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The Upland Plant Communities of Seashore State Park,Virginia Beach, Virginia

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ABSTRACT

Seashore State Park is a 1086 ha fragment of natural habitat surrounded by the urban portion of Virginia Beach City. During 1989, quantitative data were collected on the plant communities of Seashore. Multivariate analysis of these data identified eight upland community types: mesic forest (*Pinus taeda / Acer rubrum / Persea borbonia*), dune forest (*Carya* spp. - *Pinus taeda / Symplocos tinctoria*), dune woodland (*Pinus taeda / Quercus nigra / Sassafras albidum*), maritime forest (*Pinus taeda / Quercus virginiana*), maritime grassland (*Uniola paniculata - Panicum amarulum*), dune grassland (*Panicum amarulum - Iva imbricata*), foredune (*Ammophila breviligulata - Cakile edentula*), and dune crest (*Hudsonia tomentosa - Cyperus grayi*). Several of these community types are rare in Virginia. The structure, composition, environmental setting, and interrelationships of these communities are discussed.

INTRODUCTION

Seashore State Park (hereafter Seashore) is a 1086 ha natural landscape surrounded by the rapidly-growing City of Virginia Beach. Seashore is the most heavily used of Virginia's State Parks, with an annual visitation of over 1 million people. Among Virginia's State Parks, Seashore also supports the highest known concentration of rare species: 37 plants, 7 vertebrates, and at least 20 invertebrates (Clampitt et al., 1990, Wright et al., 1990).

The Department of Conservation and Recreation's Division of State Parks is currently revising the resource management plan for Seashore. To ensure that the plan considers the significance and management needs of Seashore's biological resources, the Division of Natural Heritage conducted a study of communities and rare species that occur there (Clampitt et al., 1990). The goal of the research reported here was to classify and describe the upland plant communities of Seashore.

STUDY SITE

Lying adjacent to the Atlantic Ocean, Seashore has a maritime climate (Soil Conservation Service, 1985). The average annual temperature is 15° C with an average daily high in July of 30° C and an average daily low of 0° C in January. The area receives an average annual precipitation of 112 cm, which falls almost entirely as rain (Soil Conservation Service, 1985).

Seashore is located on Cape Henry, which has formed in geologically recent times from marine sands. The current landscape has resulted from the interaction of wind, water and vegetation on the coastal sands. A generalized cross section of the Cape from north to south would show a series of parallel dunes 2 to 3 m tall

along the shore. Inland of these is the Great Dune, which rises in places to ca. 30 m above sea level. Behind the Great Dune are older, stabilized dunes up to 3 m tall. Although these dunes generally form a series of concentric arcs, this pattern is broken at irregular intervals, and smaller radial dunes connect parallel dunes. The crests of the dunes are well-drained, but the swales between the dunes hold water for much of the year.

The soils of Seashore fall into two general categories (Soil Conservation Service, 1985). The Newhan-Duckston-Corolla group includes excessively drained to poorly drained sandy soils along the Atlantic coast. The Pamlico-Fripp-Lakehurst Variant group includes excessively drained to moderately well drained sandy (Fripp and Lakehurst Variant) soils and very poorly drained organic (Pamlico) soils that lie landward of the former group. Three of the soils mapped within Seashore (Lakehurst Variant, Fripp and Newhan) are thermic, uncoated Typic Quartzipsamments. The Corolla soil is a thermic, uncoated Typic Quartzipsamments and the Pamlico soil is a sandy or sandy-skeletal, siliceous, dysic, thermic Terric Medisaprist (Soil Conservation Service, 1985).

Cape Henry has been of interest to botanists throughout this century (Kearney, 1901; Egler, 1942; Wright, et al., 1990). Although these reports include narrative descriptions of the upland communities on the Cape, few quantitative data have been collected. The sole exception appears to be a brief visit in 1987 by A. Greller and S. Ware, who collected data on the composition of the forest canopy along the Osmanthus Trail (unpubl. data).

METHODS

Field Investigation.

Field work was conducted in two stages: reconnaissance and quantitative sampling. Based on aerial photographs (Virginia Department of Transportation 1:12000 B/W and USGS National High-Altitude Photography 1:24000 CIR), the soil survey, and other sources, Seashore was divided into zones for general reconnaissance. The goal was to gain an understanding of the vegetation patterns present within each zone and to ensure that the full range of vegetation was sampled. During the reconnaissance visits, general notes were made on the composition of the vegetation, the relationships between the plants and the physical environment, and any disturbances present.

Based on the reconnaissance, 10 m X 10 m vegetation plots were established in representative areas. The locations of these plots were pinpointed on a topographic map and the profile of the plot was sketched. The following vegetation data were collected:

1) a list of the plant species present in and near the plot (nomenclature for the vascular plants follows Radford et al., 1968);
2) the cover of each plant species in the canopy, the sub-canopy, the tall (> 1 m) shrub layer, and the low shrub and herb layer; and
3) the diameter at breast height (dbh) of all trees more than 5 cm dbh.

Cover classes used here were:

1	< 1%;
2	1 to < 5%;

3	5 to <25%
4	25 to <50%;
5	50 to <75%; and
6	75 to 100%.

Cover values near the low or high end of the class were indicated, respectively, by a - or a +.

A soil auger was used to sample the soil at the center of each plot. The soil horizons, presence of organic matter, and apparent soil moisture (e.g., saturated, moist, dry) were noted.

Data Analysis.

For analysis, the vegetation data were converted to a species X plot abundance matrix, with each species assigned the greatest cover that it had in the plot (e.g., if *Pinus taeda* was present as cover class 3 in the canopy and cover class 2 in the subcanopy, it was recorded as cover class 3). Two-Way Indicator Species Analysis (TWINSPAN; Hill, 1979) was used to create a preliminary classification of the community types represented in the data set. This classification was subjectively refined on the basis of field observations.

The diameter data were summarized for each community type identified in the previous step using the PC-ORD package (McCune, 1987). From the data, PC-ORD calculated the basal area per ha, number of trees per ha (density) and frequency of occurrence within the plots. Based on these values, an Importance Value (IV) was calculated for each species in each community type.

RESULTS AND DISCUSSION

Based on the TWINSPAN analysis of the cover data, eight community types were identified at Seashore. Four of these types are dominated by trees (mesic forest, dune forest, dune woodland, and maritime forest), three are graminoid types (maritime grassland, dune grassland, and foredune), and the last (dune crest) is a sparse dwarf-shrub community. The floristic relationships among these types, as determined by TWINSPAN, is depicted in Figure 1. The following descriptions of the upland community types identified in this study are based on the quantitative data (Tables 1 - 12) as well as qualitative field observations. The Natural Heritage State Rank (Lipford et al., 1987) of each type is noted parenthetically after its name. These ranks are also given for rare species mentioned.

Mesic forests (S5) are species-rich stands of mesophytes such as *Oxydendrum arboreum*, *Fagus grandifolia* and *Quercus alba* (Tables 1, 2). Canopy dominants include *Pinus taeda*, *Acer rubrum*, *Quercus nigra*, and *Oxydendrum arboreum*. The sub-canopy is composed of *Ilex opaca* and saplings of the canopy hardwoods. Tall shrubs common in this community type are *Persea borbonia*, *Clethra alnifolia*, *Amelanchier* sp., and *Symplocos tinctoria*. The rare shrub, *Osmanthus americana* (G5/S1), is found almost exclusively in this community type. The herb layer is sparse, with *Vaccinium vacillans* and *Mitchella repens* forming extensive, low mats. *Pteridium aquilinum* can also be present. *Tillandsia usneoides* (G5/S2) occurs in many stands of this community type. *Vitis rotundifolia* and *Smilax glauca* are common vines.

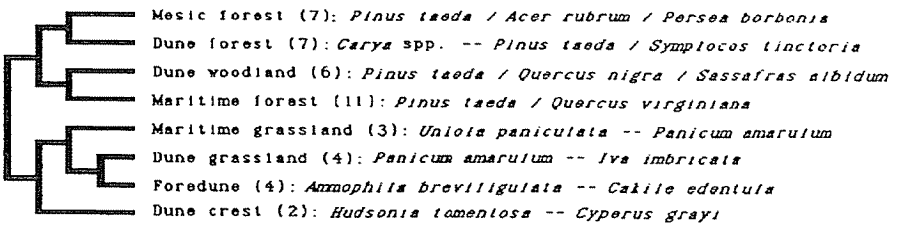

FIGURE 1. Dendrogram showing the relationships among the eight upland community types at Seashore as identified by TWINSPAN. The natural community name is followed by the number of plots and a provisional association name derived from the vegetation.

TABLE 1. Composition of the canopy and subcanopy of the seven mesic forest plots at Seashore.

Species	% Freq.	Density Trees/ha	Basal Area dm^2/ha	Relative % Freq.	Dens.	Dom.	I.V.(%)
Acer rubrum	100.00	185.71	456.22	14.89	13.83	15.11	14.61
Carya glabra	14.29	28.57	30.17	2.13	2.13	1.00	1.75
Cornus florida	14.29	57.14	83.35	2.13	4.26	2.76	3.05
Fagus grandifolia	42.86	100.00	208.56	6.38	7.45	6.91	6.91
Ilex opaca	71.43	157.14	93.84	10.64	11.70	3.11	8.48
Liquidambar styraciflua	42.86	42.86	268.82	6.38	3.19	8.90	6.16
Magnolia virginiana	28.57	42.86	61.97	4.26	3.19	2.05	3.17
Nyssa sylvatica	14.29	14.29	116.33	2.13	1.06	3.85	2.35
Osmanthus americana	28.57	57.14	25.69	4.26	4.26	0.85	3.12
Oxydendrum arboreum	85.71	171.43	185.50	12.77	12.77	6.14	10.56
Persea borbonia	57.14	114.29	52.39	8.51	8.51	1.74	6.25
Pinus taeda	57.14	85.71	990.51	8.51	6.38	32.81	15.90
Quercus nigra	71.43	228.57	406.32	10.64	17.02	13.46	13.71
Sassafras albidum	28.57	42.86	34.29	4.26	3.19	1.14	2.86
Symplocos tinctoria	14.29	14.29	5.19	2.13	1.06	0.17	1.12
Totals		1342.86	3019.16	100.02	100.00	100.00	100.00

Within Seashore, mesic forests develop on low dune ridges and along the lower slopes of large dunes, presumably where the trees are able to penetrate the water table over much of the growing season. These communities have distinct downslope boundaries with forested wetlands. Upslope they grade into dune forest. The soils underlying these communities are mapped as Fripp sand, Lakehurst Variant sand, Newhan fine sand, and Pamlico-Lakehurst Variant complex (Soil Conservation Service, 1985).

Although unusual, the presence of *Osmanthus americana* appears to be only a minor variation of a common Coastal Plain community type. Largely because of their limited extent, the stands of this community type at Seashore were not deemed to be of statewide significance.

Dune forests (S1S2) are medium-height forests of drought-tolerant species of *Quercus, Carya* and *Pinus* (Tables 3, 4). Although *Pinus taeda* has a greater basal area than any other species, it is surpassed by the combined basal area of the other dominant genera. The oaks are represented in this community type by *Quercus*

nigra and *Q. falcata*, while the hickories include *C. glabra*, *C. ovalis*, and *C. tomentosa*. Common small trees include *Acer rubrum*, *Ilex opaca*, and *Oxydendrum arboreum*. *Symplocos tinctoria* is the characteristic tall shrub. Other tall shrubs that regularly occur in this community type are *Amelanchier* sp. and *Cornus florida*. Herbs are sparse, but *Mitchella repens* often forms expansive mats on the forest floor. Other common low shrubs are *Persea borbonia* and *Gaylussacia baccata*.

Dune forests form on low dune ridges and on the lower slopes of the Great Dune and other high dunes. Dune forests are typically bounded downslope by forested wetlands. In places they grade into mesic forest. Upslope they grade into dune woodland. The soils underlying these forests are primarily mapped as Fripp sand, Newhan fine sand, and Pamlico-Lakehurst Variant complex (Soil Conservation Service, 1985). The dune forests at Seashore apparently represent a rare type in Virginia and therefore are of statewide significance.

Dune woodlands (S1S2) are open-canopy woodlands of the Great Dune and other high dunes (Tables 5, 6). *Quercus nigra* dominates the canopy, with *Pinus taeda* being the only other regularly-occurring canopy tree. *Sassafras albidum* generally occurs as a small tree or tall shrub, while *Ilex opaca* occurs less frequently. *Pteridium aquilinum* is the characteristic herbaceous species, but it rarely provides substantial ground cover.

The dunes supporting this community are generally stable, but the droughty soils apparently make them inhospitable to most plant species. Dune woodlands abruptly border, or grade into, dune forests or, less commonly, dune crests. Dune woodland is perhaps the most highly fragmented of the community types identified during this study. The soils underlying these forests are primarily mapped as Fripp sand and Newhan fine sand (Soil Conservation Service, 1985).

The dune woodlands of Seashore are significant for several reasons. First, they represent a rare community type in Virginia, second they support several rare plants. Among the rare plants found in this community are: *Desmodium strictum* (G2G4/S2), *Quercus hemisphaerica* (G5/S2), *Quercus incana* (G5/S2), *Quercus margarettae* (G5/S2), and *Stipulicida setacea* (G4G5/S1).

Maritime forests (S2S3) consist of dense shrub thickets to open forests of trees up to 10 m tall (Tables 7,8). Dominant species on the ocean side are *Quercus virginiana* and *Q. incana*. Inland, *Pinus taeda* emerge above the oaks. Additional small trees are *Ilex opaca* and *Prunus serotina*. Shrubs provide little cover, but *Sassafras albidum* and *Myrica pensylvanica* are encountered frequently. The herb layer is sparse, but relatively rich in species. Characteristic species include *Opuntia compressa*, *Heterotheca graminifolia*, and *Andropogon virginicus*. Vines are common, but rarely abundant. Among them are *Smilax glauca*, *Gelsemium sempervirens*, *Parthenocissus quinquefolia*, and *Vitis rotundifolia*, which was found in all plots sampled.

Maritime forests form the coastal border of upland forests. At Seashore, they form a gradual transition between the maritime grasslands and the dune forests or dune woodlands. Salt-laden winds apparently prune the trees to create a wedge of vegetation that starts as a low scrub thicket in the lee of a dune and rises to the more typical inland canopy height. The soils of this community type are mapped as Newhan-Corolla fine sands and Newhan fine sand (Soil Conservation Service, 1985).

TABLE 2. Cover data from the seven mesic forest plots, by stratum. Numerical values are cover classes described in the text, a + indicates that the species was present in the vicinity of the plot.

Stratum / Species	Plots 60	61	62	65	69	72	109	Frequency
Canopy								
Pinus taeda	3+	+	4	3	2	3	3	7
Liquidambar styraciflua					4-	4+		2
Carya glabra	+	3-						2
Nyssa sylvatica		+					3-	2
Quercus nigra		4-						1
Acer rubrum		4-						1
Quercus falcata	3							1
Oxydendrum arboreum		3-						1
Sub Canopy								
Acer rubrum	4-		3-	3-	3	3	5-	6
Ilex opaca	3	3-			2	3-		4
Cxydendrum arboreum	3+		3	2+			3	4
Fagus grandifolia					3	4-	3-	3
Quercus nigra			3+	3+		3		3
Persea borbonia	2	2+	3-					3
Sassafras albidum	3-				2			2
Symplocos tinctoria		2-	3+					2
Magnolia virginiana						3	2+	2
Cornus florida					4+			1
Liquidambar styraciflua			3-					1
Pinus taeda					2			1
Osmanthus americana	2+							1
Vines & Epiphytes								
Vitis rotundifolia	2	3+	2+	2+		1	2	6
Smilax glauca	+	1	3-	2+				4
Rhus radicans			+		2		+	3
Tillandsia usneoides	1	1		1				3
Smilax rotundifolia	2+	2-						2
Parthenocissus quinquefolia	+			1				2
Gelsemium sempervirens			1					1
Shrub Layer								
Persea borbonia	2	2	3	1	2	2+	3	7
Ilex opaca	2	2	2	3	2+	2+	2	7
Clethra alnifolia	4-	4+	2+		3-	2+	4-	6
Quercus nigra	2-	2-		2	+			4
Osmanthus americana	2	2		4-				3
Symplocos tinctoria		2-	3-	2+				3
Fagus grandifolia					1	3-	2	3
Amelanchier sp.		2		2+			2	3
Magnolia virginiana						2	2	2
Acer rubrum		2		2+				2
Oxydendrum arboreum	2				2+			2
Liquidambar styraciflua	2-	1						2
Juniperus virginiana		1		1				2
Euonymus americana		1	1					2
Vaccinium corymbosum		3-						1
Hamamelis virginiana		2-						1
Quercus falcata			2					1
Carya sp.				2-				1
Cornus florida					2+			1
Vaccinium stamineum							2	1

TABLE 2. *contued*

Stratum / Species	Plots 60	61	62	65	69	72	109	Frequency
Shrub Layer- *cont.*								
Pinus taeda		1						1
Castanea pumila		1						1
Quercus phellos					1			1
Quercus alba							1	1
Herb Layer								
Vaccinium vacillans	4-	4-	2+	2	2+			5
Clethra alnifolia	3+		2+	2		2+	3	5
Pteridium aquilinum	2	2+		2-	1		1	5
Mitchella repens	2+	4		5-		+		4
Persea borbonia	2+	2				2	2+	4
Osmanthus americana	2	2-		4				3
Quercus nigra		2	1		1			3
Acer rubrum	1	1	1					3
Conopholis americana		+	1	1				3
Symplocos tinctoria			3		1			2
Pinus taeda		1		1				2
Quercus phellos					1		1	2
Amelanchier sp.				2-				1
Fagus grandifolia							2	1
Ilex opaca							2	1
Goodyera pubescens	1							1
Hamamelis virginiana		1						1
Euonymus americanus		1						1
Polypodium polypodioides				1				1
Carya sp.					1			1
Tipularia discolor						1		1
Monotropa uniflora							1	1

TABLE 3. Composition of the canopy and subcanopy of the seven dune forest plots at Seashore.

Species	% Freq.	Density Trees/ha	Basal Area dm^2/ha	Relative % Freq.	Dens.	Dom.	I.V.(%)
Acer rubrum	71.43	185.71	157.00	11.90	15.29	6.62	11.27
Carya glabra	14.29	57.14	264.81	2.38	4.71	11.17	6.09
Carya ovalis	71.43	100.00	272.64	11.90	8.24	11.50	10.55
Carya tomentosa	14.29	14.29	6.83	2.38	1.18	0.29	1.28
Cornus florida	42.86	71.43	32.07	7.14	5.88	1.35	4.79
Ilex opaca	71.43	142.86	62.35	11.90	11.76	2.63	8.77
Liquidambar styraciflua	28.57	85.71	129.74	4.76	7.06	5.47	5.76
Osmanthus americana	14.29	85.71	24.95	2.38	7.06	1.05	3.50
Ostrya virginiana	28.57	28.57	10.72	4.76	2.35	0.45	2.52
Oxydendrum arboreum	42.86	42.86	35.35	7.14	3.53	1.49	4.05
Pinus taeda	57.14	71.43	657.22	9.52	5.88	27.73	14.38
Quercus falcata	42.86	100.00	396.52	7.14	8.24	16.73	10.70
Quercus nigra	57.14	171.43	290.39	9.52	14.12	12.25	11.96
Symplocos tinctoria	42.86	57.14	29.67	7.14	4.71	1.25	4.37
Totals		1214.29	2370.25	99.96	100.01	99.98	99.99

TABLE 4. Cover data from the seven dune forest plots, by stratum.See Table 2 for details.

Stratum / Species	Plots 24.1	24.2	64	101	102	105	110	Frequency
Canopy								
Pinus taeda	3-	2	2-	3+	3-	2+		6
Carya sp.	4		4-		3	5-	2+	5
Quercus falcata			+	+	3+	3+	3	5
Pinus echinata					+		2	2
Quercus nigra		5-						1
Liquidambar styraciflua			3-					1
Ilex opaca		2						1
Sub Canopy								
Acer rubrum			2+	3	3-	2+	3+	5
Ilex opaca	3-	3-	3-					3
Quercus nigra			2		3-		3	3
Ostrya virginiana	3-						2+	2
Liquidambar styraciflua				3+		2+		2
Carya sp.				3+		2+		2
Oxydendrum arboreum			2-				2	2
Osmanthus americana			4-					1
Fagus grandifolia		3-						1
Symplocos tinctoria				3-				1
Quercus falcata						3		1
Vines and Epiphytes								
Tillandsia usneoides	2	2	2	2+	1		1	6
Vitis rotundifolia	1	2	2		2	2	1	6
Gelsemium sempervirens	1		2-	+	1			4
Smilax rotundifolia	2	2						2
Rhus radicans	1					1		2
Smilax glauca						1		1
Shrub Layer								
Symplocos tinctoria	1	2	2+	2+	2	3-	2	7
Oxydendrum arboreum		3-	2	2	2		2	5
Ilex opaca			2	2	3	1	2+	5
Cornus florida				1	2	3+	3	4
Amelanchier sp.	2-		2	1		2		4
Quercus nigra	2		3-	2				3
Acer rubrum		2	2+	2				3
Hamamelis virginiana	3	4				2		3
Persea borbonia		2	+					2
Clethra alnifolia		4						1
Osmanthus americana			4					1
Ostrya virginiana							3-	1
Carya sp.				2				1
Castanea pumila					1			1
Juniperus virginiana			+					1
Quercus incana			+					1
Sassafras albidum							+	1
Herb Layer								
Mitchella repens	5	3-	5	5	4+		3	6
Quercus nigra	1	1			1	2	1	5
Persea borbonia	1	1		1		1	1	5
Gaylussacia baccata	3-	2	3		4+			4
Pinus taeda			1	1	1	1		4
Vaccinium vacillans	1	3					2	3
Acer rubrum	1	1	2-					3

TABLE 4. *-continued*

Stratum / Species	Plots 24.1	24.2	64	101	102	105	110	Frequency
Herb Layer-*cont.*								
Clethra alnifolia		1	1				2	3
Conopholis americana		1	1				1	3
Vaccinium stamineum				2		4+		2
Castanea pumila						1	2+	2
Symplocos tinctoria				2-		1		2
Ilex opaca		1				2		2
Monotropa uniflora	1						1	2
Amelanchier sp.	1	1						2
Carya sp.		1				1		2
Panicum sp.				1		1		2
Sassafras albidum				1	1			2
Polygonatum pubescens	+	1						2
Myrica sp.				+			1	2
Hamamelis virginiana	2							1
Osmanthus americana			2+					1
Quercus falcata					2			1
Gaylussacia frondosa				2+				1
Vaccinium sp.						2		1
Carex nigra	1							1
Uvularia sessilifolia	1							1
Oxydendrum arboreum							1	1
Pinus echinata						1		1
Tipularia discolor						1		1
Pteridium aquilinum						1		1
Quercus phellos			+					1

TABLE 5. Composition of the canopy and subcanopy of the six dune woodland plots at Seashore.

Species	% Freq.	Density Trees/ha	Basal Area dm^2/ha	Relative % Freq.	Dens.	Dom.	I.V.(%)
Carya tomentosa	16.67	16.67	4.71	7.69	1.18	0.29	3.05
Pinus taeda	66.67	300.00	754.28	30.77	21.18	46.82	32.92
Quercus falcata	16.67	33.33	46.71	7.69	2.35	2.90	4.31
Quercus nigra	83.33	1033.33	792.12	38.46	72.94	49.17	53.52
Sassafras albidum	33.33	33.33	13.22	15.38	2.35	0.82	6.19
Totals		1416.67	1611.05	99.99	100.00	100.00	99.99

TABLE 6. Cover data from the six dune woodland plots, by stratum. See Table 2 for details.

Stratum / Species	Plots 57	103	111	112	113	114	Frequency
Canopy							
Pinus taeda	4	2-	+	4-	4	1	6
Quercus nigra		3+	3+	4-	3+	5-	5
Quercus falcata		+		3-			2
Carya tomentosa		2					1
Oxydendrum arboreum			+				1
Ilex opaca						+	1
Vines and Epiphytes							
Gelsemium sempervirens	3-	3		3	1	3	5
Vitis rotundifolia	1	3	1			2	4
Smilax bona-nox	2+				1		2
Smilax glauca	1			1			2
Vitis aestivalis	+					+	2
Smilax rotundifolia				2			1
Shrub Layer							
Sassafras albidum	3	1	2	1	3-	2	6
Pinus taeda	2+	1			2		3
Ilex opaca		+			1		2
Quercus incana						3	1
Quercus falcata	2						1
Quercus nigra			2				
Symplocos tinctoria		2					1
Castanea pumila		2					1
Vaccinium corymbosum				2-			1
Diospyros virginiana				2-			1
Vaccinium vacillans						2-	1
Vaccinium sp.	1+						1
Rhus copallina	+						1
Herb Layer							
Sassafras albidum	2	1		1	1		4
Quercus nigra			2+	1	1	1	4
Ilex opaca	1	1	1	1			4
Pteridium aquilinum		2			6	1	3
Pinus taeda	1+				1	1	3
Gaylussacia baccata		4-	6-				2
Vaccinium stamineum				3		3-	2
Diospyros virginiana		2			1		2
Cladina sp.			1	1			2
Monotropa uniflora				1		+	2
Gaylussacia frondosa		4+					1
Andropogon virginicus	2						1
Carex emmonsii	2+						1
Myrica sp.					2		1
Quercus falcata	1						1
Cypripedium acaule		1+					1
Chimaphila maculata	1						1
Hieracium gronovii	1						1
Carya sp.		1					1
Opuntia compressa		1					1
Panicum sp.		1					1
Pinus echinata			1				1
Hamamelis virginiana			1				1
Cnidoscolus stimulosus					1		1
Solidago odora	+						1

TABLE 7. Composition of the canopy and subcanopy of the eleven maritime forest plots at Seashore.

Species	% Freq.	Density Trees/ha	Basal Area dm^2/ha	Relative % Freq.	Dens.	Dom.	I.V.(%)
Ilex opaca	27.27	54.55	69.77	11.11	7.41	3.23	7.25
Juniperus virginiana	9.09	9.09	3.80	3.70	1.23	0.18	1.70
Liquidambar styraciflua	9.09	18.18	18.76	3.70	2.47	0.87	2.35
Pinus serotina	9.09	9.09	47.53	3.70	1.23	2.20	2.38
Pinus taeda	63.64	381.82	1300.93	25.93	51.85	60.18	45.99
Prunus serotina	18.18	18.18	5.15	7.41	2.47	0.24	3.37
Quercus incana	27.27	36.36	33.24	11.11	4.94	1.54	5.86
Quercus nigra	9.09	9.09	11.16	3.70	1.23	0.52	1.82
Quercus virginiana	63.64	181.82	663.54	25.93	24.69	30.70	27.10
Sassafras albidum	9.09	18.18	7.69	3.70	2.47	0.36	2.18
Totals		736.36	2161.56	99.99	99.99	100.02	100.00

TABLE 8. Cover data from the eleven maritime forest plots, by stratum. See Table 2 for details.

Stratum / Species	Plots 38	41	42	43.1	43.2	44	47	48	49	54	82	Freq.
Canopy												
Pinus taeda	5+	3	3+	2			3+	3		4-	3+	8
Quercus virginiana	5	4	3		5+	3	5+	5	3			8
Quercus incana	3	4			4-			3				4
Ilex opaca			2+						3	3-		3
Prunus serotina		2				2						2
Sassafras albidum				2						2+		2
Pinus serotina	3											1
Myrica sp.						3-						1
Quercus nigra							3+					1
Liquidambar styraciflua											3-	1
Juniperus virginiana		2										1
Nyssa sylvatica										2-		1
Acer rubrum											2+	1
Vines and Epiphytes												
Vitis rotundifolia	+	3	3+	2	3-	+	2	3	2	3	3+	11
Smilax glauca			2		1	1	1	2			1	6
Parthenocissus quinquefolia		3	2+	1		2				+		5
Gelsemium sempervirens			1					2	2-		3+	4
Lonicera sempervirens			1	1							+	3
Smilax rotundifolia										2+	5-	2
Smilax bona-nox						+		2				2
Rhus radicans									1	+		2
Shrub Layer												
Sassafras albidum	2		3-				2	2	2+		+	6
Quercus virginiana			4		2		3		2		1	5
Quercus incana	2		4				2	2-	2			5
Quercus nigra						+		2	+	1	2	5
Myrica pensylvanica	3						1			+	2+	4
Vaccinium corymbosum							2-	2		+		3
Juniperus virginiana			1						+		+	3
Prunus serotina									3-		1	2
Pinus taeda									2		2	2

TABLE 8. *continued*

Stratum / Species	Plots											Freq.
	38	41	42	43.1	43.2	44	47	48	49	54	82	
Shrub Layer-*cont.*												
Persea borbonia										+	+	2
Quercus falcata	3											1
Liquidambar styraciflua											3	1
Acer rubrum											3	1
Ilex opaca									2+			1
Diospyros virginiana									2			1
Herb Layer												
Andropogon virginicus	2			3+	3+	3			2		3-	6
Quercus nigra	1		1	2			1		1	1		6
Heterotheca graminifolia			1	1	1	1		+	1			6
Panicum sp.	1		1				1		1		2-	5
Sassafras albidum					1		1	1			+	4
Quercus incana			2	3-	2							3
Quercus virginiana								2	2+	1		3
Quercus falcata	2			1					1			3
Ilex opaca	1		1						1			3
Prunus serotina		1		1						1		3
Opuntia compressa		1	1						1			3
Pinus taeda			1				1		1			3
Cyperus grayi			1		1				1			3
Galium hispidulum					1				+		1	3
Myrica pensylvanica				3+	3-							2
Vaccinium corymbosum							2-	1				2
Solidago odora									1		1	2
Hieracium gronovii									1		+	2
Mitchella repens											2	1
Panicum amarulum											2-	1
Persea borbonia	1											1
Erigeron canadensis					1							1
Linaria vulgaris					1							1
Astraeus hygrometricus					1							1
Liquidambar styraciflua										1		1
Aira praecox									1			1
Conopholis americana									1			1
Diodia teres											1	1
Carduus spinosissimus						+						1

North of the James River, the character of maritime forests changes markedly with evergreen oaks dropping out almost entirely. For example, the extensive maritime forests along the Eastern Shore are composed of *Pinus taeda* and various deciduous shrubs and vines (pers. obs.).

The maritime forest at Cape Henry has been heavily disturbed by various human activities: the development of a campground at Seashore, military activities at Fort Story, and the construction of residential and commercial buildings on the adjacent private lands. Despite the high level of disturbance, the maritime forests at Seashore are of statewide significance because they are some of the best remaining stands of this type in the Commonwealth.

TABLE 9. Cover data from the three maritime grassland plots, by stratum. See Table 2 for details.

Stratum / Species	Plots 87	92	96	Frequency
Herb				
Andropogon virginicus	5	3+	2+	3
Uniola paniculata	2+	3+	4-	3
Panicum amarulum		2	3	2
Iva imbricata	2+		2	2
Erigeron canadensis	2+	+		2
Heterotheca graminifolia	+	2-		2
Lactuca sp.	1	1		2
Diodia teres	1	1		2
Linaria vulgaris	1	1		2
Quercus virginiana	1	1		2
Euphorbia polygonifolia	1	1		2
Carex kobomugi			5	2
Spartina patens	2			1
Cyperus grayi		2-		1
Oenothera humifusa	1			1
Ilex opaca	1			1
Cenchrus tribuloides			1	1

TABLE 10. Cover data from the four dune grassland plots, by stratum. See Table 2 for details.

Stratum / Species	Plots 90	90.1	93	94.1	Frequency
Herb					
Panicum amarulum	5-	3+	3	2+	4
Iva imbricata	2	2	2+	4	4
Cenchrus tribuloides	1	2	1	1	4
Xanthium strumarium	1	2	1	1	4
Ammophila breviligulata	2	3+	4-		3
Erigeron canadensis	1	1		1	3
Diodia teres		2		1	2
Cakile edentula		1	1		2
Uniola paniculata				4	1
Solidago sempervirens				2	1
Spartina patens	2				1
Euphorbia polygonifolia	1				1
Iva frutescens	1				1
Salsola kali			1		1
Vitis rotundifolia	+				1
Quercus virginiana	+				1
Heterotheca graminifolia	+				1

Maritime grasslands (S5) occur on the dunes and swales inland of the primary dunes. Dominant species include *Andropogon virginicus*, *Panicum amarulum*, and *Spartina patens* (Table 9). Where the sand is less stable, *Uniola paniculata* is also abundant. Growing with the grasses are several herbs and shrubs. Among these are *Linaria canadensis*, *Erigeron canadensis*, *Quercus virginiana*, and *Iva imbricata.*

Maritime grasslands develop on stable to semi-stable dunes. At Seashore, they are bordered on the seaward side by dune grasslands, and on the inland side by

TABLE 11. Cover data from the four foredune plots, by stratum. See Table 2 for details.

Stratum	Plots				Frequency
Species	58	912	94.2	95	
Herb					
Ammophila breviligulata	3+	3	4-	1	4
Panicum amarulum	3	1	3-	1	4
Xanthium strumarium	2-	+	2	2	4
Cakile edentula	2	2	1	1	4
Salsola kali	+	1	1	1	4
Carex kobomugi	2-	1		5	3
Cenchrus tribuloides		1	2	2	3
Diodia teres	1	1	2-		3
Spartina patens			3	1	2
Distichlis spicata		1		1	2
Euphorbia polygonifolia		1	1		2
Strophostyles helvola			1	1	2
Iva imbricata			1	+	2
Uniola paniculata	+			+	2
Solidago sempervirens		1			1

TABLE 12. Cover data from the two dune crest plots, by stratum. See Table 2 for details.

Stratum	Plots		Frequency
Species	38.1	81	
Shrub			
Quercus virginiana	3	2+	2
Prunus serotina	2		1
Myrica cerifera	1		1
Herb			
Hudsonia tomentosa	3	3-	2
Panicum amarulum	2	2-	2
Cyperus grayi	1	1	2
Pinus taeda	1	1	2
Andropogon virginicus		3	1
Gelsemium sempervirens	2		1
Smilax rotundifolia	1		1
Sassafras albidum	1		1
Panicum sp.	1		1
Campsis radicans	1		1
Quercus nigra	1		1
Opuntia compressa	1		1
Solidago odora		1	1
Astraeus hygrometricus		1	1
Diodia teres		1	1
Krigia dandelion		1	1
Lechea maritima		+	1

maritime forest. In places, the dune grassland, maritime grassland and maritime forest form a mosaic. As with maritime forests, salt spray apparently limits these grasslands to salt-tolerant species. The soils underlying this community type at Seashore are mapped as Newhan fine sands (Soil Conservation Service, 1985). Extensive, pristine maritime grasslands exist on Virginia's barrier islands. The

maritime grassland at Seashore is degraded and small: it is not of statewide significance.

Dune grasslands (S4) form narrow bands of tall grasses along the primary dune. *Panicum amarulum* and *Iva imbricata* (G5/S1S2) occur here in abundance, while the characteristic species are *Uniola paniculata* and *Ammophila breviligulata* (Table 10). Herbs characteristic of the foredune grow where the tall grasses are sparse. Dune grasslands have irregular inland borders with maritime grassland, and rather abruptly border the foredune.

Dune grasslands occur above the high-tide line on the semi-stable primary dune. Blowouts, overwash, and on-shore winds directly influence this community. In places, trails have broken the rhizome mat and de-stabilized this community. Possibly a result of disturbance, *Carex kobomugi*, an exotic sedge, now dominates tens of square meters. This community is underlain by Newhan fine sands (Soil Conservation Service, 1985).

As with the maritime forests, the composition of dune grasslands shifts north of the James River. While *Uniola paniculata* is a common constituent to the south, it is replaced by *Ammophila breviligulata* along Virginia's Eastern Shore (pers. obs.). Although this community is moderately disturbed at Seashore, examples of this type with an abundance of *Uniola paniculata* are rare in Virginia.

The **foredune** (S5) consists of a narrow band of sparsely vegetated sand along the seaward base of the primary dune. Although *Ammophila breviligulata* can be abundant, the characteristic species are low-growing annuals including *Salsola kali, Cenchrus tribuloides*, *Cakile edentula*, and *Euphorbia polygonifolia* (Table 11). The foredune has a reasonably sharp boundary with the dune grassland community that lies inland. No vegetated communities exist to the seaward side.

The primary dune bears the full brunt of winter storms, including erosion, deposition, and inundation by saltwater. No true soils develop here, and the substrate of this community is simply mapped as Beach (Soil Conservation Service, 1985).

The **dune crest** (S2S4) community is a largely unvegetated expanse of unstable sand on the crest of the Great Dune. Characteristic species are *Hudsonia tomentosa*, *Cyperus grayi*, and an earth star fungus (Table 12). Woody species are sparse, stunted, and may show evidence of being buried by the shifting dune. Among the woody species found here are *Quercus virginiana*, *Q. nigra*, and *Pinus taeda*. *Panicum amarulum* and *Andropogon virginicus* are often found in patches, especially near the small trees.

The dune crest community occurs on the crest and slopes of the Great Dune that have not been stabilized by vegetation. The dune crest community typically grades into dune woodland and maritime forest, but near the southwestern corner of Seashore it ends abruptly in a brackish marsh. The underlying soil, mapped as Newhan fine sand (Soil Conservation Service, 1985), is droughty and unstable, creating harsh conditions for most plant species.

The dune crest community type is undoubtedly transient in space and time. This community type develops in the least stable sections of active dunefields, and is replaced by other community types as the sand stabilizes. Currently, there are few active dune fields in Virginia, and this community type is rare and declining.

Historical accounts of Cape Henry (e.g., Kearney, 1901) clearly indicate that there have been major changes in the vegetation of this area since Europeans first reached Virginia. The Great Dune appears to have undergone the most radical change. Latrobe (1799) described an unvegetated Great Dune encroaching upon the adjacent swamp forest at a rate of 20 m/yr. A century later, Kearney (1901) described a similar phenomenon, but noted that the rate of encroachment appeared to be substantially less. Kearney also noted that isolated pines were growing "in the middle dunes". His report includes photographs of the Great Dune with essentially no woody vegetation except the tops of *Taxodium distichium* that had been engulfed by the dune. In 1942 Egler reported that the Great Dune was still active and largely unvegetated, except for "extensive patches of *Hudsonia tomentosa*" on the "lower quiescent" portions. Thus, it appears that the maritime forests, dune forests and dune woodlands at Seashore have undergone marked changes over the past half-century. The causes of these changes are unknown, but are likely to be both natural (e.g. increasing separation of the Great Dune and the accreting shoreline) and anthropogenic (road and building construction, trampling, etc.). In light of these changes, future management of the system to protect the natural and recreational values of the Park will present a challenge.

In summary, an analysis of quantitative data on the upland plant communities of Seashore State Park revealed the presence of eight distinct types. These include forests, woodlands, dwarf-scrublands, and grasslands. Five of these types are believed to be of statewide significance in Virginia, and several support rare plants and animals. Locally, the Cape Henry ecosystem is significant because it is the only large, natural landscape unit in the urbanized portion of Viginia Beach. Because this ecosystem is dynamic, well-designed and conducted management will be critical its continued existence.

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