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Potential impact of common reed expansion on threatened high-marsh bird communities on the seaside: breeding bird surveys of selected high-marsh patches

B. J. Paxton
The Center for Conservation Biology, bjpaxt@wm.edu

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Barton J. Paxton
Center for Conservation Biology
College of William and Mary
Williamsburg, VA 23187-8795

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EXECUTIVE SUMMARY

Tidal wetlands are important to coastal ecosystems. They provide flood protection, erosion control and improve water quality. Tidal wetlands also provide essential habitats for numerous species of wildlife, many of which rely on these marsh habitats as a site for breeding and development. Historical wetland surveys indicate that as much as half of the marshes present along the Atlantic and gulf coasts in 1900 have disappeared. While direct human activities are still a leading cause of wetland loss, the structure and functioning of high marsh habitats are currently threatened from invasion of exotic and/or invasive plant species such as the common reed (*Phragmites australis*), and sea level rise due to global climatic change. Disturbance of habitat from dredging, filling, ditching, draining, and clearing, as well as the introduction of more invasive genotypes from the Old World, has enabled *P. australis* to invade habitats where it was once absent.

Stands of *P. australis* are considered poor wildlife habitat and large, monocultures of *Phragmites* offer little habitat for birds and support few individuals and low diversity. The high marsh habitats, which provide breeding habitat for several avian species of concern, including Saltmarsh Sharp-tailed Sparrows, Seaside Sparrows, Black Rails, and Willets, are most at risk from invasive *P. australis*.

Eighty 250-m transects were established within 40 high-marsh sites on the Delmarva Peninsula of Virginia. All study sites were established in marsh complexes with at least 5 hectares of high-marsh habitat and were selected to include marsh patches along the gradient of *P. australis* invasion and latitudinal position on the peninsula.

A total of 87,500 m of transects were surveyed, resulting in 2,950 detections of 81 species. The most commonly detected species were Red-winged Blackbirds, Willets, Seaside Sparrows, Common Yellowthroats, and Sharp-tailed Sparrows. Two of these species, the Seaside Sparrow and Sharp-tailed Sparrow, are species of high conservation concern. Seaside and Sharp-tailed Sparrows were found in significant numbers within large high-marsh patches on the northern portion of Virginia Delmarva Peninsula, regardless of *P. australis* presence. However these species rarely, if ever, utilized *P. australis*, and still required large patches of high-marsh grass and high-marsh shrub habitat.

BACKGROUND

Context

Tidal wetlands are a vital component to coastal ecosystems for a variety of reasons. They provide flood protection by storing and slowing runoff from upstream sources, this storing and slowing of runoff also contributes to erosion control and improves water quality by trapping sediments and pollutants. Tidal wetlands also provide essential habitats for numerous species of wildlife, many of which require these marsh environments as a site for breeding and development. Many of the wildlife species that rely upon these habitats, such as fish, shellfish and waterfowl, are not only critical components to the ecosystem, but are both economically and recreationally important.

Historical wetland surveys indicate that as much as half of the marshes present along the Atlantic and gulf coasts in 1900 have disappeared. Prior to the 1970's, when measures to curb wetland loss were enacted, most marsh losses were attributable to human activities, including dredging, filling, ditching and draining that were rapidly destroying marsh habitats (Dahl, 1990). While direct human activities are still a leading cause of wetland loss, the structure and functioning of high marsh habitats are currently threatened from invasion of exotic and/or invasive plant species such as the common reed (*Phragmites australis*), and sea level rise due to global climatic change.

Phragmites australis is a grass native to the United States that was historically found in wet meadows, riversides, and freshwater marshes. It is increasingly considered an invasive pest due to its rapid spread into habitats where it often quickly dominates native vegetation. Its rapid invasion over the last century has been facilitated by the human activities that were the primary causes of wetland loss. Disturbance of habitat from dredging, filling, ditching, draining, and clearing has enabled *P. australis* to invade habitats where it was once absent. In addition to the disturbance factors, introduction of more invasive genotypes from the Old World have promoted rapid invasion of this species (Marks et al. 1994).

Stands of *P. australis* are considered poor wildlife habitat. Within monocultures of *P. australis* faunal diversity is generally low (Roman et al. 1984). While some bird species utilize the edges of *P. australis* stands for roosting and foraging, the tall, dense growth generally restricts bird use (Benoit and Askins, 1999). Large, monocultures of *Phragmites* are considered poor habitat for birds and support few individuals and low diversity (Meyerson et. al., 2000). Surveys of tidal marshes along the Pamunkey River, VA found the lowest species richness values at points associated with *P. australis* (Paxton and Watts, 2002)

High marsh habitats are most at risk from invasive *P. australis*. The marsh zone where *P. australis* occurs at the greatest density is the zone of integration between the upland and the irregularly flooded marsh (Fig. 1). The irregularly flooded zone is favored by the short marsh grass species (*Spartina patens, Distichilis spicata*) which provide breeding habitat for several avian species of concern, including Saltmarsh

Sharp-tailed Sparrows, Seaside Sparrows, Black Rails, and Willets. Encroachment of *P. australis* into the lower portions of the irregularly flooded zone will reduce the amount of available habitat for species adapted to nesting in short marsh grasses and has been shown to significantly reduce the densities of these short grass specialists (Benoit and Askins, 1999).

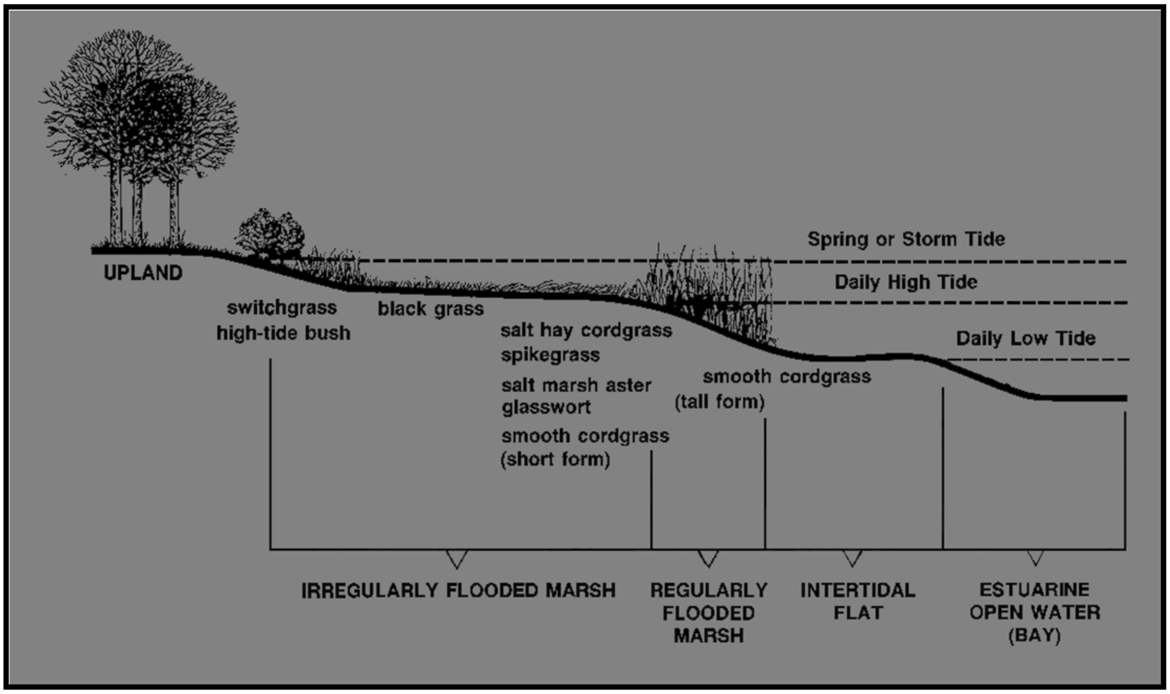

Figure 1. Salt marsh zones, from: Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Fish and Wildlife Service Biological services program. FWS/OBS-79/31

Continued efforts to control the spread of *P. australis*, on the Delmarva Peninsula of Virginia, resulted in a mapping and monitoring project conducted by the Virginia Department of Conservation and Recreation (DCR) – Division of natural heritage in 2004, and an assessment of *Phragmites* Invasion of High Marsh Habitats by The Center for Conservation Biology in 2006. The GIS layers that resulted from these efforts aid in the assessment of the impact of *P. australis* invasion on high marsh bird communities the lower Delmarva seaside.

Objectives

The primary objective of this study is to determine the effect the invasion of *P. australis* into the marsh habitats of the lower Delmarva seaside is having on the high-marsh breeding bird communities. Findings will provide benchmark data on high-marsh bird numbers and distribution to be used in future studies looking at habitat changes within this marsh system. This information will be also prove useful in guiding the *P. australis* removal and control efforts on the Delmarva seaside.

METHODS

Study Area

The area of interest for this study was high-marsh areas of the Lower Delmarva seaside of Virginia, including the lagoon system and barrier islands of Accomack and Northampton Counties. Particular emphasis was given to the eastern edge of the peninsula from just west of Wallops Island south to the tip, and the barrier and lagoon islands of Accomack County. The area of interest was subdivided into four latitudinal classifications (Fig. 2).

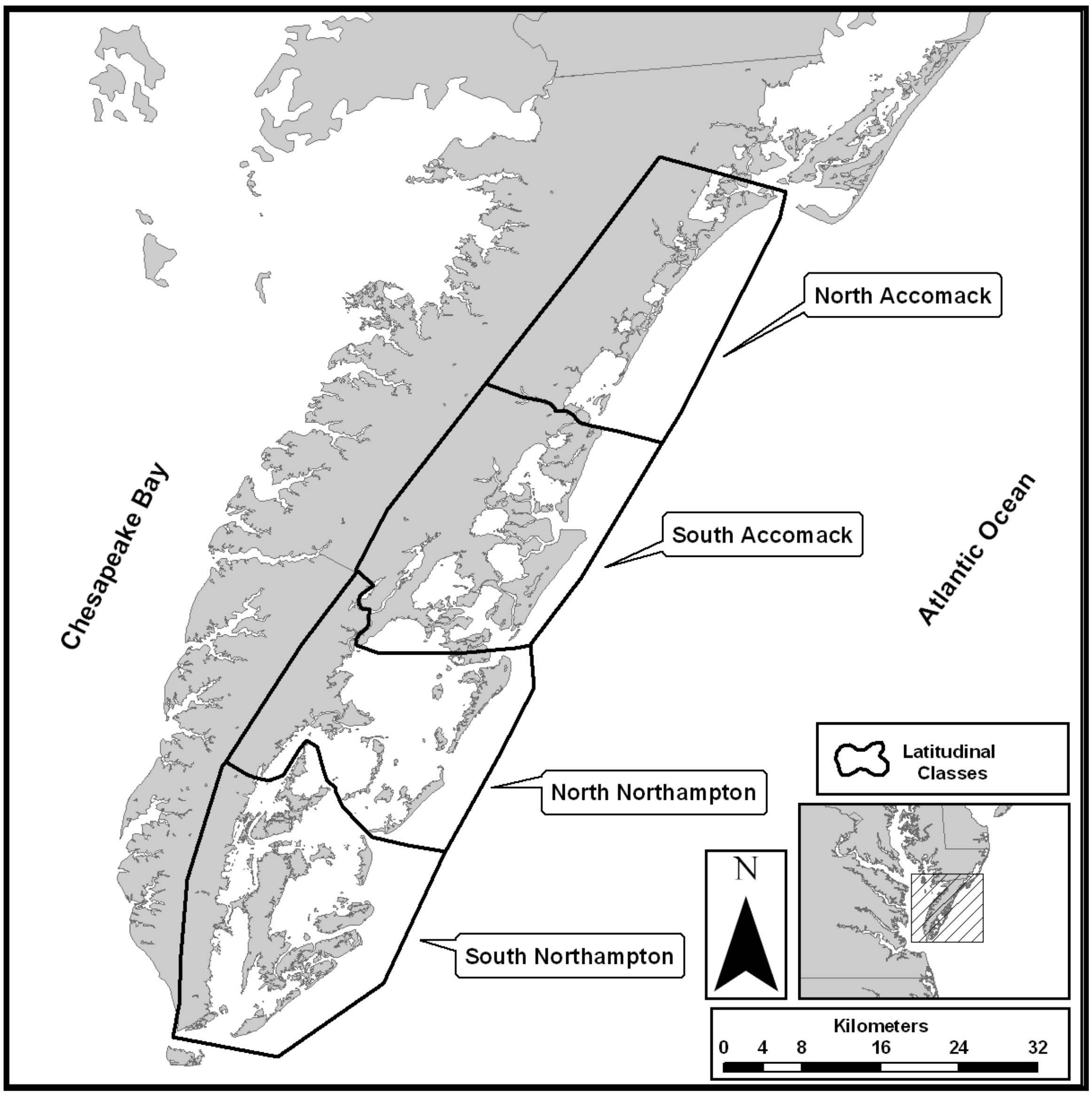

Figure 2. Map of study area of the Lower Delmarva Peninsula showing latitudinal classes.

Surveys

Eighty 250-m transects were established within 40 high-marsh sites (Fig 3). Transects were paired at sites, so that one transect focused on the high-marsh/upland ecotone and the other focused on only the high-marsh or the high-marsh/low-marsh ecotone. All study sites were established in marsh complexes with at least 5 hectares of high-marsh habitat. Sites were selected to include marsh patches along the gradient of *P. australis* invasion and latitudinal position on the peninsula (see table 1 for list and description of transects).

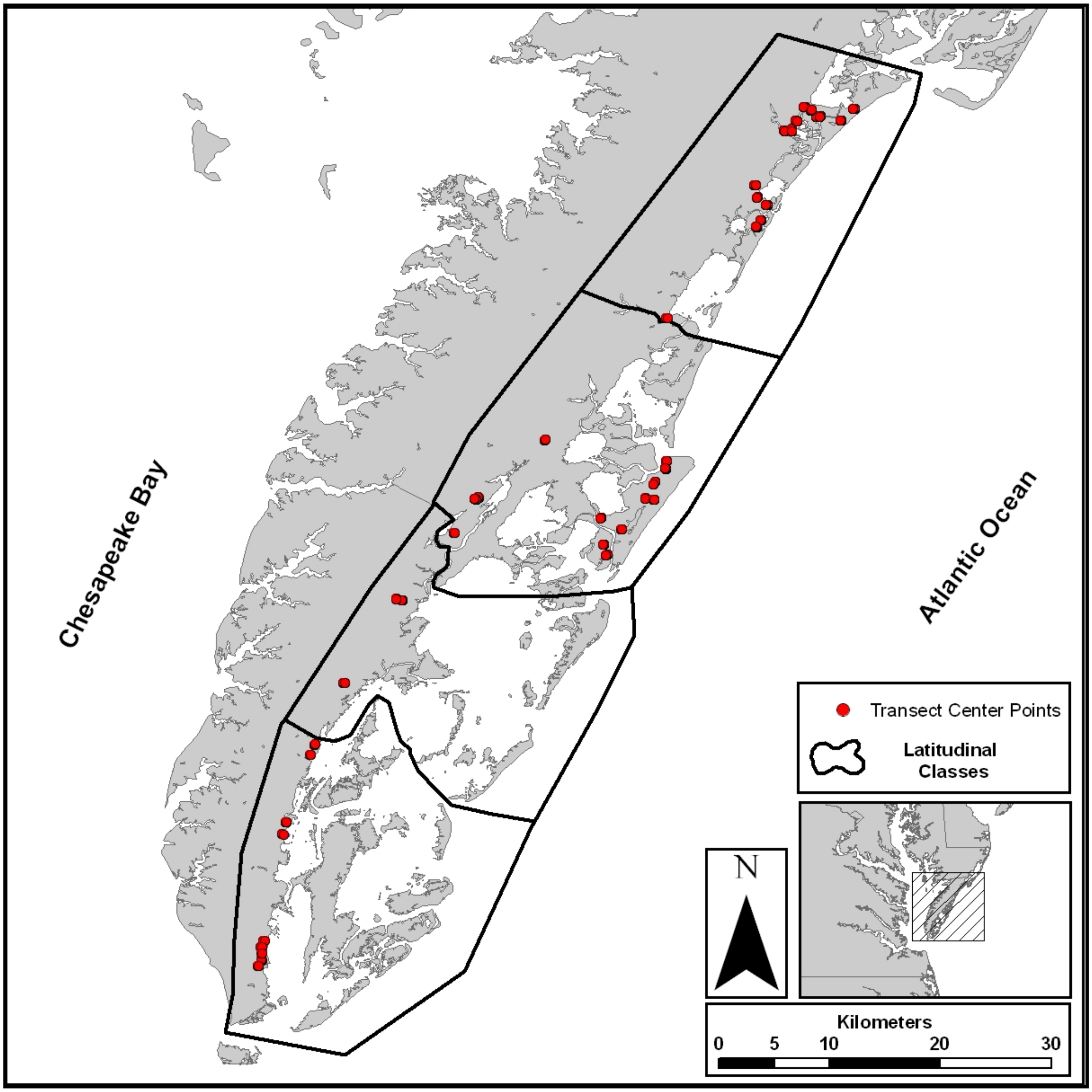

Figure 3. Map showing the center point locations of high-marsh breeding bird transects on the Lower Delmarva Peninsula.

Table 1. High-marsh breeding bird transect names, midpoints, and latitudinal segments (midpoint coordinates are in NAD 1983 State Plane Feet Virginia South).

TRANSECT	MIDPOINT X	MIDPOINT Y	LATITUDINAL SEGMENT	TRANSECT	MIDPOINT X	MIDPOINT Y	LATITUDINAL SEGMENT
arbn-1-1	12343010	3843950	North Accomack	mags-1-1	12227346	3597524	South Northampton
arbn-1-2	12343115	3843596	North Accomack	mags-1-2	12227624	3597502	South Northampton
arbn-2-1	12344834	3844654	North Accomack	meto-1-1	12338545	3817164	North Accomack
arbn-2-2	12344854	3843710	North Accomack	meto-1-2	12338277	3817224	North Accomack
arbn-3-1	12345715	3846957	North Accomack	meto-2-1	12337625	3815203	North Accomack
arbn-3-2	12345960	3846787	North Accomack	meto-2-2	12337415	3815262	North Accomack
asso-1-1	12337401	3824248	North Accomack	oyst-1-1	12232057	3636408	South Northampton
asso-1-2	12337194	3823966	North Accomack	oyst-1-2	12232314	3636244	South Northampton
asso-2-1	12339816	3821698	North Accomack	parr-1-1	12318303	3745580	South Accomack
asso-2-2	12339566	3821739	North Accomack	parr-1-2	12318613	3745617	South Accomack
bell-1-1	12274817	3733314	South Accomack	parr-2-1	12318510	3743206	South Accomack
bell-1-2	12274666	3733471	South Accomack	parr-2-2	12318170	3743358	South Accomack
bell-2-1	12274174	3732715	South Accomack	parr-3-1	12316159	3739404	South Accomack
bell-2-2	12273837	3732958	South Accomack	parr-3-2	12315565	3738536	South Accomack
bell-3-1	12269103	3722911	South Accomack	parr-4-1	12313872	3734531	South Accomack
bell-3-2	12269366	3722844	South Accomack	parr-4-2	12313918	3734335	South Accomack
boxt-1-1	12244537	3677657	North Northampton	parr-5-1	12315764	3734090	South Accomack
boxt-1-2	12244918	3677699	North Northampton	parr-5-2	12316067	3734003	South Accomack
brax-1-1	12227697	3601117	South Northampton	parr-6-1	12303645	3728348	South Accomack
brax-1-2	12228024	3601077	South Northampton	parr-6-2	12303578	3728149	South Accomack
brow-1-1	12257707	3702446	North Northampton	parr-7-1	12308398	3725024	South Accomack
brow-1-2	12257517	3702561	North Northampton	parr-7-2	12308653	3724906	South Accomack
brow-2-1	12256183	3703089	North Northampton	parr-8-1	12304617	3720341	South Accomack
brow-2-2	12256166	3702778	North Northampton	parr-8-2	12304358	3720374	South Accomack
foll-1-1	12317147	3787584	North Accomack	parr-9-1	12305534	3717381	South Accomack
foll-1-2	12317440	3787603	North Accomack	parr-9-2	12305073	3717165	South Accomack
gatn-1-1	12227489	3595454	South Northampton	pigg-1-1	12289631	3750820	South Accomack
gatn-1-2	12227695	3595430	South Northampton	pigg-1-2	12289987	3750969	South Accomack
gats-1-1	12226512	3593596	South Northampton	wall-1-1	12347740	3851025	North Accomack
gats-1-2	12226760	3593603	South Northampton	wall-1-2	12347464	3850902	North Accomack
hope-1-1	12336641	3827496	North Accomack	wall-2-1	12350681	3848407	North Accomack
hope-1-2	12337056	3827551	North Accomack	wall-2-2	12350486	3848249	North Accomack
indi-1-1	12238109	3659409	South Northampton	wall-3-1	12349165	3850091	North Accomack
indi-1-2	12238398	3659443	South Northampton	wall-3-2	12349364	3850303	North Accomack
indi-2-1	12237148	3656443	South Northampton	wall-4-1	12351393	3848532	North Accomack
indi-2-2	12237434	3656365	South Northampton	wall-4-2	12351228	3848329	North Accomack
isla-1-1	12231280	3632723	South Northampton	wall-5-1	12356303	3847221	North Accomack
isla-1-2	12231605	3632656	South Northampton	wall-5-2	12356124	3847325	North Accomack
magn-1-1	12227135	3599262	South Northampton	wall-6-1	12359296	3850742	North Accomack
magn-1-2	12227423	3599329	South Northampton	wall-6-2	12359055	3850791	North Accomack

Birds were surveyed between 18 May and 17 July, 2006. To reduce the effects of seasonal bias, censuses were conducted within rounds such that all transects were surveyed before the beginning of the subsequent round. Each transect was surveyed at least three times during the study period. Due to tidal variations and access restrictions on some properties, surveys were not restricted to morning time periods. All censuses were completed within 0.5 hours after sunrise and 3 hours before sunset.

Birds were surveyed along marked transects using a variation of the standard, variable-width transect technique (Emlen 1974). Due to the secretive nature of many of the species being surveyed, we only included birds detected within 25 meters perpendicular to the transect line. A single observer moved along transects at a slow, constant speed and searched for birds within 25 m of the transect line. All individuals encountered were identified to species and recorded. In addition to the species, how the bird was initially detected was also recorded. Detection types included aural, visual, and flushed. Distances between the observer and the birds detected (detection distance) and the distance between the bird and transect (transect distance) were also recorded in order to facilitate density estimation. Because of the inherent difficulties with unreferenced distance estimation, a stratified approach was used. For birds believed to be within 10 m of the observer, distances were estimated to 1-m resolution. For birds believed to be within 10 and 50 m away, distances were estimated to the nearest 5 m. For birds between 10 and 100 m away, distances were estimated to the nearest 10 m, and for birds greater than 100 m away distances were estimated to the nearest 50 m. When birds and time allowed, laser range finders were used to estimate distances more accurately.

Vegetation Mapping

Vegetation characteristics of each survey area were determined by mapping the actual vegetation, with the aid of laser range finders, on aerial photographs of individual study areas. The resulting vegetation patch map was then digitized using ArcView 3.3, and ArcMap 9.1 to produce a GIS layer of the habitat type present within study area.

RESULTS

A total of 87,500 m of transects were walked, resulting in 2,950 detections of 81 species (Appendix 1). The most commonly detected species were Red-winged Blackbirds, Willets, Seaside Sparrows, Common Yellowthroats, and Sharp-tailed Sparrows, witch accounted for 16, 11, 10, 6, and 6 percent of the total detections respectively. Species richness values for individual transects ranged from 2 to 21 (Table 2). As expected species richness values seemed to increase as the habitat diversity of the site increased.

Seaside Sparrows and Sharp-tailed Sparrows are 2 species that were detected at high rate and which are also considered species of conservation concern anywhere within their range (Rich et. al., 2004). Seaside and Sharp-tailed Sparrows both have very high total breeding scores (25 and 29 respectively) for the mid-Atlantic Bird Conservation Region, indicating that they or of high conservation concern within the region (Carter et. al., 2000). Seaside sparrow were detections numbered 291, and were present on 36 different transects (Fig. 4, Table 3). Maximum counts for individual surveys reached a high of 12 Seaside Sparrows, detected along a transect on Arbuckle Neck, this corresponds to a maximum observed density of 8.3 birds/ha. Detections of Sharp-tailed Sparrows numbered 185, on 26 different transect (Fig 5, Table 4). Maximum counts for individual surveys reached a high of 14 Sharp-tailed Sparrows, also detected along a transect on Arbuckle Neck, this corresponds to a maximum observed density of 9.7 birds/ha.

Table 2. High-marsh breeding bird transects with species richness values and habitat composition (“other” includes; water, mud, sand and shell).

TRANSECT	% MARSH GRASS	% MARSH SHRUB	% *P. australis*	% Upland	% Other	Richness Value	TRANSECT	% MARSH GRASS	% MARSH SHRUB	% *P. australis*	% Upland	% Other	Richness Value
arbn-1-1	62	38				10	mags-1-1	66	5		26	2	10
arbn-1-2	100					8	mags-1-2	95			3	2	3
arbn-2-1	71	12	12	5		15	meto-1-1	100					21
arbn-2-2	100					7	meto-1-2	100					8
arbn-3-1	53	13	32		1	8	meto-2-1	71	5	8		15	10
arbn-3-2	94	6				5	meto-2-2	93				7	10
asso-1-1	100					6	oyst-1-1	59	9	32			6
asso-1-2	100					6	oyst-1-2	100					4
asso-2-1	57				43	8	parr-1-1	52	26	10		12	11
asso-2-2	100					10	parr-1-2	86	13	1			10
bell-1-1	50	28		19	3	8	parr-2-1	49	51				10
bell-1-2	49	42			10	10	parr-2-2	95	5				8
bell-2-1	43	45		10	2	14	parr-3-1	94	6				8
bell-2-2	76	4			19	9	parr-3-2	88	12				5
bell-3-1	68	17		15		6	parr-4-1	52	39		9		12
bell-3-2	87	7			6	6	parr-4-2	86	14				7
boxt-1-1	63	27	1	7	1	9	parr-5-1	87	13				8
boxt-1-2	96				4	4	parr-5-2	69	31				9
brax-1-1	76	12		12		10	parr-6-1	25				75	14
brax-1-2	100					2	parr-6-2	100					4
brow-1-1	53	10	3	30	4	17	parr-7-1	90	9			1	9
brow-1-2	88	4		8		6	parr-7-2	81	15			5	6
brow-2-1	49	40		11		7	parr-8-1	60	30		6	4	13
brow-2-2	100					4	parr-8-2	82	18				3
foll-1-1	67		33			8	parr-9-1	59	41				12
foll-1-2	78				22	3	parr-9-2	65	35				8
gatn-1-1	81	10	1	5	3	14	pigg-1-1	60	14		26		10
gatn-1-2	99				1	5	pigg-1-2	68	32				6
gats-1-1	56	14	28	2		8	wall-1-1	38	44	18			9
gats-1-2	96	4				6	wall-1-2	78	1	5		17	5
hope-1-1	55	27	17			8	wall-2-1	71	18	11			9
hope-1-2	95	5				8	wall-2-2	98				2	7
indi-1-1	34	23	6	37		10	wall-3-1	66	17	16			11
indi-1-2	100					5	wall-3-2	53	12	35			8
indi-2-1	60	40				9	wall-4-1	60	17	23			5
indi-2-2	100					3	wall-4-2	63	31	6			10
isla-1-1	42	17	30	11		7	wall-5-1	35	54	2		10	10
isla-1-2	100					3	wall-5-2	49	51				9
magn-1-1	56	17	8	17	2	9	wall-6-1	10	42	30	18		7
magn-1-2	100					4	wall-6-2	96	4	0			6

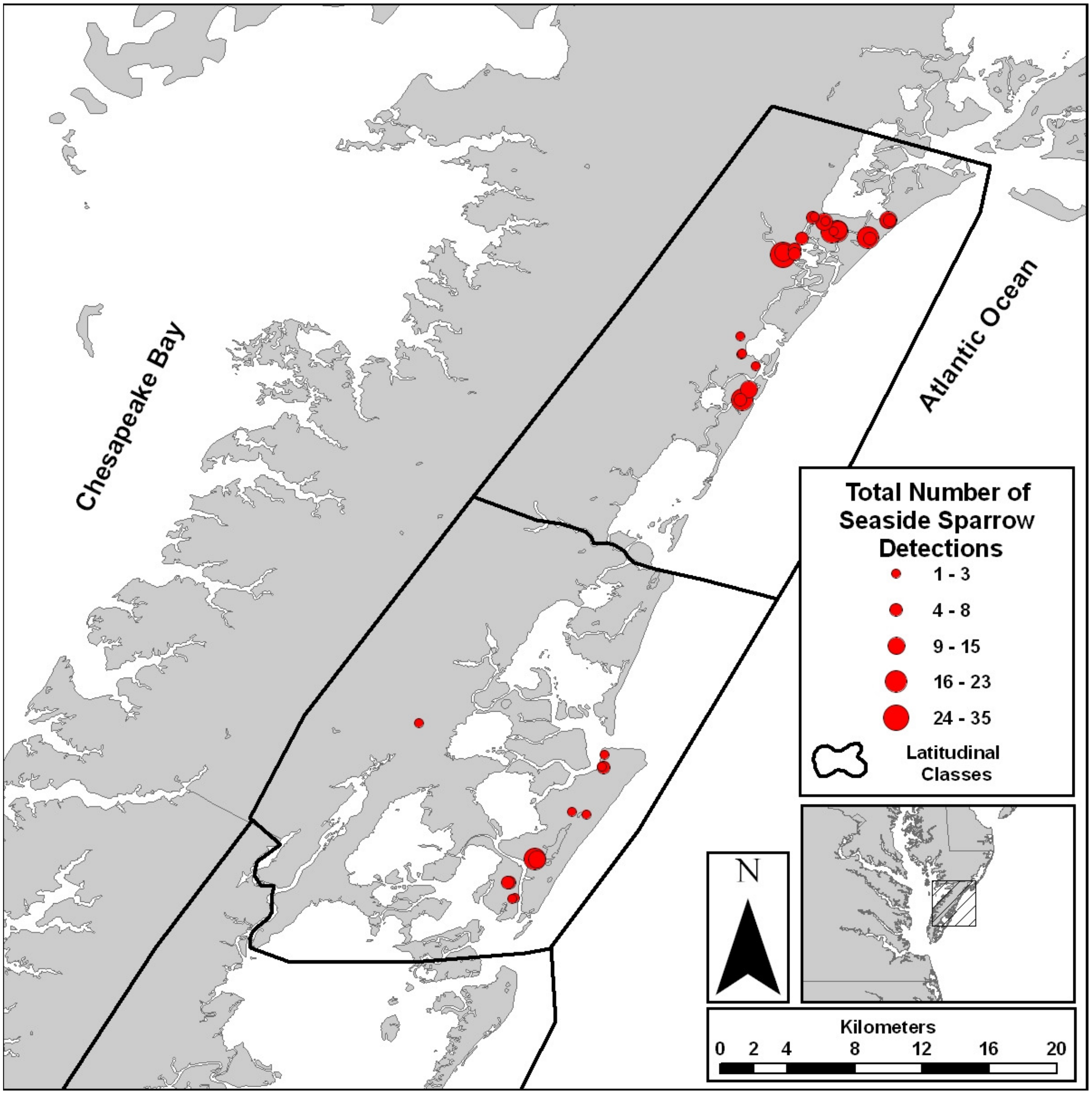

Figure 4. Map showing the location and total number of Seaside Sparrow detections from high-marsh breeding bird transects on the Lower Delmarva Peninsula.

Table 3. Detections of Seaside Sparrows by transect and survey round.

TRANSECT	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Total Detections	TRANSECT	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Total Detections
arbn-1-1	4	2	1	2	2	11	mags-1-1	0	0	0	0	0	10
arbn-1-2	12	1	6	11	5	35	mags-1-2	0	0	0	0	0	3
arbn-2-1	1	4	1	0	0	6	meto-1-1	3	2	2	1	2	21
arbn-2-2	0	2	0	2	1	5	meto-1-2	0	0	0	0	0	8
arbn-3-1	0	0	0	0	0	0	meto-2-1	7	3	5	1	1	10
arbn-3-2	0	0	1	3	0	4	meto-2-2	1	2	2	0	0	10
asso-1-1	0	0	1	0	0	1	oyst-1-1	0	0	0	0	0	6
asso-1-2	1	1	0	0	0	2	oyst-1-2	0	0	0	0	0	4
asso-2-1	0	0	0	0	0	0	parr-1-1	0	0	0	0	0	11
asso-2-2	1	0	1	0	0	2	parr-1-2	0	0	1	1	1	10
bell-1-1	0	0	0	0	0	0	parr-2-1	2	1	1	2	0	10
bell-1-2	0	0	0	0	0	0	parr-2-2	0	1	1	0	0	8
bell-2-1	0	0	0	0	0	0	parr-3-1	0	0	0	0	0	8
bell-2-2	0	0	0	0	0	0	parr-3-2	0	0	0	0	0	5
bell-3-1	0	0	0	0	0	0	parr-4-1	0	0	0	0	0	12
bell-3-2	0	0	0	0	0	0	parr-4-2	0	0	0	0	1	7
boxt-1-1	0	0	0	0	0	0	parr-5-1	0	0	0	0	0	8
boxt-1-2	0	0	0	0	0	0	parr-5-2	0	0	3	0	0	9
brax-1-1	0	0	0	0	0	0	parr-6-1	0	0	0	0	0	14
brax-1-2	0	0	0	0	0	0	parr-6-2	0	0	0	0	0	4
brow-1-1	0	0	0	0	0	0	parr-7-1	6	6	4	2	3	9
brow-1-2	0	0	0	0	0	0	parr-7-2	2	3	3	3	4	6
brow-2-1	0	0	0	0	0	0	parr-8-1	3	1	0	2	1	13
brow-2-2	0	0	0	0	0	0	parr-8-2	0	3	0	0	2	3
foll-1-1	0	0	0	0	0	0	parr-9-1	0	0	1	0	0	12
foll-1-2	0	0	0	0	0	0	parr-9-2	1	0	0	0	0	8
gatn-1-1	0	0	0	0	0	0	pigg-1-1	0	0	1	0	0	10
gatn-1-2	0	0	0	0	0	0	pigg-1-2	0	0	0	0	0	6
gats-1-1	0	0	0	0	0	0	wall-1-1	1	1	0	0	0	9
gats-1-2	0	0	0	0	0	0	wall-1-2	1	2	5	0	0	5
hope-1-1	0	0	0	0	0	0	wall-2-1	2	0	0	0	0	9
hope-1-2	2	0	0	0	0	2	wall-2-2	6	7	6	0	0	7
indi-1-1	0	0	0	0	0	0	wall-3-1	4	2	3	0	0	11
indi-1-2	0	0	0	0	0	0	wall-3-2	0	3	0	0	0	8
indi-2-1	0	0	0	0	0	0	wall-4-1	4	5	6	0	0	5
indi-2-2	0	0	0	0	0	0	wall-4-2	7	9	5	0	0	10
isla-1-1	0	0	0	0	0	0	wall-5-1	2	2	2	0	0	10
isla-1-2	0	0	0	0	0	0	wall-5-2	8	7	8	0	0	9
magn-1-1	0	0	0	0	0	0	wall-6-1	1	2	1	0	0	7
magn-1-2	0	0	0	0	0	0	wall-6-2	2	6	5	0	0	6

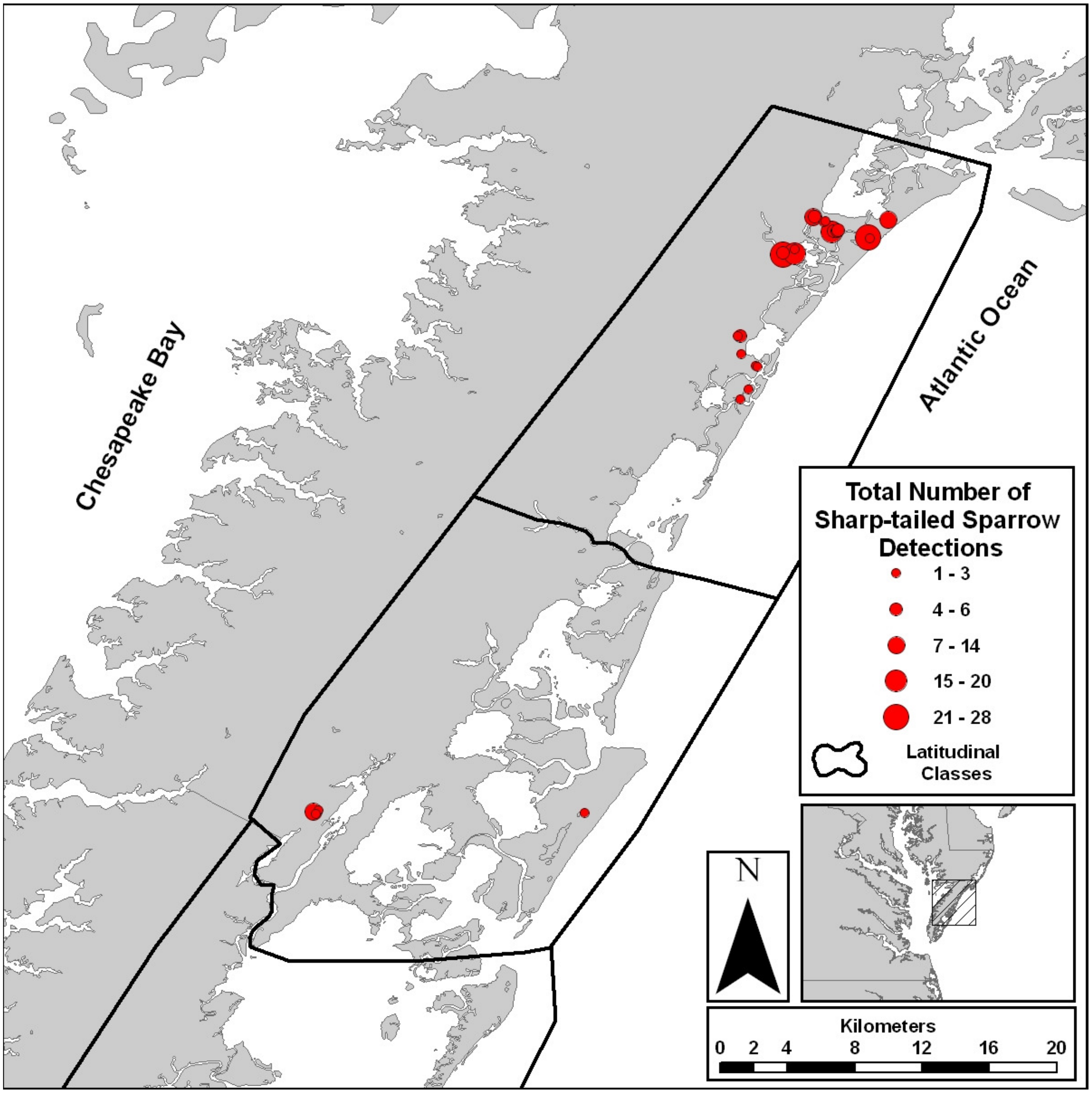

Figure 5. Map showing the location and total number of Sharp-tailed Sparrow detections from high-marsh breeding bird transects on the Lower Delmarva Peninsula.

Table 4. Detections of Sharp-tailed Sparrows by transect and survey round.

TRANSECT	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Total Detections	TRANSECT	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Total Detections
arbn-1-1	1	1	0	1	1	4	mags-1-1	0	0	0	0	0	0
arbn-1-2	6	14	2	1	4	27	mags-1-2	0	0	0	0	0	0
arbn-2-1	2	1	0	0	0	3	meto-1-1	1	0	0	0	0	1
arbn-2-2	4	8	4	2	1	19	meto-1-2	0	0	0	0	0	0
arbn-3-1	0	0	0	0	0	0	meto-2-1	0	0	0	0	0	0
arbn-3-2	0	0	0	0	0	0	meto-2-2	1	0	0	0	0	1
asso-1-1	0	0	0	0	0	0	oyst-1-1	0	0	0	0	0	0
asso-1-2	2	0	0	0	0	2	oyst-1-2	0	0	0	0	0	0
asso-2-1	0	0	1	0	0	1	parr-1-1	0	0	0	0	0	0
asso-2-2	2	0	0	0	0	2	parr-1-2	0	0	0	0	0	0
bell-1-1	0	0	0	0	0	0	parr-2-1	0	0	0	0	0	0
bell-1-2	0	0	0	0	1	1	parr-2-2	0	0	0	0	0	0
bell-2-1	0	0	0	1	0	1	parr-3-1	0	0	0	0	0	0
bell-2-2	0	3	1	6	3	13	parr-3-2	0	0	0	0	0	0
bell-3-1	0	0	0	0	0	0	parr-4-1	0	0	0	0	0	0
bell-3-2	0	0	0	0	0	0	parr-4-2	0	0	0	0	0	0
boxt-1-1	0	0	0	0	0	0	parr-5-1	0	0	0	3	0	3
boxt-1-2	0	0	0	0	0	0	parr-5-2	0	0	0	0	0	0
brax-1-1	0	0	0	0	0	0	parr-6-1	0	0	0	0	0	0
brax-1-2	0	0	0	0	0	0	parr-6-2	0	0	0	0	0	0
brow-1-1	0	0	0	0	0	0	parr-7-1	0	0	0	0	0	0
brow-1-2	0	0	0	0	0	0	parr-7-2	0	0	0	0	0	0
brow-2-1	0	0	0	0	0	0	parr-8-1	0	0	0	0	0	0
brow-2-2	0	0	0	0	0	0	parr-8-2	0	0	0	0	0	0
foll-1-1	0	0	0	0	0	0	parr-9-1	0	0	0	0	0	0
foll-1-2	0	0	0	0	0	0	parr-9-2	0	0	0	0	0	0
gatn-1-1	0	0	0	0	0	0	pigg-1-1	0	0	0	0	0	0
gatn-1-2	0	0	0	0	0	0	pigg-1-2	0	0	0	0	0	0
gats-1-1	0	0	0	0	0	0	wall-1-1	0	2	2	0	0	4
gats-1-2	0	0	0	0	0	0	wall-1-2	5	5	4	0	0	14
hope-1-1	1	0	1	0	0	2	wall-2-1	0	3	3	0	0	6
hope-1-2	4	0	0	1	0	5	wall-2-2	6	8	6	0	0	20
indi-1-1	0	0	0	0	0	0	wall-3-1	0	2	1	0	0	3
indi-1-2	0	0	0	0	0	0	wall-3-2	0	3	0	0	0	3
indi-2-1	0	0	0	0	0	0	wall-4-1	0	1	3	0	0	4
indi-2-2	0	0	0	0	0	0	wall-4-2	1	5	0	0	0	6
isla-1-1	0	0	0	0	0	0	wall-5-1	1	0	0	0	0	1
isla-1-2	0	0	0	0	0	0	wall-5-2	9	11	8	0	0	28
magn-1-1	0	0	0	0	0	0	wall-6-1	0	0	0	0	0	0
magn-1-2	0	0	0	0	0	0	wall-6-2	1	7	3	0	0	11

Seaside and Sharp-tailed Sparrows were not evenly distributed along the peninsula. Both species were restricted to high-marsh patches within the northern two latitudinal zones (Fig 4 and 5). These two species were also detected regularly in patches with high degrees *P. australis* invasion (Table 5). While Seaside and Sharp-tailed Sparrows regularly used high-marsh patches with *P. australis* present, only 1.08% of Sharp-tailed Sparrows were actually detected within *P. australis* patches, and none of the 291 Seaside sparrows detections were made within *P. australis* patches.

DISCUSSION

The high-marsh patches of the Lower Delmarva seaside are important breeding, stopover, and winter habitat for a variety of bird species. Many avian species utilize the high-marsh grass and high-marsh shrub habitat for breeding substrates. Two species of high conservation concern, the Seaside Sparrow and the Sharp-tailed Sparrow, were found in significant numbers during surveys. All detections of these two species were restricted to the northern half of the peninsula. Predictably, larger marsh patches are present within the northern half of the peninsula, and there is a strong correlation in the patch size of marshes and the abundance of the birds that occupy it (Watts, 1992). Seaside Sparrows and the Sharp-tailed Sparrows were also found with in many marshes with high degrees of *P. australis* invasion, but they were found rarely, if ever, found within patches of *P. australis*. Both of these species were found to utilize high-marsh grass and high-marsh shrub habitat almost exclusively. Within the Virginia portion of the Delmarva Peninsula the most import factors for bird that require high-marsh seem to be large marsh patch size, availability of larger expanses of high-marsh grass and high-marsh shrub habitats, and in the case of Seaside Sparrows and the Sharp-tailed Sparrows, latitude.

At the present time, the majority of *P. australis* invasion seems to be restricted to the extreme high marsh edge, along the high marsh/upland ecotone. The current level of *P. australis* invasion does not restrict the presence of high-marsh avian species. However, the abundance of high-marsh avian species may be reduced if *P. australis* is occupying areas that otherwise would be high-marsh habitat. If preserving and reclaiming habitat for high marsh avian species is a goal, it is recommended to focus *P. australis* control and eradication efforts on large contiguous patches of high marsh. Furthermore, control and eradication efforts in the in the northern portion of the peninsula should be given priority. Although *P. australis* invasion is more prevalent within the northern and southern portions of the Lower Delmarva Peninsula, removal and control of *P. australis* within the larger high marsh patches in the northern half of the peninsula would be most beneficial for high marsh avian species.

Table 5. Total number of Seaside Sparrow (SESP) and Sharp-tailed Sparrow (STSP) detections by transect, (habitat composition percentages included, "other" includes; water, mud, sand and shell).

TRANSECT	% MARSH GRASS	% MARSH SHRUB	% *P. australis*	% Upland	% Other	SESP	STSP	TRANSECT	% MARSH GRASS	% MARSH SHRUB	% *P. australis*	% Upland	% Other	SESP	STSP
arbn-1-1	62	38				11	4	mags-1-1	66	5		26	2	0	0
arbn-1-2	100					35	27	mags-1-2	95			3	2	0	0
arbn-2-1	71	12	12	5		6	3	meto-1-1	100					10	1
arbn-2-2	100					5	19	meto-1-2	100					0	0
arbn-3-1	53	13	32		1	0	0	meto-2-1	71	5	8		15	17	0
arbn-3-2	94	6				4	0	meto-2-2	93				7	5	1
asso-1-1	100					1	0	oyst-1-1	59	9	32			0	0
asso-1-2	100					2	2	oyst-1-2	100					0	0
asso-2-1	57				43	0	1	parr-1-1	52	26	10		12	0	0
asso-2-2	100					2	2	parr-1-2	86	13	1			3	0
bell-1-1	50	28		19	3	0	0	parr-2-1	49	51				6	0
bell-1-2	49	42			10	0	1	parr-2-2	95	5				2	0
bell-2-1	43	45		10	2	0	1	parr-3-1	94	6				0	0
bell-2-2	76	4			19	0	13	parr-3-2	88	12				0	0
bell-3-1	68	17		15		0	0	parr-4-1	52	39		9		0	0
bell-3-2	87	7			6	0	0	parr-4-2	86	14				1	0
boxt-1-1	63	27	1	7	1	0	0	parr-5-1	87	13				0	3
boxt-1-2	96				4	0	0	parr-5-2	69	31				3	0
brax-1-1	76	12		12		0	0	parr-6-1	25				75	0	0
brax-1-2	100					0	0	parr-6-2	100					0	0
brow-1-1	53	10	3	30	4	0	0	parr-7-1	90	9			1	21	0
brow-1-2	88	4		8		0	0	parr-7-2	81	15			5	15	0
brow-2-1	49	40		11		0	0	parr-8-1	60	30		6	4	7	0
brow-2-2	100					0	0	parr-8-2	82	18				5	0
foll-1-1	67		33			0	0	parr-9-1	59	41				1	0
foll-1-2	78				22	0	0	parr-9-2	65	35				1	0
gatn-1-1	81	10	1	5	3	0	0	pigg-1-1	60	14		26		1	0
gatn-1-2	99				1	0	0	pigg-1-2	68	32				0	0
gats-1-1	56	14	28	2		0	0	wall-1-1	38	44	18			2	4
gats-1-2	96	4				0	0	wall-1-2	78	1	5		17	8	14
hope-1-1	55	27	17			0	2	wall-2-1	71	18	11			2	6
hope-1-2	95	5				2	5	wall-2-2	98				2	19	20
indi-1-1	34	23	6	37		0	0	wall-3-1	66	17	16			9	3
indi-1-2	100					0	0	wall-3-2	53	12	35			3	3
indi-2-1	60	40				0	0	wall-4-1	60	17	23			15	4
indi-2-2	100					0	0	wall-4-2	63	31	6			21	6
isla-1-1	42	17	30	11		0	0	wall-5-1	35	54	2		10	6	1
isla-1-2	100					0	0	wall-5-2	49	51				23	28
magn-1-1	56	17	8	17	2	0	0	wall-6-1	10	42	30	18		4	0
magn-1-2	100					0	0	wall-6-2	96	4	0			13	11

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Appendix I. List of species detected with AOU Alpha code, scientific name, and total number detected.

Common Name	AOU Alpha Code	Scientific Name	Total Number Detected
Herring Gull	HEGU	*Larus argentatus*	4
Laughing Gull	LAGU	*Larus atricilla*	130
Common Tern	COTE	*Sterna hirundo*	2
Double-crested Cormorant	DCCO	*Phalacrocorax auritus*	5
Mallard	MALL	*Anas platyrhynchos*	7
American Black Duck	ABDU	*Anas rubripes*	3
Glossy Ibis	GLIB	*Plegadis falcinellus*	49
Great Blue Heron	GBHE	*Ardea herodias*	2
Great Egret	GREG	*Ardea alba*	7
Snowy Egret	SNEG	*Egretta thula*	7
Tricolored Heron	TRES	*Egretta tricolor*	1
Little Blue Heron	LBHE	*Egretta caerulea*	2
Black-crowned Night-Heron	BCNH	*Nycticorax nycticorax*	1
Clapper Rail	CLRA	*Rallus longirostris*	16
Virginia Rail	VIRA	*Rallus limicola*	1
Short-billed Dowitcher	SBDO	*Limnodromus griseus*	9
Least Sandpiper	LESA	*Calidris minutilla*	46
Dunlin	DUNL	*Calidris alpina*	12
Semipalmated Sandpiper	SESA	*Calidris pusilla*	243
Greater Yellowlegs	GRYE	*Tringa melanoleuca*	4
Lesser Yellowlegs	LEYE	*Tringa flavipes*	1
Willet	WILL	*Catoptrophorus semipalmatus*	308
Spotted Sandpiper	SPSA	*Actitis macularius*	2
Black-bellied Plover	BBPL	*Pluvialis squatarola*	27
Killdeer	KILL	*Charadrius vociferus*	7
Semipalmated Plover	SEPL	*Charadrius semipalmatus*	26
Piping Plover	PIPL	*Charadrius melodus*	5
Wilson's Plover	WIPL	*Charadrius wilsonia*	1
Ruddy Turnstone	RUTU	*Arenaria interpres*	2
American Oystercatcher	AMOY	*Haematopus palliatus*	11
Northern Bobwhite	NOBO	*Colinus virginianus*	1
Wild Turkey	WITU	*Meleagris gallopavo*	1
Mourning Dove	MODO	*Zenaida macroura*	5
Red-tailed Hawk	RTHA	*Buteo jamaicensis*	1
Great Horned Owl	GHOW	*Bubo virginianus*	1
Belted Kingfisher	BEKI	*Ceryle alcyon*	1
Downy Woodpecker	DOWO	*Picoides pubescens*	1
Red-headed Woodpecker	RHWO	*Melanerpes erythrocephalus*	5
Chimney Swift	CHSW	*Chaetura pelagica*	11
Ruby-throated Hummingbird	RTHU	*Archilochus colubris*	9
Eastern Kingbird	EAKI	*Tyrannus tyrannus*	45

Appendix I (continued). List of species detected with AOU Alpha code, scientific name, and total number detected.

Common Name	AOU Alpha Code	Scientific Name	Total Number Detected
Great Crested Flycatcher	GCFL	*Myiarchus crinitus*	1
Willow Flycatcher	WIFL	*Empidonax traillii*	2
Blue Jay	BLJA	*Cyanocitta cristata*	1
Fish Crow	FICR	*Corvus ossifragus*	2
European Starling	EUST	*Sturnus vulgaris*	1
Brown-headed Cowbird	BHCO	*Molothrus ater*	3
Red-winged Blackbird	RWBL	*Agelaius phoeniceus*	481
Eastern Meadowlark	EAME	*Sturnella magna*	42
Orchard Oriole	OROR	*Icterus spurius*	12
Common Grackle	COGR	*Quiscalus quiscula*	35
Boat-tailed Grackle	BTGR	*Quiscalus major*	89
American Goldfinch	AMGO	*Carduelis tristis*	3
Saltmarsh Sharp-tailed Sparrow	SSTS	*Ammodramus caudacutus*	178
Nelson's Sharp-tailed Sparrow	NSTS	*Ammodramus nelsoni*	7
Seaside Sparrow	SESP	*Ammodramus maritimus*	291
Field Sparrow	FISP	*Spizella pusilla*	21
Song Sparrow	SOSP	*Melospiza melodia*	159
Northern Cardinal	NOCA	*Cardinalis cardinalis*	5
Blue Grosbeak	BLGR	*Passerina caerulea*	17
Indigo Bunting	INBU	*Passerina cyanea*	4
Purple Martin	PUMA	*Progne subis*	1
Barn Swallow	BARS	*Hirundo rustica*	166
Tree Swallow	TRHE	*Tachycineta bicolor*	55
Cedar Waxwing	CEDW	*Bombycilla cedrorum*	1
White-eyed Vireo	WEVI	*Vireo griseus*	5
Yellow Warbler	YWAR	*Dendroica petechia*	18
Blackpoll Warbler	BLPW	*Dendroica striata*	1
Pine Warbler	PIWA	*Dendroica pinus*	9
Prairie Warbler	PRAW	*Dendroica discolor*	36
Common Yellowthroat	COYE	*Geothlypis trichas*	188
Yellow-breasted Chat	YBCH	*Icteria virens*	9
Northern Mockingbird	NOMO	*Mimus polyglottos*	7
Gray Catbird	GRCA	*Dumetella carolinensis*	18
Carolina Wren	CARW	*Thryothorus ludovicianus*	4
House Wren	HOWR	*Troglodytes aedon*	15
Marsh Wren	MAWR	*Cistothorus palustris*	3
Brown-headed Nuthatch	BHNU	*Sitta pusilla*	8
Carolina Chickadee	CACH	*Poecile carolinensis*	8
Blue-gray Gnatcatcher	BGGN	*Polioptila caerulea*	2
unidentified sparrow	UiSP		1