern half of the island. Initially, the naturally thin soils supported grass sufficient to feed 20 or 30 cows and about 150 sheep during the summer and autumn (Randall and Burke 1997). Settlers quickly depleted the "peat" soil in this pasture, as they used it for fuel (Saggerer 2006, 2007). Goats, sheep, pigs, and cows also heavily grazed other islands in the Shoals during the 17th and 18th centuries. The presettlement dense shrub cover (Smith 1614) gave way to low pasturage and bedrock (Boden 1977). In 1800, Reverend Morse wrote, "All the trees, and the bushes even, have been consumed, and they have cut up, dried, and burned many acres of the sward (soil), leaving only naked rocks where formerly there was the finest pasturage for cows" (Thaxter 1873, p. 25).

In the early 1800s, as a result of residents being told three decades earlier to leave the islands during the Revolutionary War, there were mostly ruins of once prosperous fishing villages. Only two islands still remained inhabited at that time, Star with 15 families and Smuttynose with three (Randall and Burke 1997).

A hotel was built in 1847 on Appledore and it quickly became a popular vacation site (Rutledge 1997). The hotel burned in 1914, and large colonies of gulls, uncommon birds in the 19th century, took over the island, along with poison ivy and shrubs (Thaxter 1894). In 1872, the Oceanic Hotel was built on Star Island. In 1873, Celia Thaxter wrote about the heavily impacted flora on Star Island: ". . . the crooked little ways between the houses are lined with tall plants of the poisonous hemlock . . . which flourishes amain, and is the only green thing out of the small walled enclosures, except the grass and the burdocks; for the cows and the children devastate the ground" (Thaxter 1873, p. 29). Soon after the Shoals' hotel era began, however, natural vegetation slowly began to recover somewhat as a result of reduced gardening and livestock grazing (Boden 1977). Exceptions occur, for example on the north end of Appledore. Although revegetated and wild now, this area was still being cleared and burned as late as the 1930s (Clarke 1936). During the same period on Star, Steiger and Schultes (1940) described the island as dominated by two cover types: well-drained low "meadows" on deeper soil, especially in northern and western areas, and "rock vegetation" covering most of the high ground. They concluded that the vegetation cover was largely the result of past agricultural use and that most of the island was likely a dense shrub thicket prior to European arrival. Over the last half century, the "rock vegetation" (Figure 2A) described by Steiger and Schultes has reverted to a shrub thicket (Figure 2B).

Currently, the Star Island Corporation maintains the Oceanic Hotel and other buildings on the northern half of Star for summer conferences. The Star Island Corporation also owns most of Appledore, leasing the land to Cornell University and the University of New Hampshire for the Shoals Marine Laboratory. The lab is dedicated to undergraduate education and research in marine sciences during the summer.

Malaga is connected to the northwest corner of Smuttynose during low tide by a man-made breakwater. Early in the 19th century, Captain Samuel Haley Jr. significantly altered the vegetation on Smuttynose. Moore (1898, p. 535) stated that Haley "found four bars of silver beneath a stone, and . . . used them in defraying the expense of the safe harbor he made 'for seamen in distress of weather' . . . He erected salt-works, . . . set up wind-mills to grind the corn and wheat he managed to raise on his few arable acres, started a bake-house, a brewery, a distillery, and a black-smith's shop, and planted

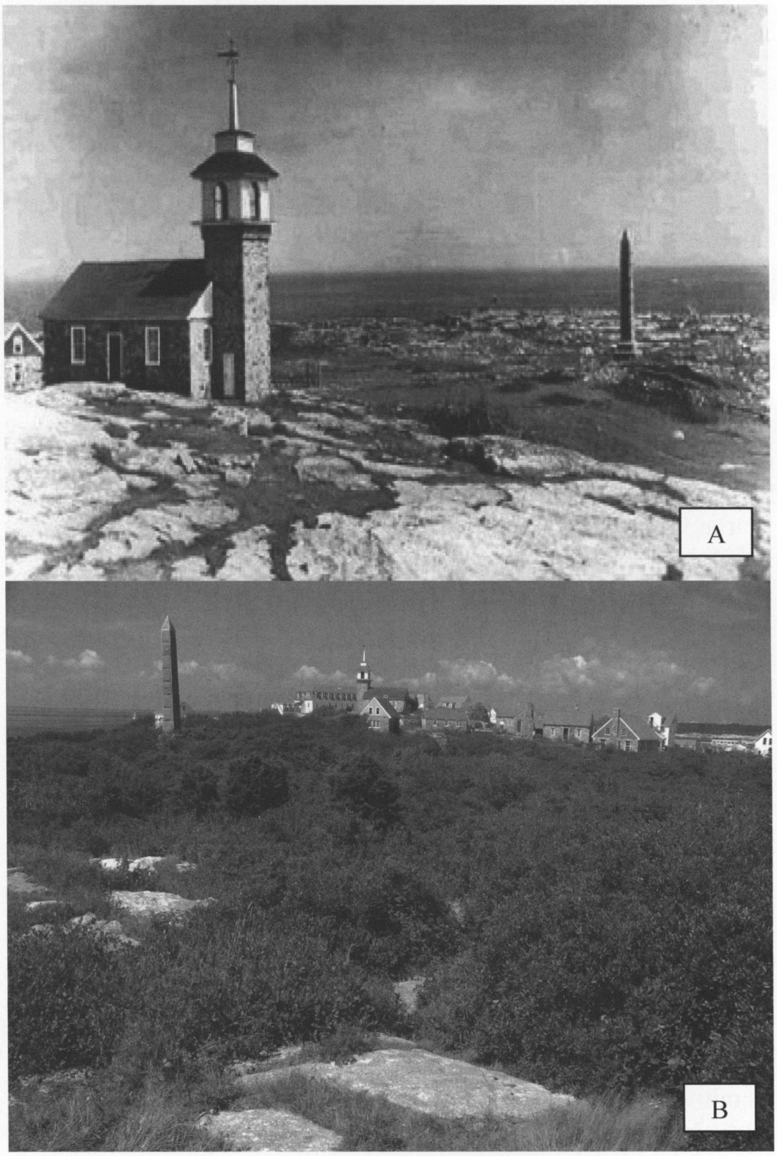

Figure 2. Changes in vegetation cover on Star Island. A. Sparse vegetation cover, described by Steiger and Schultes (1940) as "rock vegetation," common on the Shoals when this photograph was taken around 1914 (photograph courtesy of Isles of Shoals Historical and Research Association). B. Present day vegetation, here showing the maritime shrub thicket, dominant on the four larger islands (photograph courtesy of Dan Sperduto).

an orchard." Both Malaga and Smuttynose are now privately owned, but the public is welcomed by island stewards by day.

Lunging Island is also privately owned. In the early years, it was the fishing base for the London Company. The company established a trading post on the highest point of the island (Rutledge 1997). Lunging is really two islands connected by a cobble bar deposited by storm waves (Fowler-Billings 1977). Unlike the cobble bar connecting White and Seaveys, the bar on Lunging is currently not submerged at high tide. Offshore to the west is Square Rock. To the east, the rarely exposed Halfway Rocks lie between Lunging and Star Islands.

Cedar Island is privately owned by descendants of Shoaler fishing families who are themselves now lobstermen (A. Beattie, Isles of Shoals Historical & Research Association, pers. comm.). Cedar is connected to Star by a breakwater formed from large blocks of Rockport granite and to Smuttynose by a breakwater formed from granite derived mostly from quarries on Smuttynose (Fowler-Billings 1977). Cedar Island Ledge lies nearby offshore to the east; Anderson Ledge is more distant to the south.

Duck Island was named for the migratory ducks that were hunted on a small pond near the island's center. In the mid-20th century, it was used by the United States military for target practice. It is now owned by the Star Island Corporation and is a refuge for migrating birds, harbor seals, and other wildlife. Surrounding ledges are Northwest Ledges, Shag Rock, Mingo Rock, Eastern Rocks, and Jimmies Ledge.

White and Seaveys are separate islands only near high tide when a meter or more of water submerges the cobble bar that connects them. White Island lies to the southeast, Seaveys to the northwest. The original lighthouse on White Island was built in 1820. The present one was built in 1865. Owned by the State of New Hampshire, these two islands are the site of a tern restoration project sponsored by New Hampshire Fish and Game, New Hampshire Audubon, and the Shoals Marine Laboratory. White Island Ledges lies offshore to the southwest.

MATERIALS AND METHODS

Landscape analysis. The following data were examined to prioritize survey areas and to increase the efficiency of field visits: aerial photographs, National Wetland Inventory maps, surficial

(Goldthwait 1950) and bedrock geology maps (Lyons et al. 1997), Natural Resource Conservation Service soil survey maps (as available in the NH GRANIT System, University of New Hampshire), and U.S. Geological Survey (USGS) topographic quadrangles. New Hampshire Natural Heritage Bureau (NHB) and Maine Natural Areas Program (MNAP) databases provided information on rare plant taxa known to occur on the Shoals.

Field survey. Surveys were conducted on 23 days between June 20 and September 17, 2006, covering each of the nine islands of the Isles of Shoals. Data from a survey on Star Island on September 6 and 7, 2004 (Nichols 2004) were also included. Within each type of plant community, two experienced botanists developed a list of all vascular plant taxa by searching intensively until no additional taxa were found within a 10-minute interval, or until small areas were completely traversed. In habitats that were difficult to travel through, or those with very high biotic diversity, the inventory rate was about 2 ha/hour. In large areas that had not been completely searched, at the point when 10 minutes passed with no additional taxa, the remaining areas were searched but at a higher rate of travel. This technique has been found to be effective in locating an estimated 92% of the taxa actually present (Nichols et al. 1998).

On each island, community data were collected in releve plots placed at two or more representative locations in each natural community type. Determination of natural community type was based on differences in physical conditions and plant species composition, structure, and cover (Sperduto and Nichols 2004). At each releve, percent cover was estimated for all plant species in each stratum, and physical site characteristics (e.g., substrate, slope, aspect, topographic position), evidence of human disturbance, size of the community, and wildlife evidence were noted.

Vascular plant taxonomy and nomenclature generally follow the Flora of North America Editorial Committee (1993a–2006c), then Kartesz (1999), and occasionally Gleason and Cronquist (1991). Voucher specimens were deposited at the Hodgdon Herbarium (NHA) at the University of New Hampshire.

A Garmin 12 Global Positioning System (GPS) was used to gather locational information for releve plots and rare plant populations on the nine islands. A GPS unit was also used to determine the location of several invasive plant populations. The estimated accuracy of the data based on satellite configuration was generally within 15 meters. Field data and site locations for rare plant populations and exemplary natural communities have been catalogued and incorporated into the NHB and MNAP databases. Invasive plant occurrence data will be entered into the Invasive Plant Atlas of New England database (Mehrhoff et al. 2003).

Analysis of species-area relationship. Using a digital USGS topographic quadrangle as a base map (NH GRANIT System, University of New Hampshire), area for each of the islands was determined by digitizing their boundaries in a geographic information system (GIS) using ArcView GIS 3.3 software (ESRI, Redlands, CA). Simple linear regressions were used to examine the relationship between island size and species richness.

RESULTS

Plant species richness. Through extensive inventory on all nine islands and review of past studies on Appledore and Star Islands (Boden 1977; Borror 1994; Clarke 1936; George 1980; Goldenberg 1976; Howard 1968; Nichols 2004; Steiger and Schultes 1940), a comprehensive list of 430 native or naturalized vascular plant taxa present between 1936 and 2006 was compiled for the Isles of Shoals (see Appendix 1). Also on the list are 35 other taxa known from the islands but not thought to be naturalized. Of the 71 families in the flora, those best represented were Asteraceae (58 taxa), Poaceae (49 taxa), and Rosaceae (35 taxa); the largest of the 242 genera were *Carex* (9 taxa), *Juncus* (8 taxa), *Persicaria* (7 taxa), and *Solidago* (7 taxa).

Proportions among life forms on the Shoals were 86% herbs, 12% shrubs, and 2% trees. Forty-two percent of the 430 plant taxa were non-native. Twenty native or naturalized plant taxa were common to all nine islands while 186 taxa were documented on just one of the islands. Plant richness for extant taxa totaled 333 and varied from 53 on White to 246 on Appledore. Plant density ranged from 6.2 taxa/ha on Appledore to 76.6 taxa/ha on Malaga (Table 1).

Species-area relationship. Island size (ranging from 0.77 to 39.46 ha) was significantly related to vascular plant richness (r^2 = 0.75; p = 0.003; n = 9; Figure 3A). Limiting the analysis of the species-area relationship to include only native plants resulted in an even stronger relationship between area and species richness (r^2 = 0.86; p = 0.001; n = 9; Figure 3B). The relationship for non-native

Table 1. Vascular plant richness on the nine islands in the Isles of Shoals, New Hampshire and Maine (islands are ordered by area). Spp = total native and naturalized taxa seen in the field during present study; Area = island area in ha; Den = density in taxa per hectare; H = number of herbaceous taxa; S = shrub taxa, including woody vines; T = tree taxa; N = native taxa; NN = non-native taxa.

				Vascular Plant Counts				
Island	Spp	Area	Den	H	S	T	N	NN
Appledore	246	39.46	6.2	211	29	6	158	88
Smuttynose	185	15.75	11.7	162	20	3	104	81
Star	242	14.71	16.5	204	32	6	128	114
Cedar	106	3.68	28.8	89	15	2	59	47
Duck	59	3.12	18.9	58	1	0	34	25
Lunging	88	2.40	36.7	79	8	1	44	44
White	53	1.31	40.5	52	1	0	25	28
Seaveys	58	1.13	51.3	50	8	0	29	29
Malaga	59	0.77	76.6	55	4	0	23	36

plants was weaker but still significant ($r^2 = 0.54$; $p = 0.025$; $n = 9$; Figure 3C).

Rare plant species. Fifteen rare plant taxa were documented on the Isles of Shoals during the present study (Table 2). None of these taxa are globally rare. *Rumex pallidus*, a rare plant species in New Hampshire previously documented on Star (Howard 1968), was found only on Appledore. This species is not considered rare in Maine. *Potentilla pensylvanica* var. *litoralis* was not re-located on Star Island, although a new population was found on White. Locations for *Leymus mollis*, *Mertensia maritima*, *P. pensylvanica* var. *litoralis*, and *R. pallidus* on New Hampshire islands in the Shoals are the only records for these taxa in the state. These taxa approach the southern limit of their range on the Shoals. The occurrence of *Carex nigra* on Star is one of only two populations in New Hampshire. On the Maine side, *Prunus maritima* was newly discovered on the Shoals from Cedar and Smuttynose. New populations for *Cyperus erythrorhizos* were found on Duck and Smuttynose. Previously historic populations of *Chenopodium rubrum* and *Cyperus erythrorhizos* on Appledore were re-located. *Cyperus erythrorhizos* is found in Maine only on the Shoals, here reaching the northern limit of its range. Similarly, *P. maritima* and *Symphyotrichum subulatum* reach their northern limit on the Shoals and at a few sites nearby in southern Maine (A. Haines, New England Wild Flower Society, pers. comm.).

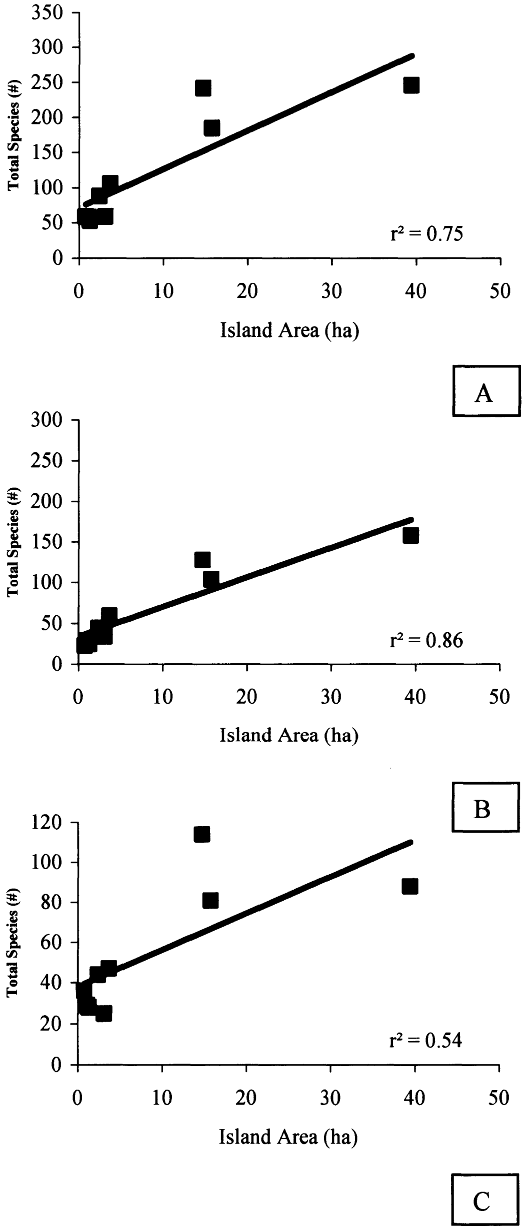

Figure 3. Relationship between island size and vascular plant richness on the nine islands in the Isles of Shoals, New Hampshire and Maine. A. Island size related to total plant richness (r^2 = 0.75; p = 0.003; n = 9). B. Island size related to native plant richness (r^2 = 0.86; p = 0.001; n = 9). C. Island size related to non-native plant richness (r^2 = 0.54; p = 0.025; n = 9).

Non-native invasive plants. Because of the Shoal's early history of human habitation, prosperity, and international commerce, George (1980) and Boden (1977) concluded that some of the first non-native introductions to the New World must have taken place on the Isles of Shoals and that the Shoals likely served as a gateway for some of the earliest European introductions to the mainland (e.g., *Rumex crispus*). Twenty-three of the non-native plant taxa documented on the islands (Table 3) are considered invasive in New England (Mehrhoff et al. 2003), their locations often associated with human-disturbed habitats. Two of the 23 invasive plant taxa occurred on all nine islands: *Poa compressa* and *Solanum dulcamara*. Ten invasive taxa occurred or had occurred on just one of the islands (Table 3). Star had the highest number of invasive taxa (19); White had the lowest (2).

Natural communities and disturbed areas. Previous natural community descriptions for the Isles of Shoals have been limited to Star (Nichols 2004; Steiger and Schultes 1940) and Appledore (Boden 1977; Goldenberg 1976). Steiger and Schultes (1940) described four cover types on Star: meadow, rock vegetation, freshwater bog, and disturbed areas and waste places. On the same island, Nichols (2004) described seven natural communities and one disturbed cover type. Goldenberg (1976) studied only one community on Appledore, a small salt marsh. Boden (1977) described and mapped 12 plant associations on Appledore. These plant associations are cross-walked in Table 4 to MNAP (Brown 1993; Gawler and Cutko 2003; MNAP 1991) and NHB (Sperduto and Nichols 2004) natural communities.

In all, 14 NHB natural communities and two human-disturbed cover types were identified on the nine islands in the Isles of Shoals (Table 5). The order of community types described below begins with those found intertidally, then upland communities, and finally small, freshwater wetlands found within the upland matrix. The last two descriptions are cover types whose vegetation composition and structure is noticeably affected by current or recent human-related disturbances. See Appendix 2 for a key to the natural communities on the Isles of Shoals. Appledore, over twice the size of the next largest island, supported all 14 communities and both human-disturbed cover types. Seaveys, the second smallest island, supported just three communities. The maritime intertidal rocky shore and maritime rocky barren were the only communities

Table 2. Rare plant taxa recorded for the nine islands in the Isles of Shoals, New Hampshire and Maine. State Status: SE = State Endangered; ST = State Threatened; SW = State Watch; SU = Status Uncertain (but possibly in peril); IND = Indeterminate; NR = Not Rare. The primary determinant of a taxon's rarity is the number of populations occurring in a state. In general, SE = 1–5 statewide populations, ST = 6–20 populations, and SW = 21–100 populations. Indeterminate taxa are thought to be rare but their degree of rarity and/or taxonomy is unclear.

Rare Plant Taxa	State Status	Location on the Isles of Shoals
Bolboschoenus robustus	ME - SU NH - SW	One population in a brackish water pool on Star. Other populations in similar habitat on Smuttynose and Appledore.
Carex nigra	ME - NR NH - SE	Wet meadow on Star.
Chenopodium rubrum	ME - ST NH - SE	One population on cobble beach on Appledore.
Cyperus erythrorhizos	ME - SE NH - SE	Found in coastal salt pond marshes on Appledore, Duck, and Smuttynose.
Eleocharis uniglumis	ME - NR NH - ST	Uncommon on islands in brackish water pools, damp crevices, and other moist areas in the maritime rocky barren.
Epilobium ciliatum	ME - NR NH - IND	Uncommon on islands in damp crevices and other moist areas in the maritime rocky barren.
Glaux maritima	ME - NR NH - SW	One population in an intertidal zone on Star. Other populations in similar habitat on Smuttynose and Appledore.
Leymus mollis	ME - NR NH - SE	One population on cobble beach on Lunging.
Lythrum hyssopifolia	ME - NR NH - SW	Uncommon on islands in brackish water pools, damp crevices, and other moist areas in the maritime rocky barren.
Mertensia maritima	ME - NR NH - SE	Reported by Celia Thaxter (1873) on Lunging. One plant found on cobble beach on Duck.
Potentilla pensylvanica var. *litoralis*	ME - NR NH - IND	One population on rocky barren on White. Reported by Howard (1968) on Star.
Prunus maritima	ME - SE NH - SW	On Cedar and Smuttynose in maritime shrub thicket.
Ranunculus cymbalaria	ME - NR NH - SW	One population in a brackish water pool on Star. A few populations in similar habitat on Maine islands.
Rumex pallidus	ME - NR NH - SE	Reported by Howard (1968) on Star. One population on rocky barren on Appledore.

Table 2. Continued.

Rare Plant Taxa	State Status	Location on the Isles of Shoals
Symphyotrichum subulatum	ME - SE NH - SW	On Appledore, Cedar, and Smuttynose scattered in brackish water pools, damp crevices, and other moist areas in the maritime rocky barren. Also in similar habitats on Lunging, Star, and White.

common to all nine islands; the fenny marsh occurred on just Appledore. Due to the scarcity of maritime islands in New Hampshire, all of the maritime-restricted communities on the Shoals are rare in the state. None of the maritime-restricted communities found on these islands are rare in Maine (which has numerous maritime islands and a long convoluted coastline).

1. Maritime Intertidal Rocky Shore

Rocky shores occur around all nine islands along the water's edge within the intertidal zone. This broadly defined community type is particularly exposed to wave action, tides, salt spray, sun, and wind. These environmental factors have a strong influence on species composition and zonation. Vascular plants are absent. In the supralittoral and high littoral zones, non-vascular taxa include cyanobacteria or "blue-green algae" and lichens. Commonly seen macroalgae in lower intertidal zones include the rockweeds *Ascophyllum nodosum*, *Fucus* spp., and many other taxa (Borror 1994).

2. Low Salt Marsh

Seven small, poorly developed pockets of salt marsh occur on the Shoals along intertidal shorelines protected from high-energy waves behind rocky ledges and in eroded shoreline trap dikes. These marshes are found on Appledore (Sandpiper Beach, east end of Devil's Dance Floor, and by a cobble beach on the northwest shore), Duck (relic marsh in cove on northeast shore), and Smuttynose (southeastern end and in two small pockets on southwest end). Pockets of low salt marsh characterized by halophytic graminoids and forbs form at best only small mats or grow from bedrock crevices. The low salt marsh occurs seaward of the high marsh, between mean high tide and mean sea level. Associates of *Spartina alterniflora*, the most frequent species, are *Atriplex prostrata*, *Limonium carolinianum*, *Salicornia depressa*, *Spartina patens*, *Spergularia marina*, *Suaeda maritima*, and macroalgae such as *Ascophyllum nodosum* and *Fucus* spp.

Table 3. Invasive plant taxa (following Mehrhoff et al. 2003) documented on each island in the Isles of Shoals, New Hampshire and Maine. Island abbreviations: A = Appledore; C = Cedar; D = Duck; L = Lunging; M = Malaga; Se = Seaveys; Sm = Smuttynose; St = Star; W = White. E = extant; H = historic (not documented in at least 20 years).

	Island								
Invasive Plant Taxa	A	C	D	L	M	Se	Sm	St	W
Aegopodium podagraria	–	–	–	–	–	–	–	H	–
Berberis vulgaris	–	–	–	–	–	–	–	E	–
Bromus tectorum	E	–	–	–	E	–	E	H	–
Celastrus orbiculatus	–	–	–	–	–	–	E	E	–
Chelidonium majus	E	–	–	–	–	–	E	E	–
Cirsium arvense	E	E	–	E	E	E	E	E	–
Datura stramonium	H	–	–	–	–	–	–	–	–
Epilobium hirsutum	E	–	–	–	–	–	–	–	–
Fallopia japonica	–	–	–	–	–	–	–	H	–
Glechoma hederacea	E	–	–	E	–	–	–	E	–
Hesperis matronalis	E	–	–	E	–	–	–	–	–
Iris pseudacorus	–	–	–	–	–	–	–	E	–
Lonicera morrowii	–	–	–	–	–	–	–	E	–
Lythrum salicaria	E	E	–	–	E	–	E	E	–
Phalaris arundinacea	–	–	–	–	–	–	–	E	–
Phragmites australis	–	–	–	–	–	–	–	E	–
Poa compressa	E	E	E	E	E	E	E	E	E
Populus alba	E	–	–	–	–	–	–	E	–
Ranunculus repens	E	E	–	E	–	–	E	E	–
Rorippa nasturtium-aquaticum	–	–	E	–	–	–	–	–	–
Rosa rugosa	E	E	–	E	E	–	E	E	–
Rumex acetosella	E	E	–	E	E	E	E	E	–
Solanum dulcamara	E	E	E	E	E	E	E	E	E

3. High Salt Marsh

Similar in size to low salt marshes (see #2) on the Shoals, high salt marshes lie between the upper reach of spring tides and mean high water. Halophytic graminoids, most frequently *Juncus gerardii* and *Spartina patens*, grow out of bedrock crevices or from small, shallow organic mats in low, flat areas. *Juncus gerardii* typically occurs landward of *S. patens* beginning at about mean spring high water, where decreased tidal flooding and soil water salinity occur. Other taxa occasionally associated with *J. gerardii* higher in the marsh are *Festuca rubra*, *Hordeum jubatum*, *Lythrum hyssopifolia*, *Solidago sempervirens*, and *Symphyotrichum subulatum*. Taxa associated with *Spartina patens* between mean spring high water and mean high tide include *Argentina egedii* subsp. *groenlandica*, *Atriplex prostrata*,

Table 4. Plant associations on Appledore Island, Maine (Boden 1977) cross-walked to MNAP (Brown 1993; Gawler and Cutko 2003; MNAP 1991) and NHB (Sperduto and Nichols 2004) natural community types. Human-disturbed areas do not directly cross-walk to NHB or MNAP community types. For MNAP natural communities, * = MNAP 1991; ** = Brown 1993; no asterisk = Gawler and Cutko 2003.

Plant Association	MNAP Natural Community Type	NHB Natural Community Type(s)
Uplands		
Dry shrub thicket	Rose–bayberry maritime shrubland	Maritime shrub thicket
Exposed margin	Seaside goldenrod–goosetongue open headland	Maritime meadow
Rocky beach	Beach strand	Maritime cobble beach
Bare rock	Seaside goldenrod–goosetongue open headland	Maritime rocky barren
Wetlands		
Moist shrub thicket	*Shrub swamp community	Highbush blueberry–winterberry shrub thicket
Large depression	*Shrub swamp community	Highbush blueberry–winterberry shrub thicket
Boggy area	Brackish tidal marsh	Coastal salt pond marsh
Freshwater marsh	Mixed graminoid–shrub marsh	Shallow emergent marsh Fenny marsh
Pond margin	Mixed graminoid–shrub marsh	Short graminoid–forb emergent marsh/mud flat
Bare rock	**Rock: exposed	Maritime intertidal rocky shore Brackish water pool
Rocky beach	Beach strand	Coastal shoreline strand/swale
Salt marsh	Spartina salt marsh	High salt marsh Low salt marsh
Human-disturbed areas		
Formerly disturbed area	–	Recovering area
Presently disturbed area	–	Presently disturbed area

Table 5. NHB natural communities and human-disturbed cover types on the nine islands in the Isles of Shoals, New Hampshire and Maine. Island abbreviations: A = Appledore; C = Cedar; D = Duck; L = Lunging; M = Malaga; Se = Seaveys; Sm = Smuttynose; St = Star; W = White. E = extant.

Natural Community/Human-Disturbed Cover Type	Island								
	A	C	D	L	M	Se	Sm	St	W
Uplands									
Maritime cobble beach	E	E	E	E	–	–	E	–	E
Maritime meadow	E	–	E	E	E	E	E	E	E
Maritime rocky barren	E	E	E	E	E	E	E	E	E
Maritime shrub thicket	E	E	–	–	–	–	E	E	–
Wetlands									
Brackish water pool	E	E	E	–	E	–	E	E	E
Coastal salt pond marsh	E	–	E	–	–	–	E	–	–
Coastal shoreline strand/swale	E	–	E	–	–	–	E	E	–
Fenny marsh	E	–	–	–	–	–	–	–	–
Highbush blueberry–winterberry shrub thicket	E	–	–	–	–	–	E	E	–
High salt marsh	E	–	E	–	–	–	E	–	–
Low salt marsh	E	–	E	–	–	–	E	–	–
Maritime intertidal rocky shore	E	E	E	E	E	E	E	E	E
Shallow emergent marsh	E	–	–	–	–	–	E	E	–
Short graminoid–forb emergent marsh/mud flat	E	–	–	–	–	–	E	E	–
Human-disturbed cover type									
Presently disturbed area	E	E	–	E	–	–	E	E	E
Recovering area	E	E	–	E	–	–	E	E	E

Bolboschoenus maritimus subsp. *paludosus*, *B. robustus*, *Glaux maritima*, *Limonium carolinianum*, *Puccinellia maritima*, *Salicornia depressa*, *Spartina alterniflora*, and *Spergularia marina*. See low salt marsh description for high marsh locations on the Shoals.

4. Coastal Shoreline Strand/Swale

This is a low-energy, upper intertidal community found on some protected shorelines on Appledore, Duck, Smuttynose, and Star Islands. The community is flooded less than daily and is characterized by a low cover (typically < 25%) of halophytic herbs. The substrate consists of fine to coarse soils or various types of bedrock. Plant stems and other detritus are often washed in on the higher tides and can cover much of the substrate's surface. These strands are important habitat for various arthropods, shore birds, and other animals. Plant taxa include *Argentina egedii* subsp.

groenlandica, *Atriplex prostrata*, *Glaux maritima*, *Limonium carolinianum*, *Puccinellia maritima*, *Salicornia depressa*, *Spergularia marina*, and *Suaeda maritima*. *Juncus gerardii* and *Spartina patens* may be present landward at slightly higher elevations. Macroalgae (e.g., *Ascophyllum nodosum* and *Fucus* spp.) begin to dominate seaward.

5. Maritime Cobble Beach

This community, characterized by forbs and graminoids on a cobble and/or gravel dominated substrate, is found along short stretches of shoreline above the reach of spring tides but overwashed during severe storms. Cobble beaches occur at Broad Cove, Devil's Dance Floor, and other areas on Appledore and along some shores on Cedar, Duck, Lunging, Smuttynose, and White. These dynamic beaches can be significantly altered over relatively short periods of time. On Lunging, the cobble beach has grown 3.5 m in elevation over the last 20 years (R. Randall, pers. comm.) as a result of storm waves moving sand, gravel, cobble, and larger rock landward onto the beach. Vascular plant cover is low to moderate. Frequent taxa are *Achillea millefolium*, *Ambrosia artemisiifolia*, *Cakile edentula*, *Calystegia sepium*, *Chenopodium album*, *Elymus repens*, *Galeopsis bifida*, *Lathyrus japonicus*, *Raphanus raphanistrum*, *Rumex crispus*, *Sisymbrium altissimum*, *Solanum dulcamara*, and *Solidago sempervirens*. The only location on the Shoals for extant populations of *Mertensia maritima* and the adventive *Phalaris canariensis* occur on a cobble beach on Duck Island. The beach on Lunging supports the only extant population of *Leymus mollis* on the Shoals and in New Hampshire.

6. Coastal Salt Pond Marsh

This is a broadly defined community type with vegetation zones distributed along hydrologic and salinity gradients. Basins are typically seasonally to semi-permanently flooded. They support a greater number of freshwater shallow emergent marsh taxa closer to their upper margins and medium-depth emergent marsh taxa tolerant of wetter, more brackish conditions in lower areas. Salinities fluctuate seasonally and yearly in response to freshwater input, evaporation, and periodic infusion with salt water. This community is uncommon in Maine and rare in New Hampshire where just a single site occurs on the mainland shore. Four examples occur on the Shoals, all on Maine islands: two on Appledore (Central Pond in the central valley and North Pond), one near the center of Duck, and one on the east end of Smuttynose. These marshes are separated from the coastal shoreline by maritime cobble beach ridges that are periodically overwashed by seawater. The central valley on Appledore had been washed across by the sea during severe storms several times in recent memory (A. Cook, Isles of Shoals Historical & Research Assoc., pers. comm.; Kingsbury 1976). The other three salt pond marshes on the Shoals were likely inundated by seawater during these storms as well. Soils in the central valley marsh consist of an organic horizon overlying a gravelly silt loam containing scattered coarse sand. Frequent shallow emergent marsh taxa occurring on higher ground include *Agrostis stolonifera*, *Bidens cernua*, *Calystegia sepium*, *Elymus repens*, *E. virginicus*, *Impatiens capensis*, *Lycopus americanus*, *L. uniflorus*, *Lythrum hyssopifolia*, *Persicaria maculosa*, *P. pensylvanica*, *P. punctata*, *Rumex crispus*, and *Solanum dulcamara*. Scattered shrubs include *Ilex verticillata*, *Sambucus canadensis*, and *Toxicodendron radicans*. Frequent taxa in medium-depth emergent marsh zones are *Lythrum salicaria*, *Schoenoplectus pungens*, *Typha angustifolia*, and *T. latifolia*. Other taxa on exposed, saturated mud include *Eleocharis obtusa*, *E. uniglumis*, *Lemna minor*, *Ludwigia palustris*, *Ranunculus cymbalaria*, and *Rorippa nasturtium-aquaticum*. Many of these taxa occur in both freshwater and brackish habitats, but when these plants are commonly found together, they often indicate brackish conditions.

7. Maritime Rocky Barren

This sparsely vegetated community, dominated by exposed bedrock, occurs on all nine islands between the maritime intertidal rocky shore (see #1) and the maritime shrub thicket (see #9) or maritime meadow (see #10). Plant cover is affected by concentrations of seabird guano, lack of soil, and exposure to heavy surf, wind, and salt spray. A low cover of herbs and even fewer shrubs creeps down into protected crevices from more vegetated communities above. Most frequent are *Achillea millefolium*, *Elymus repens*, *Festuca rubra*, *Lepidium ruderale*, *L. virginicum*, *Polygonum aviculare*, *Portulaca oleracea*, *Solanum dulcamara*, *Solidago sempervirens*, *Spergularia rubra*, and *Symphyotrichum novi-belgii*.

8. Brackish Water Pool

Brackish pools occur on most islands in small depressions within maritime rocky barrens (see #7). Because of the small size of these pools (less than a few to several square meters), they alternatively could be considered fine-scale variation within rocky barrens rather than as a separate community type. Depending on salinity, fresh and/or brackish water graminoids and forbs occur within and along the margins of these pools. Salinity fluctuates as a result of salt inputs from storm waves and salt spray, fresh water precipitation, and evaporation. Fresh water taxa include *Anagallis arvensis*, *Epilobium ciliatum*, *Hordeum jubatum*, *Iris versicolor*, *Lemna minor*, *Lycopus uniflorus*, *Lythrum salicaria*, *Persicaria hydropiper*, *P. pensylvanica*, *P. punctata*, *Portulaca oleracea*, *Ranunculus sceleratus*, *Scutellaria galericulata*, and *Typha latifolia*. Taxa present that are often associated with brackish conditions, especially when they are commonly found together, include *Agrostis stolonifera*, *Argentina egedii* subsp. *groenlandica*, *Bolboschoenus robustus*, *Carex hormathodes*, *Eleocharis uniglumis*, *Juncus bufonius*, *J. gerardii*, *J. pelocarpus*, *Lythrum hyssopifolia*, *Plantago maritima* var. *juncoides*, *Schoenoplectus pungens*, *Solidago sempervirens*, *Spergularia salina*, *Symphyotrichum novi-belgii*, *S. subulatum*, and *Typha angustifolia*.

9. Maritime Shrub Thicket

This community dominates natural upland habitats landward of maritime rocky barrens (see #7) on the larger islands (i.e., Appledore, Cedar, Smuttynose, and Star). Two expressions occur: 1) a short to moderate-height shrub thicket comprising stunted and low-growing shrubs on thin-soiled, exposed ridgelines and areas closer to shorelines near rocky barrens, and 2) a moderate to tall shrub thicket in more protected island interiors in deeper soils. Both expressions support similar shrub taxa, including *Amelanchier canadensis*, *A. stolonifera*, *Gaylussacia baccata*, *Myrica pensylvanica*, *Parthenocissus quinquefolia*, *Photinia floribunda*, *P. melanocarpa*, *Rosa rugosa*, *R. virginiana*, *Rubus allegheniensis*, *R. idaeus*, *Toxicodendron radicans*, and occasionally, stunted forms of *Acer rubrum* and *Prunus serotina*. Common herbs are *Achillea millefolium*, *Agrostis capillaris*, *Anthoxanthum odoratum*, *Elymus repens*, *Fallopia scandens*, *Festuca rubra*, *Fragaria virginiana*, *Maianthemum stellatum*, *Poa compressa*, *P. pratensis*, *Sedum* spp., *Sibbaldiopsis tridentata*, and *Symphyotrichum novi-belgii*.

10. Maritime Meadow

This community, characterized by forbs and graminoids and invariably linked to seabird nesting colonies, dominates upland habitats landward of maritime rocky barrens (see #7) on most of the smaller islands (i.e., Duck, Malaga, Seaveys, and White) and considerable areas of Appledore and Smuttynose where sizable nesting colonies occur. Guano deposition from gulls and cormorants plays a significant role in maintaining species composition and structure in this community (Ellis et al. 2006). Gulls and cormorants also pull and trample vegetation in nesting areas. Shrub cover is markedly reduced or absent. George (1980, p. 1) notes "the influence of larger birds on Duck Island, where hardly a sprig of a living woody form can be found, and where the air reeks of guano is the extreme example." On thinner, drier soils in more exposed areas, herb cover is sparse to moderate and characterized by *Achillea millefolium*, *Ambrosia artemisiifolia*, *Festuca rubra*, *Rumex acetosella*, *Solidago rugosa*, and *Symphyotrichum novi-belgii*, with lesser amounts of *Anagallis arvensis*, *Bromus tectorum*, *Lepidium ruderale*, *L. virginicum*, *Persicaria maculosa*, *Polygonum aviculare*, *Portulaca oleracea*, and *Solanum nigrum*. In more protected areas where soil accumulation and moisture increases, a moderate to dense cover of herbs can occur. Together with the taxa mentioned above, additional herbs characteristic of these less exposed areas are *Artemisia vulgaris*, *Elymus repens*, *Ligusticum scothicum*, *Persicaria lapathifolia*, *P. pensylvanica*, *P. punctata*, *Raphanus raphanistrum*, *Sisymbrium altissimum*, *S. officinale*, *Solidago sempervirens*, and *Stellaria media*. The few shrubs or woody vines that may be present typically include *Rubus allegheniensis*, *R. idaeus*, *Solanum dulcamara*, and *Toxicodendron radicans*.

11. Highbush Blueberry–Winterberry Shrub Thicket

This tall-shrub dominated wetland community is found only on the three larger islands (i.e., Appledore, Smuttynose, and Star) near pond margins and in low damp swales in eroded trap dikes within the maritime shrub thicket matrix (see #9). Appledore supports the largest example of this community type on the Shoals. All other occurrences on the three islands are relatively small. Common woody associates of the dominant *Ilex verticillata* are *Photinia floribunda*, *Rosa virginiana*, *Rubus allegheniensis*, *R. idaeus*, *Sambucus canadensis*, *Toxicodendron radicans*, and *Viburnum dentatum* var. *lucidum*. Less frequent woody plants are *Acer rubrum*, *Amelanchier canadensis*, *Lyonia ligustrina*, *Parthenocissus quinquefolia*, *Prunus serotina*, *Rosa palustris*, and *Solanum dulcamara*. The most frequent herbs are *Athyrium filix-femina* var. *angustum*, *Fragaria virginiana*, *Lycopus uniflorus*, *Onoclea sensibilis*, *Osmunda cinnamomea*, *Ranunculus repens*, and *Thelypteris palustris* var. *pubescens*. In New Hampshire, this widespread community is often expressed with *Vaccinium corymbosum* codominating with *I. verticillata*. However, in many examples (including those on the Shoals) *V. corymbosum* may be sparse or altogether absent.

12. Shallow Emergent Marsh

Medium to tall graminoid and forb dominated emergent marshes occur in damp soil around pond margins, in eroded trap dikes, and in other small depressions on Appledore, Duck, Smuttynose, and Star Islands. Organic rich mineral soils in these wetlands are temporarily flooded or saturated to just moist later in the growing season. *Lythrum salicaria* is often the most frequent taxon. Other common taxa are *Agrostis stolonifera*, *Alopecurus pratensis*, *Elymus repens*, *Iris versicolor*, *Juncus effusus*, *Lycopus americanus*, *L. uniflorus*, *Persicaria maculosa*, *P. pensylvanica*, *P. punctata*, and *Symphyotrichum novi-belgii*. Less frequent are *Calystegia sepium*, *Cuscuta gronovii*, *Impatiens capensis*, *Leersia oryzoides*, *Ludwigia palustris*, *Rumex crispus*, *Spartina pectinata*, and *Teucrium canadense*. Scattered woody taxa include *Ilex verticillata*, *Sambucus canadensis*, *Solanum dulcamara*, and *Toxicodendron radicans*.

13. Short Graminoid–Forb Emergent Marsh/Mud Flat

This community, characterized by short to medium height graminoids and forbs, occurs on drawn-down muddy pondshore margins on Appledore, Smuttynose, and Star Islands. Common taxa include *Agrostis stolonifera*, *Bidens cernua*, *Eleocharis flavescens* var. *olivacea*, *E. obtusa*, *E. palustris*, *Hypericum boreale*, *H. mutilum*, *Juncus canadensis*, *Ludwigia palustris*, and *Lycopus uniflorus*, among others.

14. Fenny Marsh

Fenny marshes are transitional between fen and marsh, with well-decomposed organic soils and a modest *Sphagnum* cover, but are dominated by graminoids and forbs of at least weakly minerotrophic and more marshy tendencies (i.e., they are not restricted to fen habitats; Sperduto and Nichols 2004). This natural community only occurs on Appledore in a small basin called the "Old Reservoir." Soils are saturated around the basin's edge and shallowly ponded in lower areas within the basin's interior. *Lemna minor*, *Typha angustifolia*, and small floating herb mats with *Bidens cernua*, *Hypericum boreale*, *Ludwigia palustris*, and *Lycopus uniflorus* are common in the small ponded area. Frequent plants along the margin are *Agrostis stolonifera*, *Dulichium arundinaceum*, *Eleocharis flavescens* var. *olivacea*, *E. obtusa*, *E. palustris*, *Iris versicolor*, *Juncus canadensis*, *J. effusus*, *Persicaria punctata*, *Scirpus cyperinus*, *Solanum dulcamara*, *Sphagnum* sp., *Spiraea alba* var. *latifolia*, and *Toxicodendron radicans*.

15. Recovering Area

These areas are recovering from recent human disturbance and are usually reverting to either maritime shrub thickets (see #9) or maritime meadows (see #10). Numerous non-native plants, including several invasive taxa, are often present in these areas. Taxa that may or may not be present in maritime thickets and meadows but are particularly characteristic of this community are *Alopecurus pratensis*, *Ambrosia artemisiifolia*, *Artemisia vulgaris*, *Asclepias syriaca*, *Calystegia sepium*, *Cirsium arvense*, *C. vulgare*, *Elymus repens*, *Ligusticum scothicum*, *Lythrum salicaria*, *Oenothera biennis*, *Poa compressa*, *P. pratensis*, *Ranunculus repens*, *Rhus hirta*, *Rosa rugosa*, *Rubus allegheniensis*, *R. idaeus*, *Rumex crispus*, *Solanum dulcamara*, *Solidago rugosa*, *Sonchus arvensis*, *S. oleraceus*, *Toxicodendron radicans*, and *Urtica dioica*. Recovering areas are absent only on Duck, Malaga, and Seaveys, small islands without recent human settlement.

16. Presently Disturbed Area

These areas, currently managed for human use, include fields, lawns, paths, dirt roads, cellar holes, graveyards, and other grounds by buildings and other structures. Most of the horticultural taxa occurring on the islands as well as numerous naturalized taxa occur here. Presently disturbed areas are absent only on Duck, Malaga, and Seaveys Islands.

Natural community systems. Natural community systems are particular sets of natural communities that co-occur in the landscape and are linked by a common set of driving forces, such as landforms, flooding, soils, and nutrient regime (Sperduto 2005). The Isles of Shoals are characterized by a maritime rocky shore system. Although not rare in Maine, the maritime rocky shore system occurs in New Hampshire only on these islands. Natural communities associated with other systems also occur on the islands. However, because of the small size of these communities and absence of other communities diagnostic to these other systems, no other fully formed systems occur on the Shoals.

1. Maritime Rocky Shore System

This system on the Shoals formed as a result of the constant exposure of these small islands to the surrounding maritime environment. Several natural processes influence vegetation patterns, including tides, wave action, storm washover, salt spray, sun exposure, wind, guano deposition, and fire. Despite a long history of human use, these islands support substantial natural areas. Diagnostic natural communities of this system on the Shoals are the brackish water pool, coastal salt pond marsh, maritime cobble beach, maritime intertidal rocky shore, maritime meadow, maritime rocky barren, and maritime shrub thicket. Peripheral or occasional natural communities are coastal shoreline strand/swale and highbush blueberry–winterberry shrub thicket.

DISCUSSION

The present vegetation patterns of the Isles of Shoals reflect the land use history and maritime position of these islands. Because of thin soils and exposure to maritime elements, the Shoals probably never had more than a few sizable trees, these growing in the most protected hollows. Observations from the early 1600s (Boden 1977; Penrose 1957) suggest current vegetation cover and composition characterizing natural areas on the islands may be similar to those present when observations were first made.

In other areas, particularly on parts of Appledore and Star, vegetation cover and composition around buildings differ markedly from those occurring here 400 years ago. The sometimes intense past and present land use and present seasonal human population density, together with the influence of seabird nesting colonies (Ellis et al. 2006; Hogg and Morton 1983; McMaster 2005), largely explains the higher percentage of non-native vascular plant taxa on the Shoals (42%) compared to that documented on the nearby mainland [27% in New Hampshire (George 1998); 30% in Maine (Campbell et al. 1995)]. Avian transport of plant propagules by large numbers of seabirds using maritime islands can increase the presence and cover of non-native plant taxa (Heatwole and Walker 1989), especially ruderal species. McMaster (2005, p. 487), studying maritime islands off the coast of northeastern North America, states "Pelagic bird populations may have a compound effect on the ratio of non-native species richness to total species richness, reducing the number of native plant species through nest-building while also enhancing immigration of non-native species that are tolerant of, possibly even dependent upon, disturbance."

The toxic nature of high levels of seabird guano, particularly to shrub and tree species, and the exposure of these islands to the maritime elements, limiting the establishment and growth of trees in all but the most protected areas, largely explain the difference in proportions among life forms on the Shoals (86% herbs, 12% shrubs, and 2% trees) compared to on the mainland (e.g., in New Hampshire 75% herbs, 17.5% shrubs, and 7.5% trees; Kartesz 1999).

The two dominant communities found on the Shoals, the maritime shrub thicket and maritime meadow, are absent or poorly developed on the coastal mainland, where offshore winds prevail and seabird nesting colonies are small and infrequent. The presence and composition of most other communities on the Shoals is similar to those found on the mainland, largely because they share similar environmental conditions (e.g., disturbance, water chemistry, and hydrologic regime) important in the formation of these communities.

All of the 15 rare plant taxa on the Shoals are rare in New Hampshire; only four are rare in Maine. Because Lunging, Seaveys, Star, and White are the only maritime islands in New Hampshire, more of the plants restricted to maritime communities that occur on these islands are also rare in the state. With numerous maritime islands, maritime-restricted communities in Maine support many occurrences of most of the taxa considered rare on the Shoals in New Hampshire. Several of the 15 rare plant taxa on the Shoals have a broadly north coastal distribution in North America; these are *Carex nigra*, *Chenopodium rubrum*, *Eleocharis uniglumis*, *Glaux maritima*, *Leymus mollis*, *Lythrum hyssopifolia*, *Prunus maritima*, and *Ranunculus cymbalaria*. The distributions of *Mertensia maritima* and *Rumex pallidus* are more strictly north coastal. *Bolboschoenus robustus* and *Symphyotrichum subulatum* occur along most of the east coast of North America in saline or brackish marshes. Other rare taxa on the Shoals, including *Cyperus erythrorhizos*, *Epilobium ciliatum*, and *Potentilla pensylvanica* var. *litoralis*, can be found throughout much of North America, especially in the east and northeast.

Geographic area is related to species richness over a wide range of spatial scales (Huston 1994; MacArthur and Wilson 1967; Rosenzweig 1995). However, examination of the species-area relationship for islands of less than 100 ha is understudied (Lomolino and Weiser 2001). In our study, island size (ranging from 0.77 to 39.46 ha) was significantly related to vascular plant richness. Typically, as island size increases, there are more diverse habitats, each habitat occupies larger areas, plant populations are larger, and propagules are more likely to reach the island. These factors all increase the likelihood that larger islands will support higher levels of species richness compared to smaller islands. Star Island, however, supported unusually high numbers of vascular plant taxa, presumably because of a greater degree of human visitation over the last several decades, highest present-day human population, and current intense land management in portions of the island. Compared to most other islands in the Shoals, Star supports a more complex mosaic of disturbed landscape patches, including two human-disturbed cover types (recovering areas and presently disturbed areas). On Star, the number of native plant taxa considered alone was more in line with that expected based on island size (Table 1).

The stronger relationship between area and native plant richness and weaker (but still significant) relationship for non-native plants has been shown in other studies (Nichols et al. 1998). Disturbance is likely the primary factor diminishing the strength of the relationship between area and species diversity. "Non-native species are abundant in disturbed environments (Denslow 1980; Hobbs 1989; Hobbs and Huenneke 1992; Rejmanek 1989), and disturbance confuses the species-area relationship by increasing the importance of physiological tolerances to stress (Denslow 1980) while potentially decreasing the overall influence of geomorphological heterogeneity" (Nichols et al. 1998, p. 377).

The Isles of Shoals have a rich history of human habitation but retain extensive areas where vegetation reflects natural processes associated with the surrounding maritime environment. The Shoals are home to several rare plants and natural communities not found elsewhere in New Hampshire and Maine. Continued responsible stewardship will ensure that the remarkable vegetation of these islands remains a part of New England's landscape.

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LITERATURE CITED

Bloom, A. L. 1963. Late-Pleistocene fluctuations of sealevel and postglacial crustal rebound in coastal Maine. Amer. J. Sci. 261: 862–879.

Boden, G. T. 1977. The Vascular Flora of Appledore Island. Shoals Marine Laboratory, Cornell Univ., Ithaca, NY.

Borror, A. C. 1994. Checklist of Flora and Fauna of the Isles of Shoals. Shoals Marine Laboratory, Cornell Univ., Ithaca, NY.

Boyce, S. G. 1954. The salt spray community. Ecol. Monogr. 24: 29–67.

Brown, B. 1993. A Classification System of Marine and Estuarine Habitats in Maine: An Ecosystem Approach to Habitats. Maine Natural Areas Program, Dept. Conservation, Augusta, ME.

Campbell, C. S., et al. 1995. Checklist of Vascular Plants of Maine, 3rd ed. Bull. 844, Maine Agricultural and Forest Experiment Station, Orono, ME.

Clarke, W. H. 1936. Flora of Appledore Island, Isles of Shoals. Marine Zoological Laboratory, Isles of Shoals, Portsmouth, NH. [33 pp. unpubl. manuscript available at Harvard Botany Libraries, Cambridge, MA]

Clayton, J. L. 1972. Salt spray and mineral cycling in two California coastal ecosystems. Ecology 53: 74–81.

Denslow, J. S. 1980. Patterns of plant species diversity during succession under different disturbance regimes. Oecologia 46: 18–21.

Ellis, J. C., J. M. Farina, and J. D. Witman. 2006. Nutrient transfer from sea to land: The case of gulls and cormorants in the Gulf of Maine. J. Anim. Ecol. 75: 565–574.

Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. Vols. 1–5, 19–23, 25 & 26. Oxford Univ. Press, Oxford and New York.

Fowler-Billings, K. 1977. Geology of the Isles of Shoals. New Hampshire Dept. Resources and Economic Development, Concord, NH.

Gawler, S. C. and A. R. Cutko. 2003. Natural Landscapes of Maine: A Classification of Vegetated Natural Communities and Ecosystems. Maine Natural Areas Program, Dept. Conservation, Augusta, ME.

George, C. J. 1980. Remarks on the More Conspicuous Vascular Plants of Appledore Island, Isles of Shoals, Maine. Union College, Schenectady, NY.

George, G. G. 1998. Vascular Plants of New Hampshire. New Hampshire Natural Heritage Bureau, Dept. Resources and Economic Development, Concord, NH.

Gleason, H. A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd ed. The New York Botanical Garden, Bronx, NY.

Goldenberg, G. 1976. Appledore's Only Salt Marsh. Union College, Schenectady, NY. [29 pp. unpubl. manuscript available at Shoals Marine Laboratory Library, Creek Farm Cottage, Portsmouth, NH]

Goldthwait, J. W. 1950. Surficial Geology Map. New Hampshire State Planning and Development Commission, Concord, NH.

Griffiths, M. E., R. P. Keith, and C. M. Orians. 2006. Direct and indirect effects of salt spray and fire on coastal heathland plant physiology and community composition. Rhodora 108: 32–42.

Haines, A. and T. Vining. 1998. Flora of Maine. V. F. Thomas Co., Bowdoin, ME.

Heatwole, H. and T. A. Walker. 1989. Dispersal of alien plants to coral cays. Ecology 70: 787–790.

Hobbs, R. J. 1989. The nature and effects of disturbance relative to invasions, pp. 389–405. *In*: J. A. Drake, H. A. Mooney, F. di Castri, R. H. Groves, F. J. Kruger, M. Rejmanek, and M. Williamson, eds., Biological Invasions: A Global Perspective. Wiley, Chichester, U.K.

——— and L. F. Huenneke. 1992. Disturbance, diversity, and invasion: Implications for conservation. Conservation Biol. 6: 324–337.

Hogg, E. H. and J. K. Morton. 1983. The effects of nesting gulls on the vegetation and soil of islands in the Great Lakes. Canad. J. Bot. 61: 3240–3254.

Howard, R. A. 1968. Flowers of Star Island. Arnold Arboretum, Boston, MA.

Humphreys, M. O., M. P. Kraus, and R. G. Wyn Jones. 1986. Leaf-surface properties in relation to tolerance of salt spray in *Festuca rubra* subsp. *litoralis* (G.F.W. Meyer) Auquier. New Phytol. 103: 717–723.

Huston, M. A. 1994. Biological Diversity. Cambridge Univ. Press, Cambridge, U.K.

Jenness, J. 1884. The Isles of Shoals: An Historical Sketch, 3rd ed. Houghton, Mifflin & Co., Boston, MA.

Kartesz, J. T. 1999. A Synonymized Checklist and Atlas with Biological Attributes for the Vascular Flora of the United States, Canada, and Greenland, 1st ed. *In*: J. T. Kartesz and C. A. Meacham, eds., Synthesis of the North American Flora, version 1.0. North Carolina Botanical Garden, Chapel Hill, NC.

Kelso, G. K. and F. Harrington. 1989. Pollen record formation processes at the Isles of Shoals: Botanical records of human behavior. NorthE. Hist. Arch. 18: 70–84.

Kingsbury, J. M. 1975. Oil and Water—The New Hampshire Story. Shoals Marine Laboratory, Cornell Univ., Ithaca, NY.

———. 1976. Transect Study of the Intertidal Biota of Star Island, Isles of Shoals. Shoals Marine Laboratory, Cornell Univ., Ithaca, NY.

Lomolino, M. V. and M. D. Weiser. 2001. Towards a more general species-area relationship: Diversity on all islands, great and small. J. Biogeogr. 28: 431–445.

Lyons, J. B., W. A. Bothner, R. H. Moench, and J. B. Thompson. 1997. Bedrock Geologic Map of New Hampshire. U.S. Geological Survey in cooperation with the U.S. Dept. Energy and the State of New Hampshire, Concord, NH.

MacArthur, R. H. and E. O. Wilson. 1967. The Theory of Island Biogeography. Princeton Univ. Press, Princeton, NJ.

Maine Natural Areas Program. 1991. Natural Landscapes of Maine: A Classification of Ecosystems and Natural Communities. Maine Natural Areas Program, Dept. Conservation, Augusta, ME.

Malloch, A. J. C. 1972. Salt-spray deposition on the maritime cliffs of the Lizard Peninsula. J. Ecol. 60: 103–112.

McGill, P. A. 1977. Breeding Ecology and Competition Between Great Black-backed and Herring Gulls. M.S. thesis, Cornell Univ., Ithaca, NY.

McMaster, R. T. 2005. Factors influencing vascular plant diversity on 22 islands off the coast of eastern North America. J. Biogeogr. 32: 475–492.

Mehrhoff, L. J., J. A. Silander Jr., S. A. Leicht, E. S. Mosher, and N. M. Tabak. 2003. IPANE: Invasive Plant Atlas of New England. Dept. Ecology and Evolutionary Biology, Univ. Connecticut, Storrs, CT. Website (http://www.ipane.org). Accessed Jan 2007.

Moore, A. W. 1898. The Story of the Isles of Shoals. The New England Magazine, Boston, MA 18: 519–536.

Nichols, W. F. 2004. Ecological Inventory of Star Island, New Hampshire. New Hampshire Natural Heritage Bureau, Concord, NH.

———, K. T. Killingbeck, and P. V. August. 1998. The influence of geomorphological heterogeneity on biodiversity. Conservation Biol. 112: 371–379.

Novak, I. D. 1971. The origin, distribution, and transport of gravel on Broad Cove Beach, Appledore Island, Maine. Ph.D. dissertation, Cornell Univ., Ithaca, NY.

Penrose, C. 1957. They Live on a Rock! The Newcomen Society in North America, New York.

PIKE, R. B. AND A. R. HODGDON. 1962. Changes in flora of the Machias Seal Islands. Rhodora 64: 340–346.

RANDALL, P. E. AND M. BURKE, eds. 1997. Gosport Remembered. Publ. No. 23, The Portsmouth Marine Society. Published for the Society by Peter Randall, Publisher, Portsmouth, NH.

REJMANEK, M. 1989. Invasibility of plant communities, pp. 369–388. *In*: J. A. Drake, H. A. Mooney, F. di Castri, R. H. Groves, F. J. Kruger, M. Rejmanek, and M. Williamson, eds., Biological Invasions: A Global Perspective. Wiley, Chichester, U.K.

RICH, P. A. 1976. Physiognomic Differences Between the Windward, Leeward, and Sheltered Populations of *Rosa rugosa*; Appledore Island, Maine. Union College, Schenectady, NY. [70 pp. unpubl. manuscript available at Shoals Marine Laboratory Library, Creek Farm Cottage, Portsmouth, NH]

ROSENZWEIG, M. L. 1995. Species Diversity in Space and Time. Cambridge Univ. Press, Cambridge, U.K.

RUTLEDGE, L. V. 1997. Ten Miles Out, 7th ed. Isles of Shoals Association, Boston, MA.

SAGGERER, M. 2006. Historic references to flora at the Isles of Shoals. Isles of Shoals Historical and Research Association Newsletter, Vol. 15, Issue 2.

———. 2007. Historic references to flora at the Isles of Shoals. Isles of Shoals Historical and Research Association Newsletter, Vol. 16, Issue 1.

SALISBURY, E. 1952. Downs and Dunes. G. Bell and Sons, London, U.K.

SMITH, J. 1614. *In*: J. S. Jenness, ed., 1875. The Isles of Shoals: An Historical Sketch, 2nd ed. Hurd & Houghton, New York. [p. 27; reprinted in 1975 by Peter E. Randall, Publisher, Portsmouth, NH]

SPERDUTO, D. D. 2005. New Hampshire Natural Community Systems. New Hampshire Natural Heritage Bureau, Concord, NH.

——— AND W. F. NICHOLS. 2004. Natural Communities of New Hampshire. New Hampshire Natural Heritage Bureau. Concord, NH. [published by Univ. New Hampshire Cooperative Extension, Durham, NH]

STEIGER, T. AND R. SCHULTES. 1940. The Flora of Star Island. Isles of Shoals Historical and Research Association. [5 pp. unpubl. manuscript available at Shoals Marine Laboratory Library, Creek Farm Cottage, Portsmouth, NH]

THAXTER, C. 1873. Among the Isles of Shoals. Houghton, Mifflin & Co., Boston, MA.

———. 1894. An Island Garden. Houghton, Mifflin & Co., Boston, MA.

WAISEL, Y. 1972. Biology of Halophytes. Academic Press, New York.

APPENDIX 1

COMPREHENSIVE LIST OF VASCULAR PLANT TAXA DOCUMENTED FROM THE ISLES OF SHOALS, NEW HAMPSHIRE AND MAINE

A comprehensive vascular plant checklist for each of the nine islands is presented below. This list was compiled from plant collections made by the authors in 2004 and 2006, from other studies where voucher specimens were collected, and from reliable literature sources. Island abbreviations: A = Appledore; C = Cedar; D = Duck; L = Lunging; M = Malaga; Se = Seaveys; Sm = Smuttynose; St = Star; W = White. Researcher(s): n = present study; b = Boden (1977) including updates compiled by Borror (1994); g = George (1980); h = Howard (1968); r = R. Rollins and R. Howard (unpubl. data); c = Clarke (1936). Taxonomy and nomenclature generally follow the treatments published to date in the *Flora of North America* (1993+), then primarily Kartesz (1999), and occasionally Gleason and Cronquist (1991). * = Non-native taxa, primarily following Haines and Vining (1998), then Gleason and Cronquist (1991). ** = Non-native invasive taxa, following Mehrhoff et al. (2003). *** = Seen during this study and/or noted in one or more earlier studies but not thought to be naturalized. Fr = estimated frequency on the Isles of Shoals, using the following categories: 1 = historic or extant and rare; 2 = uncommon; 3 = occasional; 4 = common.

		Island								
Vascular Plant Taxa	Fr	A	C	D	L	M	Se	Sm	St	W
Acer rubrum L.	2	n b g c	n	–	–	–	–	n	n h	–
****Acer saccharinum* L.	1	c	–	–	–	–	–	–	–	–
****Acer saccharum* Marshall	1	b	–	–	–	–	–	–	–	–
Achillea millefolium L.	4	n b g c	n	n	n	n	n	n	n h	n
***Aegopodium podagraria* L.	1	–	–	–	–	–	–	–	h	–
****Aesculus hippocastanum* L.	1	b	–	–	–	–	–	–	–	–
**Agrostis capillaris* L.	2	n b c	n	–	–	–	n	n	n h	–
**Agrostis gigantea* Roth	1	b	n	–	–	–	–	–	–	–
Agrostis perennans (Walter) Tuck.	1	–	–	–	–	–	–	–	h	–
Agrostis scabra Willd.	1	n	–	–	–	–	–	–	–	–
**Agrostis stolonifera* L.	3	n	n	n	–	–	n	n	n	n
**Allium schoenoprasum* L.	1	b	–	–	–	–	–	–	n h	–
**Alopecurus pratensis* L.	3	n b	n	–	n	n	–	n	n h	–
**Amaranthus hybridus* L.	1	g	–	–	–	–	–	–	–	–
****Amaranthus hypochondriacus* L.	1	c	–	–	–	–	–	–	–	–
**Amaranthus retroflexus* L.	2	n b g	–	–	–	n	–	–	n h	–
Ambrosia artemisiifolia L.	4	n b g c	n	n g	n	n	n	n	n h	n
Amelanchier canadensis L.	2	n b g c	n	–	–	–	–	n	n	–
Amelanchier intermedia Spach	1	h	–	–	–	–	–	–	–	–
Amelanchier stolonifera Wiegand	1	–	–	–	–	–	–	–	n h	–
Ammophila breviligulata Fernald	1	–	–	–	–	–	–	n	–	–
**Anagallis arvensis* L.	3	n b c	n	n	n	n	n	n	n h	n
Anemone quinquefolia L.	1	b	–	–	–	–	–	–	–	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	A	C	D	L	M	Se	Sm	St	W
		Island								
Angelica atropurpurea L.	1	c	–	–	–	–	–	–	–	–
Angelica lucida L.	2	b g	–	–	–	–	–	–	n h	–
Antennaria plantaginifolia (L.) Richardson	1	c	–	–	–	–	–	–	–	–
**Anthemis cotula* L.	1	c	n	–	–	–	–	–	–	–
**Anthoxanthum odoratum* L.	2	n b	–	–	–	–	–	n	n h	–
Aquilegia canadensis L.	1	b	–	–	–	–	–	–	–	–
**Aquilegia vulgaris* L.	1	–	–	–	–	–	–	–	h	–
**Arctium lappa* L.	1	c	–	–	–	–	–	–	–	–
**Arctium minus* Bernh.	2	n b	n	–	–	n	–	n	n h	–
**Arenaria serpyllifolia* L.	1	–	–	–	–	–	–	–	h	–
Argentina egedii (Wormsk.) Rydb. subsp. *groenlandica* (Tratt.) Á. Löve	2	n b c	–	–	–	n	–	n	n h	–
Arisaema triphyllum (L.) Schott	2	n b c	–	–	–	–	–	–	h	–
**Armoracia rusticana* G. Gaertn., B. Mey. & Scherb.	1	b h c	–	–	–	–	–	–	h	–
Aronia arbutifolia (L.) Pers.	1	b g	–	–	–	–	–	–	h	–
Aronia floribunda (Lindl.) Spach	2	n	n	–	–	–	n	n	n h	–
Aronia melanocarpa (Michx.) Elliott	2	n b g	n	–	–	–	–	n	n h	–
**Artemisia ludoviciana* Nutt.	1	–	–	–	–	–	–	–	h	–
**Artemisia pontica* L.	1	–	–	–	–	–	–	–	h	–
**Artemisia stelleriana* Besser	1	–	–	–	–	–	–	–	h	–
**Artemisia vulgaris* L.	3	n b	–	n	–	–	–	n	n	–
**Aruncus dioicus* (Walter) Fernald	1	h	–	–	–	–	–	–	–	–
Asclepias syriaca L.	2	n b	–	–	–	–	–	n	n h	–
**Asparagus officinalis* L.	1	n b c	–	–	–	–	–	n	h	–
Athyrium filix-femina (L.) Roth *ex* Mertens var. *angustum* (Willd.) G. Lawson	2	n b	–	–	–	–	–	–	n h	–
Atriplex glabriuscula Edmondston	1	g	–	–	g	–	–	–	h	–
**Atriplex prostrata* Boucher *ex* DC.	3	n b g	n	n	n g	n	n	n	n h	n
****Baptisia australis* (L.) R. Br.	1	–	–	–	–	–	–	–	h	–
**Barbarea vulgaris* Aiton f.	2	n b	–	–	–	–	–	n	n h	–
***Berberis vulgaris* L.	1	–	–	–	–	–	–	–	n	–
Betula papyrifera Marshall	1	b	–	–	–	–	–	–	–	–
**Bidens cernua* L.	1	n	–	–	–	–	–	–	–	–
Bidens connata Muhl. *ex* Willd.	2	n	–	n	–	–	–	–	n	–
Bidens frondosa L.	2	n b	n	n	n	n	–	n	n h	–
****Blephilia hirsuta* (Pursh) Benth.	1	b	–	–	–	–	–	–	–	–
Boehmeria cylindrica (L.) Sw.	1	–	–	–	–	–	–	–	n	–
Bolboschoenus maritimus (L.) Palla subsp. *paludosus* (A. Nelson) T. Koyama	1	–	–	–	–	–	–	n	h	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	Island: A	C	D	L	M	Se	Sm	St	W
Bolboschoenus robustus (Pursh) Sojak	2	n	–	–	–	–	–	n	n	–
Botrychium dissectum Spreng.	1	b	–	–	–	–	–	–	–	–
**Brassica juncea* (L.) Czern.	1	–	–	–	–	–	–	–	h	–
****Brassica kaber* (DC.) L.C. Wheeler var. *pinnatifida* (Stokes) L.C. Wheeler	1	c	–	–	–	–	–	–	–	–
**Brassica nigra* (L.) W.D.J. Koch	2	b g	–	–	–	n	–	n	n h	n
**Bromus hordeaceus* L.	1	n	–	–	–	–	–	–	–	–
**Bromus marginatus* Nees *ex* Steud.	1	b	–	–	–	–	–	–	–	–
***Bromus tectorum* L.	2	n b	–	–	–	n	–	n	h	–
Cakile edentula (Bigelow) Hook.	2	n b g c	n	n	n	–	n	n	n h	n
Calamagrostis canadensis (Michx.) P. Beauv.	1	n c	–	–	–	–	–	–	n	–
Calystegia sepium (L.) R. Br.	4	n b c	n	n	n	n	n	n	n h	–
**Campanula rapunculoides* L.	1	–	–	–	–	–	–	–	n h	–
**Campanula* sp.	1	b	–	–	–	–	–	–	–	–
**Capsella bursa-pastoris* (L.) Medik.	2	n b c	–	–	n	–	–	n	n h	n
Carex canescens L.	1	n	–	–	–	–	–	–	–	–
Carex crinita Lam.	1	n	–	–	–	–	–	–	–	–
Carex debilis Michx. var. *rudgei* L.H. Bailey	1	n b	–	–	–	–	–	–	–	–
Carex echinata Murray	1	b	–	–	–	–	–	–	–	–
Carex hormathodes Fernald	2	n	n	–	–	–	n	n	n	n
Carex nigra (L.) Reichard	1	–	–	–	–	–	–	–	n h	–
Carex pensylvanica Lam.	2	n	n	–	n	–	–	n	–	–
Carex scoparia Schkuhr *ex* Willd.	2	n b	n	–	–	–	–	n	n h	–
Carex silicea Olney	2	n	n	–	n	–	–	n	n	n
***Celastrus orbiculatus* Thunb.	1	–	–	–	–	–	–	n	n	–
Celastrus scandens L.	1	c	–	–	–	–	–	–	–	–
**Centaurea cyanus* L.	1	–	–	–	–	–	–	–	h	–
**Cerastium fontanum* Baumg. subsp. *vulgare* (Hartm.) Greuter & Burdet	2	n b	n	–	n	–	n	n	n	–
**Cerastium tomentosum* L.	1	b	–	–	–	–	–	–	n h	–
***Chelidonium majus* L.	2	n b	–	–	–	–	–	n	n h	–
**Chenopodium album* L.	3	n b g c	–	n g	n g	n	n	n	n h	–
Chenopodium berlandieri Moq. var. *macrocalycium* (Aellen) Cronquist	1	–	–	n	–	–	–	–	h	–
* *Chenopodium desiccatum* A. Nelson	1	–	–	n	n	n	–	n	n	–
**Chenopodium glaucum* L.	1	b	–	–	–	–	–	–	n	–

Appendix 1. Continued.

		Island								
Vascular Plant Taxa	Fr	A	C	D	L	M	Se	Sm	St	W
Chenopodium rubrum L.	1	n b	–	–	–	–	–	–	–	–
****Chrysanthemum sibiricum* Forbes & Hemsl.	1	–	–	–	–	–	–	–	h	–
**Cichorium intybus* L.	2	b c	–	–	–	–	–	–	n h	–
Cicuta maculata L.	1	c	–	–	–	–	–	n	–	–
Circaea lutetiana L. subsp. *canadensis* (L.) Asch. & Magnus	1	n	–	–	–	–	–	–	–	–
***Cirsium arvense* (L.) Scop.	3	n b c	n	–	n	n	n	n	n h	–
**Cirsium vulgare* (Savi) Ten.	2	n b c	n	–	–	–	n	n	n h	n
****Clematis × jouiniana* C.K. Schneid.	1	b	–	–	–	–	–	–	–	–
**Conium maculatum* L.	1	–	–	–	–	–	–	–	h	–
**Convallaria majalis* L.	1	b	–	–	–	–	–	–	–	–
**Convolvulus arvensis* L.	1	b	–	–	–	–	–	–	–	–
Conyza canadensis (L.) Cronquist	1	n b	–	–	–	–	–	–	n h	n
****Cotoneaster adpressus* Boiss.	1	–	–	–	–	–	–	–	h	–
**Crataegus* sp.	1	b	–	–	–	–	–	–	–	–
Cuscuta gronovii Willd. *ex* J.A. Schultes	2	n b c	n	n	n	n	n	n	n h	n
Cyperus erythrorhizos Muhl.	1	n b	–	n	–	–	–	n	–	–
Cyperus sp.	1	b	–	–	–	–	–	–	h	–
**Dactylis glomerata* L.	1	–	–	–	–	–	–	–	n h	–
Danthonia spicata (L.) P. Beauv. *ex* Roemer & J.A. Schultes	1	–	n	–	–	–	–	–	n h	–
***Datura stramonium* L.	1	b	–	–	–	–	–	–	–	–
**Daucus carota* L.	2	b g	n	–	–	–	–	n	n h	–
Dennstaedtia punctilobula (Michx.) T. Moore	2	n	–	–	–	–	–	–	n h	–
Deschampsia flexuosa (L.) Trin.	2	n	n	–	–	–	–	n	n	–
**Dianthus deltoides* L.	1	–	n	–	–	–	–	–	h	–
Dichanthelium acuminatum (Sw.) Gould & C.A. Clark subsp. *implicatum* (Scribn.) Freckmann & Lelong	2	n b	n	–	–	–	–	–	n h	–
**Digitaria ischaemum* (Schreb.) Muhl.	1	n	–	–	–	–	–	–	–	–
**Digitaria sanguinalis* (L.) Scop.	1	–	–	–	–	–	–	–	n	–
Dryopteris carthusiana (Vill.) H.P. Fuchs	1	n b	–	–	–	–	–	–	n h	–
Dulichium arundinaceum (L.) Britton	1	n	–	–	–	–	–	–	–	–
Eleocharis acicularis (L.) Roemer & J.A. Schultes	1	b	–	–	–	–	–	–	–	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	Island: A	C	D	L	M	Se	Sm	St	W
Eleocharis flavescens (Poir.) Urban var. *olivacea* (Torr.) Gleason	1	n	–	–	–	–	–	–	–	–
Eleocharis obtusa (Willd.) J.A. Schultes	1	n b	–	–	–	–	–	n	–	–
Eleocharis palustris (L.) Roemer & J.A. Schultes	2	n b	–	–	–	–	–	–	n	–
Eleocharis parvula (Roemer & J.A. Schultes) Link *ex* Bluff, Nees & Schauer	1	n	–	–	–	–	–	–	–	–
Eleocharis uniglumis (Link) J.A. Schultes	2	n b	–	–	–	–	–	n	n h	–
Elymus repens (L.) Gould	4	n b c	n	n	n	n	n	n	n h	n
Elymus virginicus L.	3	n b g	n	n	n	n	n	n	n h	n
Epilobium angustifolium L.	1	c	–	–	–	–	–	–	–	–
Epilobium ciliatum Raf.	2	n b	n	–	–	–	–	n	n h	–
Epilobium coloratum Biehler	1	n	–	–	–	–	–	–	n	–
***Epilobium hirsutum* L.	1	n	–	–	–	–	–	–	–	–
Epilobium palustre L.	1	n b	–	–	–	–	–	–	–	–
Equisetum arvense L.	1	b c	–	–	–	–	–	–	h	–
Eragrostis pectinacea (Michx.) Nees *ex* Steud.	1	n	–	–	–	–	–	–	–	–
Erechtites hieraciifolia (L.) Raf. *ex* DC.	2	n	–	–	–	–	–	n	n h	–
Erigeron annuus (L.) Pers.	1	b	–	–	–	–	–	–	h	–
Erythronium americanum Ker-Gawl.	1	n b	–	–	–	–	–	–	–	–
Euthamia graminifolia (L.) Nutt.	2	n b	–	–	–	–	–	n	n	–
**Fallopia convolvulus* (L.) Á. Löve	2	n b g	–	–	n	–	–	–	h	n
***Fallopia japonica* (Houtt.) Ronse Decr.	1	–	–	–	–	–	–	–	h	–
Fallopia scandens (L.) Holub	3	n b	n	n	n	n	–	n	n	n
**Festuca filiformis* Pourret	1	b	–	–	–	–	–	–	n h	–
**Festuca ovina* L.	1	b	–	–	–	–	–	–	–	–
Festuca rubra L.	4	n b	n	n	n	n	n	n	n h	n
**Filipendula rubra* (Hill) B.L. Rob.	1	–	–	–	–	–	–	–	h	–
****Forsythia* sp.	1	–	–	–	–	–	–	–	n	–
Fragaria vesca L.	1	b	–	–	–	–	–	–	–	–
Fragaria virginiana Duchesne	2	n b c	–	–	n	–	–	n	n h	–
Fraxinus americana L.	1	h	–	–	–	–	–	–	h	–
****Galanthus nivalis* L.	1	b	–	–	–	–	–	–	–	–
**Galeopsis bifida* Boenn.	2	n b c	n	n	–	–	–	n	n h	–
**Galinsoga parviflora* Cav.	1	–	–	–	–	–	–	–	h	–
**Galinsoga quadriradiata* Ruiz & Pavon	1	b	–	–	–	–	–	–	h	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	Island: A	C	D	L	M	Se	Sm	St	W
Galium aparine L.	2	n b h	–	–	–	–	–	n	–	–
Galium asprellum Michx.	1	n c	–	–	–	–	–	–	–	–
Galium tinctorium (L.) Scop.	1	n b	–	–	–	–	–	–	–	–
Galium trifidum L.	1	n	–	–	–	–	–	–	h	–
**Galium verum* L.	1	–	–	–	–	–	–	–	h	–
Gaylussacia baccata (Wangenh.) K. Koch	2	n b h c	–	–	–	–	–	–	n h	–
Gaylussacia dumosa (Andrews) Torr. & A. Gray var. *bigeloviana* Fernald	1	c	–	–	–	–	–	–	–	–
**Geranium robertianum* L.	1	b c	–	–	n	–	–	–	n h	–
Geum sp.	1	c	–	–	–	–	–	–	–	–
Glaux maritima L.	2	n c	–	–	–	–	–	n	n h	–
***Glechoma hederacea* L.	2	n c	–	–	n	–	–	–	n	–
Glyceria septentrionalis A.S. Hitchc.	1	–	–	–	n	–	–	n	–	–
Gnaphalium uliginosum L.	2	n b c	n	–	–	–	–	n	n h	n
**Hemerocallis fulva* (L.) L.	2	n b c	–	–	n	–	–	n	n h	–
Heracleum maximum Bartram	2	n b	n	n	n	n	–	n	n	–
***Hesperis matronalis* L.	1	n	–	–	n	–	–	–	–	–
**Hibiscus trionum* L.	1	–	–	–	–	–	–	n	–	–
**Hieracium aurantiacum* L.	1	–	–	–	–	–	–	–	h	–
**Hieracium caespitosum* Dumort.	2	b	n	–	–	–	–	n	n h	–
Hieracium canadense Michx.	1	b	–	–	–	–	–	–	–	–
**Hieracium pilosella* L.	1	–	–	–	–	–	–	–	n	–
Hordeum jubatum L.	2	n b	–	–	–	–	–	n	n h	–
**Hosta lancifolia* Tratt.	1	–	–	–	–	–	–	–	n	–
Houstonia caerulea L.	2	n b c	n	–	–	–	–	–	n h	–
**Humulus lupulus* L.	1	n b	–	–	–	–	–	n	n h	–
**Hylotelephium telephium* (L.) H. Ohba	2	n b c	–	–	n	–	–	–	n h	–
**Hyoscyamus niger* L.	1	–	–	–	–	–	–	–	h	–
Hypericum boreale (Britton) Bicknell	1	n	–	–	–	–	–	–	n	–
Hypericum canadense L.	1	b c	–	–	–	–	–	–	–	–
Hypericum gentianoides (L.) Britton, Sterns & Poggenb.	1	–	–	–	–	–	–	–	n h	–
Hypericum mutilum L.	1	–	–	–	–	–	–	–	n	–
**Hypericum perforatum* L.	2	n b g c	–	–	–	–	–	n	n h	–
Ilex verticillata (L.) A. Gray	2	n b g c	–	–	–	–	–	n	n h	–
Impatiens capensis Meerb.	2	n b g c	–	–	–	–	–	–	n h	–
***Iris pseudacorus* L.	1	–	–	–	–	–	–	–	n	–
Iris versicolor L.	2	n b c	n	–	n	–	–	n	n h	–

Appendix 1. Continued.

		Island								
Vascular Plant Taxa	Fr	A	C	D	L	M	Se	Sm	St	W
****Iris* sp. [Iris cultivar; could be *I. germanica* L. listed by Howard (1968)]	1	–	–	–	–	–	–	–	n h	–
Juncus acuminatus Michx.	1	–	–	–	–	–	–	–	n	–
Juncus brevicaudatus (Engelm.) Fernald	1	–	–	–	–	–	–	–	n	–
Juncus bufonius L.	2	n b	n	–	n	–	n	n	n h	n
Juncus canadensis J. Gay *ex* Laharpe	1	n	–	–	–	–	–	–	n	–
Juncus effusus L.	2	n b g h	–	–	–	–	n	n	n h	–
Juncus gerardii Loisel.	2	n b g	n	–	n	n	–	n	n h	n
Juncus greenei Oakes & Tuck.	2	n	n	–	–	–	–	–	n	–
Juncus tenuis Willd.	2	n b g	n	–	–	–	–	n	n h	–
Juniperus communis L. var. *depressa* Pursh	1	n b c	–	–	–	–	–	–	h	–
Juniperus virginiana L.	1	b	n	–	–	–	–	–	n h	–
Kalmia angustifolia L.	1	c	–	–	–	–	–	–	–	–
Lactuca biennis (Moench) Fernald	2	n b c	n	–	n	–	–	n	n h	–
Lactuca canadensis L.	1	c	–	–	–	–	–	–	h	–
**Lactuca serriola* L.	2	n b	–	–	–	–	–	n	n h	–
****Larix* sp.	1	–	n	–	–	–	–	–	–	–
Lathyrus japonicus Willd.	3	n b g c	n	n	n	n	n	n	n h	n
Leersia oryzoides (L.) Sw.	1	n	–	–	–	–	–	n	–	–
Lemna minor L.	2	n b g h	–	–	–	–	–	n	n h	–
**Leontodon autumnalis* L.	2	b c	–	–	–	–	–	–	n h	–
**Leonurus cardiaca* L.	1	–	–	–	–	–	n	–	–	–
**Lepidium campestre* (L.) Aiton f.	1	–	–	–	–	–	–	–	h	–
**Lepidium ruderale* L.	2	n b	n	n	–	n	n	n	n	n
Lepidium virginicum L.	3	n b g c	n	n	n	n	n	n	n g h	–
**Leucanthemum vulgare* Lam.	2	n b g c	–	–	–	–	–	n	n h	–
Leymus mollis (Trin.) Hara	1	–	–	–	n	–	–	–	–	–
Ligusticum scothicum L.	2	n b	n	–	n	n	–	n	n h	n
**Lilium lancifolium* Thunb.	2	–	–	–	n	–	–	n	n h	–
Limonium carolinianum (Walter) Britton	1	n	–	–	–	–	–	n	n	–
**Linaria vulgaris* P. Mill.	2	c	n	–	–	–	–	–	n h	n
Lindernia dubia (L.) Pennell	1	b	–	–	–	–	–	–	–	–
**Lolium arundinaceum* (Schreb.) Darbyshire	1	–	–	–	–	–	–	–	n	–
**Lolium multiflorum* Lam.	1	–	–	–	–	–	–	–	h	–
**Lolium perenne* L.	1	n	–	–	–	–	–	–	n	–
**Lolium pratense* (Huds.) Darbyshire	2	n	–	–	–	n	–	n	n	n
***Lonicera morrowii* A. Gray	1	–	–	–	–	–	–	–	n	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	Island									
		A	C	D	L	M	Se	Sm	St	W
Ludwigia palustris (L.) Elliott	2	n b	–	–	–	–	–	n	n	–
Luzula multiflora (Ehrh.) Lej.	1	b	–	–	–	–	–	–	–	–
**Lycium chinense* P. Mill.	1	–	–	–	–	–	–	–	h	–
**Lycopersicon esculentum* P. Mill.	1	–	–	–	n	–	–	–	n h	–
Lycopus americanus Muhl. *ex* W. Bartram	2	n b	–	–	–	–	–	n	–	–
Lycopus uniflorus Michx.	2	n b	–	–	–	–	–	n	n h	–
Lycopus virginicus L.	1	c	–	–	–	–	–	n	n	–
Lyonia ligustrina (L.) DC.	1	n b h	–	–	–	–	–	–	–	–
Lythrum hyssopifolia L.	2	n b c	n	n	–	n	–	n	n h	–
***Lythrum salicaria* L.	2	n b	n	–	–	n	–	n	n	–
Maianthemum canadense Desf.	1	n b c	–	–	–	–	–	–	h	–
Maianthemum racemosum (L.) Link	1	b c	–	–	–	–	–	–	–	–
Maianthemum stellatum (L.) Link	2	n b c	–	–	–	–	–	n	n h	–
**Malus sylvestris* P. Mill.	1	n b c	–	–	–	–	–	–	n h	–
**Malva alcea* L.	1	–	–	–	–	–	–	–	h	–
**Malva neglecta* Wallr.	2	n b	–	–	n	–	–	–	n h	n
**Malva rotundifolia* L.	1	c	–	–	–	–	–	–	–	–
**Matricaria matricarioides* (Less.) Porter	2	n b	–	n	–	n	–	–	n h	–
**Medicago lupulina* L.	2	n b	n	–	–	n	–	n	n h	n
**Melilotus officinalis* (L.) Lam.	2	b h c	–	–	–	–	–	–	n	–
****Mentha alopecuroides* Hull	1	–	–	–	–	–	–	–	n h	–
Mentha arvensis L.	1	n	–	–	–	–	–	n	n	–
Mertensia maritima (L.) S.F. Gray	1	–	–	n	h	–	–	–	–	–
**Mirabilis nyctaginea* (Michx.) MacMill.	1	–	–	–	–	–	–	–	h	–
Moehringia lateriflora (L.) Fenzl	2	n b g	–	–	–	–	n	n	h	–
Myrica pensylvanica Loisel.	3	n b g c	n	–	–	–	n	n	n h	–
Myriophyllum sp.	1	r	–	–	–	–	–	–	–	–
**Nepeta cataria* L.	2	n b c	n	–	–	–	–	n	n h	–
Nuttallanthus canadensis (L.) D.A. Sutton	2	n b c	–	–	–	–	–	–	n h	–
Nymphaea odorata Aiton	1	c	–	–	–	–	–	–	–	–
Oenothera biennis L.	2	n b c	n	n	n	–	–	n	n h	–
Onoclea sensibilis L.	2	n b	–	–	–	–	–	–	n h	–
Orobanche uniflora L.	1	b	–	–	–	–	–	–	–	–
Osmunda cinnamomea L.	2	n b	–	–	–	–	–	n	n h	–
Osmunda regalis L. var. *spectabilis* (Willd.) A. Gray	1	b	–	–	–	–	–	–	n h	–
Oxalis stricta L.	2	n b c	n	–	n	–	–	n	n	–
Panicum capillare L.	2	n	–	n	–	–	–	n	n	–
Panicum dichotomiflorum Michx.	2	n b	–	n	n	–	–	n	–	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	Island								
		A	C	D	L	M	Se	Sm	St	W
Parthenocissus quinquefolia (L.) Planch.	2	n b c	–	–	–	–	–	n	n h	–
**Pastinaca sativa* L.	1	–	–	–	–	–	–	n	n h	–
Persicaria amphibia (L.) S.F. Gray	1	n	–	–	–	–	–	–	–	–
**Persicaria hydropiper* (L.) Opiz	2	n g	–	n	–	–	–	–	n h	–
Persicaria lapathifolia (L.) S.F. Gray	2	n b g	–	n	–	–	–	n	–	–
**Persicaria maculosa* S.F. Gray	3	n b g c	n	n	n	n	n	n	n h	–
**Persicaria orientalis* (L.) Spach	1	–	–	–	–	–	–	–	n	–
Persicaria pensylvanica (L.) G. Maza	3	n b g	n	n	n	–	n	n	n h	–
Persicaria punctata (Elliott) Small	3	n	n	n	–	n	n	n	n h	–
**Petunia axillaris* (Lam.) Britton, Sterns & Poggenb.	1	–	–	–	–	–	–	–	h	–
***Phalaris arundinacea* L.	1	–	–	–	–	–	–	–	n h	–
**Phalaris canariensis* L.	1	–	–	n	–	–	–	–	–	–
**Phleum pratense* L.	2	n b g c	n	–	–	–	–	n	n h	–
***Phragmites australis* (Cav.) Trin. *ex* Steud.	1	–	–	–	–	–	–	–	n	–
****Picea glauca* (Moench) Voss	1	–	n	–	–	–	–	–	n h	–
****Picea* sp.	1	–	–	–	–	–	–	–	n	–
****Pinus nigra* Arnold	1	–	–	–	–	–	–	–	n h	–
****Pinus rigida* P. Mill.	1	–	–	–	–	–	–	–	h	–
****Pinus strobus* L.	1	c	–	–	–	–	–	–	–	–
****Pinus sylvestris* L.	1	–	–	–	–	–	–	–	n h	–
Plantago intermedia DC.	1	–	–	–	–	–	–	n	–	–
**Plantago lanceolata* L.	2	n b c	–	–	–	–	n	n	n h	–
**Plantago major* L.	3	n b c	n	–	n	n	n	n	n h	n
Plantago maritima L. subsp. *juncoides* (Lam.) A. Gray	2	n b c	–	–	–	–	n	n	n h	n
**Poa annua* L.	2	n	n	–	–	n	n	n	n	n
***Poa compressa* L.	4	n	n	n	n	n	n	n	n h	n
Poa palustris L.	1	n	–	–	–	–	n	–	–	–
**Poa pratensis* L.	3	n b	n	–	n	n	n	n	n h	n
Polygonatum biflorum (Walter) Elliott	1	n b c	–	–	–	–	–	–	n h	–
Polygonatum pubescens (Willd.) Pursh	1	n	–	–	–	–	–	–	–	–
**Polygonum aviculare* L. subsp. *aviculare*	4	n b g	n	n	n	n	n	n	n h	n
**Polygonum aviculare* L. subsp. *neglectum* (Besser) Arcang.	2	n	–	–	–	–	–	n	n	–
Polygonum buxiforme Small	2	n	–	n	n	n	–	n	n	n
Polypodium virginianum L.	1	b	–	–	–	–	–	–	–	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	Island								
		A	C	D	L	M	Se	Sm	St	W
***Populus alba* L.	1	n b h	–	–	–	–	–	–	n	–
Populus tremuloides Michx.	2	n b g h c	–	–	n	–	–	–	n	–
**Portulaca oleracea* L.	3	n b g	n	n	n	n	n	n	n h	n
Potamogeton sp.	1	r	–	–	–	–	–	–	–	–
**Potentilla argentea* L.	2	n c	–	–	–	–	–	n	n h	–
Potentilla canadensis L.	1	c	–	–	–	–	–	n	–	–
Potentilla norvegica L.	3	n b c	n	–	n	n	–	n	n h	–
Potentilla pensylvanica L. var. *litoralis* (Rydb.) Boivin	1	–	–	–	–	–	–	–	h	n
**Potentilla recta* L.	2	n b	–	–	–	–	–	–	n h	–
Potentilla simplex Michx.	2	n b c	n	–	–	–	–	n	n h	–
Prenanthes alba L.	1	c	–	–	–	–	–	–	–	–
Prenanthes altissima L.	1	b	–	–	–	–	–	–	–	–
Prenanthes trifoliolata (Cass.) Fernald	1	n	–	–	–	–	–	–	–	–
****Prunus avium* L.	1	b g	–	–	–	–	–	–	–	–
Prunus maritima Marshall	1	–	n	–	–	–	–	n	–	–
Prunus pensylvanica L. f.	2	n b g h c	–	–	–	–	–	–	n	–
****Prunus persica* (L.) Batsch	1	–	–	–	–	–	–	–	h	–
Prunus serotina Ehrh.	3	n b g h	n	–	–	–	–	n	n	–
Prunus virginiana L.	3	n b g c	n	–	n	–	n	n	n h	–
Pseudognaphalium obtusifolium (L.) Hilliard & B.L. Burtt	1	n b	–	–	–	–	–	n	–	–
Pteridium aquilinum (L.) Kuhn *ex* Decken var. *latiusculum* (Desv.) Underwood *ex* Heller	1	n b	–	–	–	–	–	–	–	–
Puccinellia maritima (Huds.) Parl.	2	b	–	–	n	–	–	n	–	–
**Pyrus communis* L.	2	n	–	–	–	–	–	n	n h	–
Ranunculus abortivus L.	1	n b	–	–	–	–	–	–	–	–
**Ranunculus acris* L.	2	n b c	–	–	–	–	–	n	n h	–
**Ranunculus bulbosus* L.	1	b	–	–	–	–	–	–	–	–
Ranunculus cymbalaria Pursh	1	c	–	n	–	–	–	–	n h	–
***Ranunculus repens* L.	2	n b c	n	–	n	–	–	n	n h	–
Ranunculus sceleratus L.	2	n	–	n	–	–	–	n	n	–
**Raphanus raphanistrum* L.	4	n b g	n	n	n	n	n	n	n h	n
**Rheum rhaponticum* L.	1	–	–	–	n	–	–	–	h	–
Rhus hirta (L.) Sudworth	2	n b g c	n	–	–	–	–	n	n h	–
Ribes americanum P. Mill.	1	–	–	–	–	–	–	–	h	–
Ribes hirtellum Michx.	1	n b c	–	–	–	–	–	–	–	–
Ribes lacustre (Pers.) Poir.	1	n b	–	–	–	–	–	–	–	–
***Rorippa nasturtium-aquaticum* (L.) Hayek	1	–	–	n	–	–	–	–	–	–
Rorippa palustris (L.) Besser	1	b c	–	n	–	–	–	–	–	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	A	C	D	L	M	Se	Sm	St	W
		Island								
**Rosa multiflora* Thunb. *ex* Murray var. *cathayensis* Rehder & Wilson	1	h	–	–	–	–	–	–	n h	–
Rosa palustris Marshall	2	n c	–	–	–	–	–	n	n	–
**Rosa rugosa* Thunb.	2	n b	n	–	n	n	–	n	n h	–
Rosa virginiana P. Mill.	4	n b	n	–	n	n	n	n	n h	–
Rubus allegheniensis Porter	3	n b g h	n	–	n	–	n	n	n	–
Rubus flagellaris Willd.	2	n c	–	–	–	–	–	n	n h	–
Rubus hispidus L.	1	c	–	–	–	–	–	–	–	–
Rubus idaeus L.	3	n b g c	–	–	n	–	n	n	n h	–
**Rumex acetosella* L.	4	n b g c	n	–	n	n	n	n	n h	–
Rumex crispus L.	4	n b g c	n	n	n	n	n	n	n h	n
Rumex maritimus L.	1	c	–	–	–	–	–	–	–	–
Rumex obtusifolius L.	1	n b	–	–	–	–	–	–	–	–
Rumex pallidus Bigelow	1	n	–	–	–	–	–	–	h	–
Sagina procumbens L.	2	n b	n	–	–	–	–	n	n h	n
Salicornia depressa Standl.	2	n b	–	–	–	–	–	n	n	–
Salix alba L.	1	c	–	–	–	–	–	–	n h	–
Salix bebbiana Sarg.	1	–	–	–	–	–	–	–	n h	–
Salix humilis Marshall	1	–	–	–	–	–	–	–	n	–
Salsola kali L.	1	n	–	–	n	–	–	–	–	–
Sambucus canadensis L.	2	n b h c	n	–	n	–	–	n	n h	–
Sambucus racemosa L. subsp. *pubens* (Michx.) House	1	b	–	–	–	–	–	–	–	–
Saponaria officinalis L.	1	–	–	–	–	–	–	–	n h	–
Schoenoplectus acutus (Bigelow) Á. & D. Löve	1	b	–	–	–	–	–	–	–	–
Schoenoplectus pungens (Vahl) Palla	2	n b	–	–	–	–	–	n	n h	–
Schoenoplectus tabernaemontani (C.C. Gmel.) Palla	1	b g	–	–	–	–	–	–	h	–
***Scilla siberica* Andrews	1	b	–	–	–	–	–	–	–	–
Scirpus cyperinus (L.) Kunth	1	n	–	–	–	–	–	–	–	–
Scleranthus annuus L.	1	–	–	–	–	–	–	–	n	–
Scutellaria galericulata L.	2	n b c	–	–	–	–	–	n	n h	–
Securigera varia (L.) Lassen	1	–	–	–	–	–	–	–	h	–
Sedum acre L.	2	n b	–	–	n	–	–	n	n h	–
Sedum aizoon L.	1	b	–	–	–	–	–	–	–	–
Sedum album	1	–	–	–	–	–	–	–	n h	–
***Sedum ellacombianum* Praeger	1	–	–	–	–	–	–	–	h	–
Sedum kamtschaticum Fisch. & C.A. Mey.	1	b	–	–	–	–	–	–	–	–
Sedum spurium M. Bieb.	1	–	–	–	n	–	–	–	n	–
***Sempervivum montanum* L.	1	–	–	–	–	–	–	–	h	–
Sempervivum tectorum L.	1	–	–	–	–	–	–	–	h	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	Island								
		A	C	D	L	M	Se	Sm	St	W
Senecio aureus L.	1	c	–	–	–	–	–	–	–	–
*_Senecio jacobaea_ L.	1	b	–	–	–	–	–	–	–	–
Sibbaldiopsis tridentata (Aiton) Rydb.	2	c	n	–	–	–	–	–	n h	–
*_Silene dioica_ (L.) Clairville	1	n	–	–	–	–	–	–	n h	–
*_Silene latifolia_ Poir. subsp. _alba_ (P. Mill.) Greuter & Burdet	2	n b g c	n	–	n	–	–	n	n h	–
*_Silene vulgaris_ (Moench) Garcke	1	c	–	–	–	–	–	–	–	–
*_Sisymbrium altissimum_ L.	3	n	n	n	n	n	n	n	n	n
*_Sisymbrium officinale_ (L.) Scop.	2	n b c	–	–	–	–	–	–	n	–
Sisyrinchium angustifolium P. Mill.	1	c	–	–	–	–	–	–	–	–
Sisyrinchium montanum Greene var. _crebrum_ Fernald	2	b	n	–	–	–	–	–	n h	–
Smilax herbacea L.	1	n b c	–	–	–	–	–	–	–	–
Smilax rotundifolia L.	1	n b	–	–	–	–	–	–	–	–
**_Solanum dulcamara_ L. (including forma _albiflorum_ House)	4	n b g	n	n	n	n	n	n	n h	n
*_Solanum nigrum_ L.	3	n b g	n	n	n	n	n	n	n h	n
Solidago altissima L.	1	c	–	–	–	–	–	–	–	–
Solidago × _asperula_ Desf.	1	b g	–	–	–	–	–	–	h	–
Solidago bicolor L.	1	–	–	–	–	–	–	–	n	–
Solidago canadensis L.	1	b	–	–	–	–	–	–	–	–
Solidago juncea Aiton	1	n b	–	–	–	–	–	n	–	–
Solidago rugosa P. Mill.	3	n b g	n	–	n	–	–	n	n h	–
Solidago sempervirens L.	4	n b g c	n	n	n	n	n	n	n h	n
*_Sonchus arvensis_ L.	2	n	–	–	–	n	–	n	n h	–
*_Sonchus asper_ (L.) Hill	2	b	–	–	–	–	–	n	n	–
*_Sonchus oleraceus_ L.	3	n b c	n	–	n	n	n	n	n h	n
Spartina alterniflora Loisel.	2	n b g	–	–	–	–	–	n	–	–
Spartina patens (Aiton) Muhl.	2	n b g	–	n	–	–	–	n	n h	–
Spartina pectinata Link	2	g	–	–	–	–	n	n	–	n
*_Spergularia rubra_ (L.) J. & C. Presl	3	n b g c	n	n	n	n	n	n	n h	n
*_Spergularia salina_ J. & C. Presl	3	n b g	n	n	n	n	n	n	n h	n
Spiraea alba Du Roi var. _latifolia_ (Aiton) Dippel	2	n b g c	–	–	–	–	–	–	n h	–
*_Spiraea japonica_ L. f.	1	–	–	–	–	–	–	–	n h	–
*_Stellaria graminea_ L.	2	n b h c	–	–	–	–	–	n	n h	–
*_Stellaria media_ (L.) Vill.	3	n b c	n	n	n	n	n	n	n h	n
Suaeda linearis (Elliott) Moq.	2	g	–	–	–	–	–	n	n h	–
*_Suaeda maritima_ (L.) Dumort.	2	n b c	n	–	–	–	–	n	–	–
Symphyotrichum lanceolatum (Willd.) G.L. Nesom	1	–	–	–	–	–	–	–	h	–
Symphyotrichum novae-angliae (L.) G.L. Nesom	1	c	–	–	–	–	–	–	–	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	A	C	D	L	M	Se	Sm	St	W
		Island								
Symphyotrichum novi-belgii (L.) G.L. Nesom	3	n b	n	n	n	–	–	n	n h	n
Symphyotrichum praealtum (Poir.) G.L. Nesom	1	b g	–	–	–	–	–	–	h	–
Symphyotrichum subulatum (L.) G.L. Nesom	2	n b	n	–	n	–	–	n	n	n
****Symphytum officinale* L.	1	c	–	–	–	–	–	–	n	–
**Syringa vulgaris* L.	2	n b c	–	–	–	–	–	n	n h	–
****Tagetes patula* L.	1	–	–	–	–	–	–	–	h	–
**Tanacetum vulgare* L.	2	b	–	–	–	–	–	n	n h	–
**Taraxacum officinale* F.H. Wigg.	2	n b g c	–	n	n	–	–	n	n	–
Teucrium canadense L.	3	n b c	n	–	n	n	n	n	n h	n
Thelypteris palustris Schott var. *pubescens* (Lawson) Fernald	2	b	–	–	–	–	–	–	n h	–
**Thlaspi arvense* L.	1	–	n	–	–	–	–	n	–	–
****Thuja occidentalis* L.	1	c	–	–	–	–	–	–	–	–
****Thymus praecox* Opiz subsp. *arcticus* (Durand) Jalas	1	–	–	–	–	–	–	–	h	–
Torreyochloa pallida (Torr.) Church var. *pallida*	2	–	–	n	–	–	n	–	–	–
Torreyochloa pallida (Torr.) Church var. *fernaldii* (A.S. Hitchc.) Dore *ex* Koyama & Kawano	2	n	–	n	n	–	n	n	n	–
Toxicodendron radicans (L.) Kuntze	4	n b g h c	n	–	n	n	n	n	n h	–
Triadenum virginicum (L.) Raf.	1	n	–	–	–	–	–	–	–	–
Trientalis borealis Raf.	1	n b c	–	–	–	–	–	–	h	–
**Trifolium arvense* L.	2	c	–	–	–	–	–	n	n h	–
**Trifolium aureum* Pollich	1	c	–	–	–	–	–	–	h	–
**Trifolium hybridum* L.	1	c	–	–	–	–	–	n	–	–
**Trifolium pratense* L.	3	n b c	n	–	n	n	–	n	n h	–
**Trifolium repens* L.	3	n b c	n	–	n	–	–	n	n h	n
Triglochin maritimum L.	1	b	–	–	–	–	–	–	h	–
**Tunica saxifraga* (L.) Scop.	1	–	–	–	–	–	–	–	h	–
**Typha angustifolia* L.	1	n	–	–	–	–	–	–	–	–
Typha latifolia L.	2	n b g c	–	n	–	–	–	n	n h	–
****Ulmus americana* L.	1	b h	–	–	–	–	–	–	n	–
**Urtica dioica* L.	2	n b c	n	–	–	–	–	n	–	–
Vaccinium angustifolium Aiton	1	n b c	–	–	–	–	–	–	h	–
Vaccinium corymbosum L.	2	b c	–	–	–	–	–	–	n h	–
Vaccinium macrocarpon Aiton	1	b	–	–	–	–	–	–	–	–
Vaccinium oxycoccos L.	1	c	–	–	–	–	–	–	h	–
**Verbascum thapsus* L.	2	n b c	n	–	n	–	–	n	n h	–
**Veronica arvensis* L.	2	n b	–	–	–	–	–	n	h	–
****Veronica bachofenii* Heuffel	1	–	–	–	–	–	–	–	h	–

Appendix 1. Continued.

Vascular Plant Taxa	Fr	A	C	D	L	M	Se	Sm	St	W
			Island							
Veronica peregrina L. subsp. *xalapensis* (Kunth) Pennell	1	n	–	–	–	–	–	–	n	–
**Veronica persica* Poir.	1	–	–	–	–	–	–	–	n	–
Veronica scutellata L.	1	n	–	–	–	–	–	–	–	–
Veronica serpyllifolia L.	2	n	–	–	n	–	–	n	n	–
Viburnum dentatum L. var. *lucidum* Aiton	2	n b h	n	–	–	–	–	–	n	–
Viburnum nudum L. var. *cassinoides* (L.) Torr. & A. Gray	1	b	–	–	–	–	–	–	–	–
**Vicia cracca* L.	2	n b c	–	–	–	–	–	–	n h	–
**Vicia sativa* L.	2	n b c	–	–	–	n	–	n	n h	–
**Vicia villosa* Roth	1	b h	–	–	–	–	–	–	–	–
Viola lanceolata L.	2	n b c	–	–	–	–	–	–	n h	–
Viola sororia Willd.	2	n	–	–	–	–	–	–	n	–
Vitis labrusca L.	1	n	–	–	–	–	–	–	–	–
Xanthium strumarium L. var. *canadense* (P. Mill.) Torr. & A. Gray	1	n b	–	–	–	–	–	–	–	–
****Yucca filamentosa* L.	1	–	–	–	–	–	–	–	n h	–
Zizania aquatica L.	1	n	–	–	–	–	–	–	–	–
Zizia aurea (L.) W.D.J. Koch	1	c	–	–	–	–	–	–	–	–
Zostera marina L. var. *stenophylla* Asch. & Graebn.	1	b	–	–	–	–	–	–	–	–

APPENDIX 2

KEY TO NATURAL COMMUNITIES ON THE ISLES OF SHOALS, NEW HAMPSHIRE AND MAINE

1a. Upland communities; not exposed to regular tidal inundation or in freshwater depressions 2
  2a. Community dominated by shrubs (typically > 25% cover) . . . . **maritime shrub thicket**
  2b. Shrub cover low to absent (typically < 10%). 3
    3a. Substrate dominated by cobble and other loose rock . . . . **maritime cobble beach**
    3b. Substrate dominated by bedrock 4
      4a. Herb cover low (< 5%); typically adjacent to and landward of maritime intertidal rocky shore . . . . **maritime rocky barren**

4b. Herb cover somewhat low to high (5% to > 60%); typically adjacent to and landward of maritime rocky barren . . . . **maritime meadow**

1b. Wetland communities; intertidal or in freshwater depressions . . 5

5a. Estuarine and marine communities; soil water salinity > 0.5 ppt (brackish to haline) 6

6a. Vascular plants absent . . **maritime intertidal rocky shore**

6b. Vascular plants present 7

7a. Intertidal communities occurring between mean sea level and the upper reach of spring tides 8

8a. Flooded daily and occurring between mean sea level and mean high tide; *Spartina alterniflora* always present and usually dominates; typically adjacent to and seaward of high salt marsh . . . . **low salt marsh**

8b. Flooded less than daily and occurring between mean high tide and the upper reach of spring tides 9

9a. Characterized primarily by *Spartina patens* and *Juncus gerardii*; substrate mineral soil or a shallow organic mat over mineral soil; typically adjacent to and landward of low salt marsh . . . . **high salt marsh**

9b. Characterized primarily by *Spergularia marina*, *Salicornia depressa*, *Suaeda maritima*, *Atriplex prostrata*, *Limonium carolinianum*, *Puccinellia maritima*, *Argentina egedii* subsp. *groenlandica*, and *Glaux maritima*; substrate mineral soil . . . . **coastal shoreline strand/swale**

7b. Intertidal communities occurring beyond the upper reach of spring tides but periodically infused with salt water from wave splash and/or high water during storm events 10

10a. Small pooled depressions (less than a few to several square meters) within maritime rocky barrens. . . . . . . **brackish water pool**

10b. Larger (> 20 m^2), seasonally (to semi-permanently) flooded basins embedded within maritime meadows or maritime shrub thickets; separated from the coastal shoreline by maritime cobble beach ridges that are periodically overwashed by seawater during severe storms . . . . **coastal salt pond marsh**

5b. Freshwater communities; soil water salinity 0.5 ppt or less 11

11a. Shrub cover moderate to high (typically > 20%) . . . . **highbush blueberry–winterberry shrub thicket**

11b. Shrub cover low to absent (typically < 10%) 12

12a. *Sphagnum* cover typically between 10% to over 50% . . . . **fenny marsh**

12b. *Sphagnum* cover absent, or if present, usually no more than a few percent 13

13a. Characterized by short herbaceous vegetation on drawn-down muddy pond margins . . . . **short graminoid–forb emergent marsh/mud flat**

13b. Characterized by medium to tall herbaceous vegetation around pond margins and in small damp depressions . . . . **shallow emergent marsh**