2014

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Recommended Citation

Wilson, M. D. 2014. Assessing the role of marsh habitat change on the distribution and decline of Black Rails in Virginia. Center for Conservation Biology Technical Report Series, CCBTR-14-09. College of William and Mary and Virginia Commonwealth University, Williamsburg, VA. 14 pp.

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Cover Photo: Aerial view of marsh by Bryan D. Watts

This publication was completed by funds provided by the Virginia Department of Game and Inland Fisheries (DGIF) through a Federal Aid in Wildlife Restoration grant from the U.S. Fish and Wildlife Service.

The Center for Conservation Biology is an organization dedicated to discovering innovative solutions to environmental problems that are both scientifically sound and practical within today's social context. Our philosophy has been to use a general systems approach to locate critical information needs and to plot a deliberate course of action to reach what we believe are essential information endpoints.

Executive Summary

The Black Rail is the most imperiled bird species within the Chesapeake Bay region and along the Atlantic Coast. Black Rail populations have been declining in the eastern United States for over a century, resulting in a retraction of its breeding range, an overall reduction in the number of breeding locations within its core range, and a loss of individuals within historic strongholds. The Chesapeake Bay has historically supported the bulk of the Black Rail populations within the Mid-Atlantic region. However, systematic survey efforts in the Chesapeake Bay and along the seaside of the Delmarva Peninsula have shown that populations of the Black Rail have declined by more than 85% in a relatively short time span of 15 years.

Loss and transformation of habitat is often attributed as one reason for the dramatic decline of Black Rails. The Chesapeake Bay is undergoing a relatively high rate of sea-level rise that has been suspected of altering habitats in the past and is expected to continue to do so into the future. The objective of this project was to investigate the potential influence of physical changes observable through remote sensing on Black Rail habitat availability and, eventually, population status.

We examined how changes in Black Rail distribution may be influenced by habitat change at two points in time by comparing recent and historical data on marsh vegetation composition and black rail breeding locations. Marsh vegetation was digitized from aerial photography into distinct low and high marsh classes for 1994 and 2006, and Black Rail occupancy was summarized using data from observations and surveys conducted in the early 1990s and a systematic survey in 2007. These two points in time coincide with a period of steep decline for Black Rails within the Chesapeake Bay.

Results suggest a consistent pattern in the loss and transformation of high marsh into low marsh for places where Black Rails have disappeared between the early 1990s and 2007. The best examples of the potential for habitat-mediated population losses are found at Pig Point and Dix Hammock. Both of these marshes have experienced the greatest transformation of high marsh to low marsh and have lost Rail occupation. This is the type of habitat change that would be expected to result in a negative response by Black Rails because they require high marsh for nesting and foraging.

Direct physical changes in habitat as a consequence of sea-level rise are likely not the only factor contributing to population declines of Black Rails. Nest predation and increased tidal inundation that drowns nests are also likely contributors. Taken together, these factors suggest that management actions to reverse population declines of Black Rails may need to take many forms. Abating sea-level rise with management may be impossible. However, the creation of managed impoundments with water control structures that are located inland may provide the best management option. These impoundments could also be designed to exclude predators. There is still a need to develop specific management recommendations to manage impoundments and Black Rails.

Introduction

The Black Rail is the most imperiled bird species within the Chesapeake Bay region and along the Atlantic Coast. Black Rail populations have been declining in the eastern United States for over a century, resulting in a retraction of its breeding range, an overall reduction in the number of breeding locations within its core range, and a loss of individuals within historic strongholds. The Chesapeake Bay has historically supported the bulk of the Black Rail populations within the Mid-Atlantic region. However, systematic survey efforts in the Chesapeake Bay have shown that populations of the Black Rail have declined by more than 85% in a relatively short time span of 15 years.

The recent dramatic decline of Black Rails may be a result of one or more factors. These factors can broadly be separated into two functional sources, 1) those associated with habitat loss and degradation and 2) those associated with the disruption of population demographics (e.g., survivorship and reproduction). It is difficult to separate the relative contribution of these two possible sources of population loss without first investigating each of them separately.

Loss of habitat results in an obvious population bottleneck for Black Rails. Marsh habitats in the Chesapeake Bay that Black Rails rely on have been undergoing loss and degradation for over a century. Gross reductions in marsh habitat availability can be attributed to impacts such as the human conversion of marshes to other uses and sea-level rise. Additionally, the rate of sea-level rise in the Chesapeake Bay is nearly two times greater than the global average and has been accelerating over recent decades (Zervas 2001). Salt marshes of the Bay are particularly vulnerable to sea-level rise due to their low elevational position on the landscape. In many areas of the Chesapeake Bay region, large portions of marshes are already being submerged where the sea is rising faster than marshes can accumulate sediments to maintain elevation. As sea-levels rise, increased flooding of marshes will convert many areas of high marsh to low marsh even if the total area of marsh remains constant. Over a regional scale, changes in the composition in marshes resulting from sea-level rise may be enough to affect the entire system state of an ecosystem and habitat availability for Black Rails. Black Rails specifically require high marsh habitats for nesting and foraging.

The objective of this project is to investigate the potential for habitat changes to influence Black Rail populations by examining physical changes at sites in Virginia that are currently or were historically occupied by Black Rails. Black Rails breed within the upper elevational zone of tidal salt marshes known as the high marsh. The high marsh is only inundated during extreme high tide events and is dominated over most of the Atlantic coast by plant species such as salt meadow hay (*Spartina patens*), saltgrass (*Distichlis spicata*), and low forms of smooth cordgrass (*S. alterniflora*). These dominant species are often interspersed with shrubs such as marsh elder (*Iva frutescens*) or saltbush (*Baccharis hamilifolia*) and stunted red cedar (*Juniperus virginiana*) or pine (*Pinus sp.*) trees. The vegetation difference between high marsh and low marsh (dominated by tall *S. alterniflora*) is recognizable from high quality aerial photographs and can therefore be digitized to provide area coverage.

Methods

Black Rail Distribution

Changes in Black Rail occupation patterns and marsh area/composition were compared between different sets of historical data. These data included the only systematic survey of Black Rails in Virginia (Wilson et al. 2007) and anecdotal observations from Stephen Rottenborn (Armistead 1991), Wilson et al. (2012), and other unpublished accounts. The 2007 study surveyed 242 locations on the lower Delmarva Peninsula. The results presented in this report provide the first opportunity to quantify habitat characteristics of sites occupied and not occupied by Black Rails in Virginia.

Marsh Habitat Cover

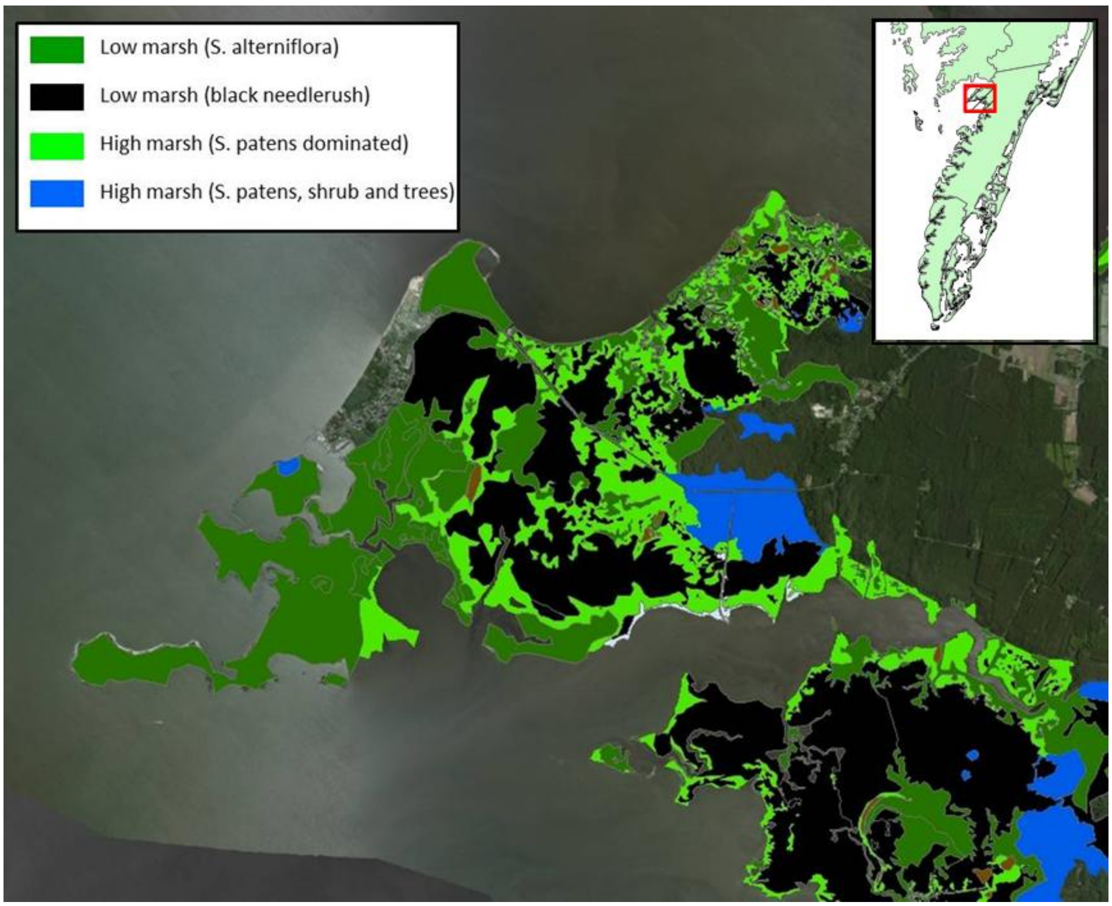
We selected the years 1994 and 2006 as two time frames that coincided with available orthophotography, spanned a significant period of decline for Black Rails in the Chesapeake Bay, and nearly overlapped with the 2007 Black Rail survey in Virginia.

Marsh vegetation was delineated into GIS by dover Digital Ortho Quarter-Quandrangle aerial photos taken in 1994 and current Base Map Imagery aerial photographs taken in 2006 (Figure 1). We mapped vegetation into 6 categories: 1) Low marsh dominated by smooth cordgrass, 2) low marsh dominated by black needlerush, 3) high marsh dominated by saltmeadow hay, 4) high marsh comprised of saltmeadow hay and also containing shrub and stunted tree coverage, 5) pine hummocks embedded within marshes, and 6) ghost hummocks, defined as areas where significant tree mortality has occurred within pine hummocks embedded in marshes.

We trained ourselves on distinguishing marsh vegetation from these photographs for a period of one week by examining areas known to us and comparing aerial images to U.S. Fish and Wildlife Wetland data and the Center for Coastal Resource Management tidal marsh inventory. We expect that some error in photointerpretation occurred, particularly since we used two markedly different photographic sources between years. Omission and commission errors are expected and, taken together, likely generated a 3-5% error rate in habitat composition.

Habitat cover was summarized for total area and percent cover at different spatial levels as required for the following comparisons. We placed a 300m buffer around the center of all survey locations from the 2007 survey to compare location occupied and non-occupied by Black Rails. Similarly, we made comparisons within these 300m buffers for changes in occupancy between 2007 and earlier detections for several marshes. For marshes where the exact location of a Black Rail record was not known, we summarized vegetation cover across entire marshes rather than within 300m buffers.

Figure 1. Example of vegetation mapping of Freeschool and Michaels marshes, which are part of the Saxis Wildlife Management Area located in Accomack County, Virginia.



Results

Habitat Use Patterns

The percent of low marsh and shrub cover were significantly different between occupied and unoccupied points (Table 1). The average percentage of low marsh around occupied points was far lower than at points that were not occupied. Conversely, shrub cover was nearly three times greater at occupied points compared to points that were not occupied. However, all vegetation parameters exhibited high standard deviations, suggesting that marsh conditions varied widely.

Table 1. Mann-Whitney U comparisons for percent vegetation cover between survey points occupied and not occupied by Black Rails during a systematic survey conducted in 2007.

Vegetation	Occupied (N = 12) Mean % ± SD	Not Occupied (N = 104) Mean % ± SD	U	*P*
Low Marsh	15.7 ± 22.74	42.3 ± 31.39	262.5	< 0.001
Black Needlerush	27.9 ± 23.82	25.2 ± 28.87	536.0	> 0.10
High Marsh	26.4 ± 24.82	21.9 ± 24.28	602.0	> 0.10
Shrub	20.1 ± 22.60	8.3 ± 18.6	350.0	< 0.05
Pine Hammock	8.0 ± 14.12	2.1 ± 4.67	598.0	> 0.10

Changes in Marsh Cover and Black Rails

Changes in marsh composition over time showed relatively consistent results between points that continue to support Black Rails and those that are no longer occupied (Table 2). Both groups shared similar losses of high marsh cover and comparable gains in low marsh vegetation. Sites that still harbor birds over time had increases in black needlerush while sites that lost birds over time had increases in the percentages of low marsh vegetation (i.e., *S. alterniflora*). These patterns may be a function of system-wide changes in the lower Bay. Relating habitat changes to Black Rail distribution at this gross scale may mask more important fine scale changes that are better examined at the level of individual marshes (see below).

Table 2. Comparisons for percent cover based on aerial photography from 1994 and 2010 between marsh patches that maintained occupancy over similar survey times (1991 and 2007) and those that lost birds during that time.

	Hectares (% cover)	
Vegetation	1994	2010
No Change In Occupancy		
Low Marsh	92.5 (29%)	91.9 (28%)
Black Needlerush	72.9 (22%)	94.0 (28%)
High Marsh	136.4 (42%)	121.7 (36%)
Shrub	21.0 (7%)	21.6 (8%)
Loss of Occupancy		
Low Marsh	33.5 (34%)	59.2 (40%)
Black Needlerush	24.8 (25%)	32.5 (22%)
High Marsh	36.2 (37%)	45.7 (31%)
Shrub	3.2 (3%)	7.9 (5%)

Changes for Selected Marsh Patches

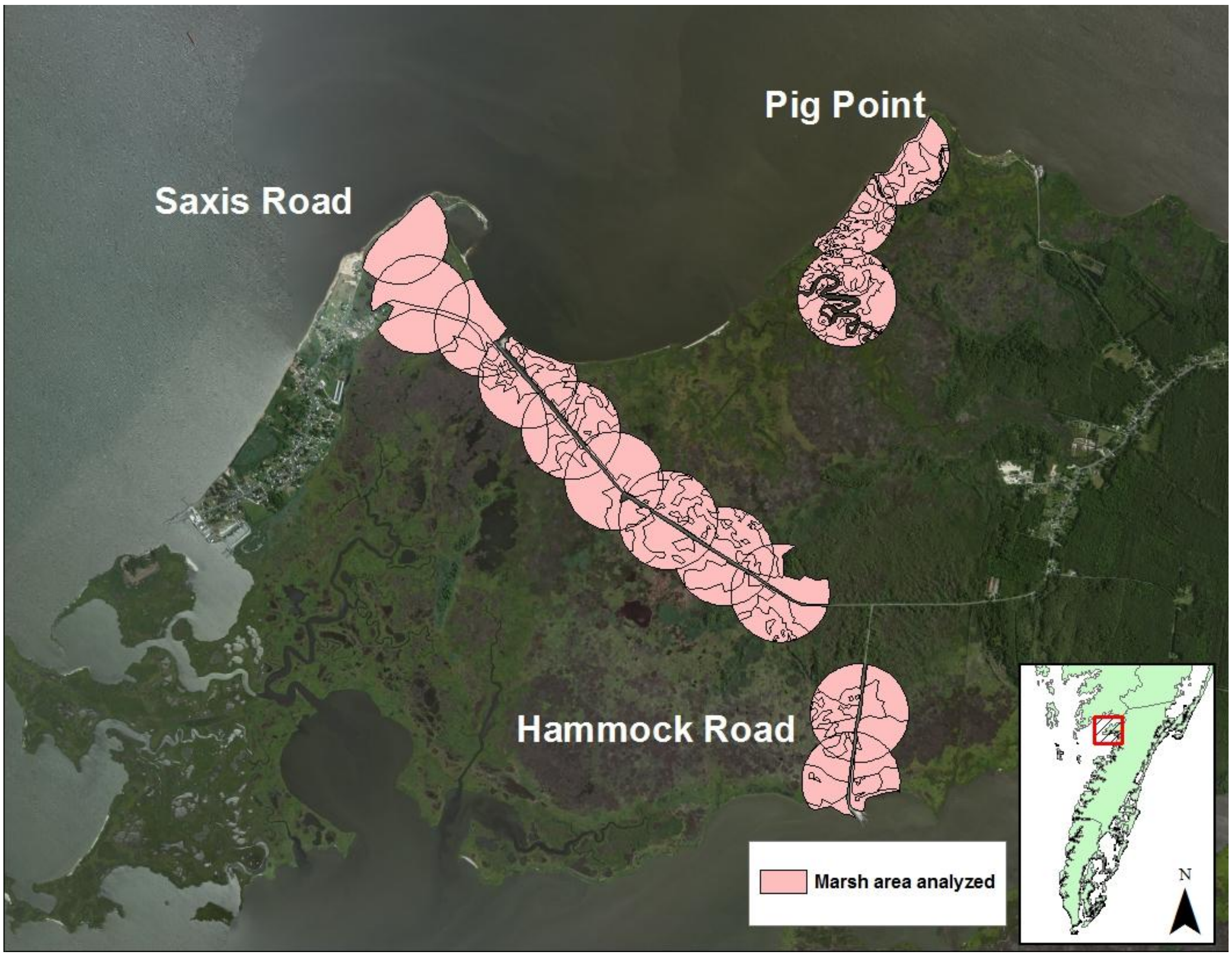
Freeschool Marsh – Saxis WMA

Pig Point - Black Rails were detected in the northeastern portion of Freeschool Marsh known generally as Pig Point (Figure 2) by S. Rottenborn in 1991 (unpublished data, Armistead 1991). In 2007, three points were surveyed in the area, but no birds were detected. A summary of vegetation change between 1994 and 2010 (Table 3) indicated positive changes in the percentage of low marsh and black needlerush at the expense of a substantial decrease in the percent cover of high marsh.

Table 3. Vegetation differences between 1994 and 2010 for Pig Point area of Freeschool Marsh.

	Hectares (% cover)	
Vegetation	1994	2010
Low Marsh	21.7 (40 %)	26.5 (53%)
Black Needlerush	11.0 (21%)	17.4 (35%)
High Marsh	18.8 (35%)	4.8 (9%)
Shrub	2.0 (3%)	1.4 (3%)

Figure 2. General locations of Pig Point, Saxis Road, and Hammock Landing marsh areas within Freeschool Marsh, Saxis Wildlife Management Area.



Saxis Road - Saxis Road (State Road 695) bisects Freeschool Marsh en route to the town of Saxis. The area south of this road and before the hummock tree line has been known to support Black Rails for decades. Don Schwab and others (unpublished data) have had high counts of >30 birds as recently as the late 1980s and early 1990s. In general, Black Rails occurred in areas perpendicular to the road starting from the upland edge and travelling west for approximately < 1km. During the 2007 survey, multiple sampling stations were placed along the road at 250 m intervals beginning at the upland edge. Birds were only detected at the first two stations and estimated to be 4 calling birds. This was the first systematic example of a dramatic decline in the number of calling birds at this marsh. Many anecdotal visits to this portion of Freeschool Marsh have agreed with the notion that the overall numbers of Black Rails have declined here. The vegetation was summarized within all survey points along Saxis Road to reveal relatively small but positive changes in the percentages of low marsh and black needlerush and an 11% loss of high marsh habitat between 1994 and 2010 (Table 4).

Table 4. Vegetation comparisons between 1994 and 2010 for the Saxis Road portion of Freeschool Marsh, Saxis Wildlife Management Area.

	Hectares (% cover)	
Vegetation	1994	2010
Low Marsh	47.5 (29 %)	56.7 (32 %)
Black Needlerush	47.7 (29 %)	63.5 (35 %)
High Marsh	63.4 (39%)	59.4 (28 %)
Shrub	3.9 (3 %)	7.5 (4 %)

Hammock Landing - Hammock Landing Road (State Road 788) is in the southeast zone of Freeschool Marsh (Figure 2). The road bisects a relatively large portion of high marsh interspersed with black needlerush. There are a few general records for Black Rails along each side of the road, but actual numbers that have been detected remain unknown. However, two birds were detected within 250m of this road and just south of the pine hummock during the 2007 survey. We summarized the vegetation within the two survey points that spans marsh cover on both sides of the road. Between 1994 and 2010 the vegetation appears relatively similar with small increases in the percentage of high marsh mostly at the expense of black needle rush (Table 5). There is a substantial shrub component within this area that occupies the zone of higher elevation between the marsh and the upland hummock. The percentage of shrub cover here remained relatively similar between these two time frames.

Table 5. Vegetation comparisons between 1994 and 2010 near the Hammock Landing Road in Freeschool Marsh

Vegetation	Hectares (% cover) 1994	2010
Low Marsh	4.7 (11 %)	3.5 (8 %)
Black Needlerush	12.7 (31 %)	17.4 (39 %)
High Marsh	16.1 (39 %)	14.1 (32 %)
Shrub	7.8 (19 %)	8.6 (20 %)

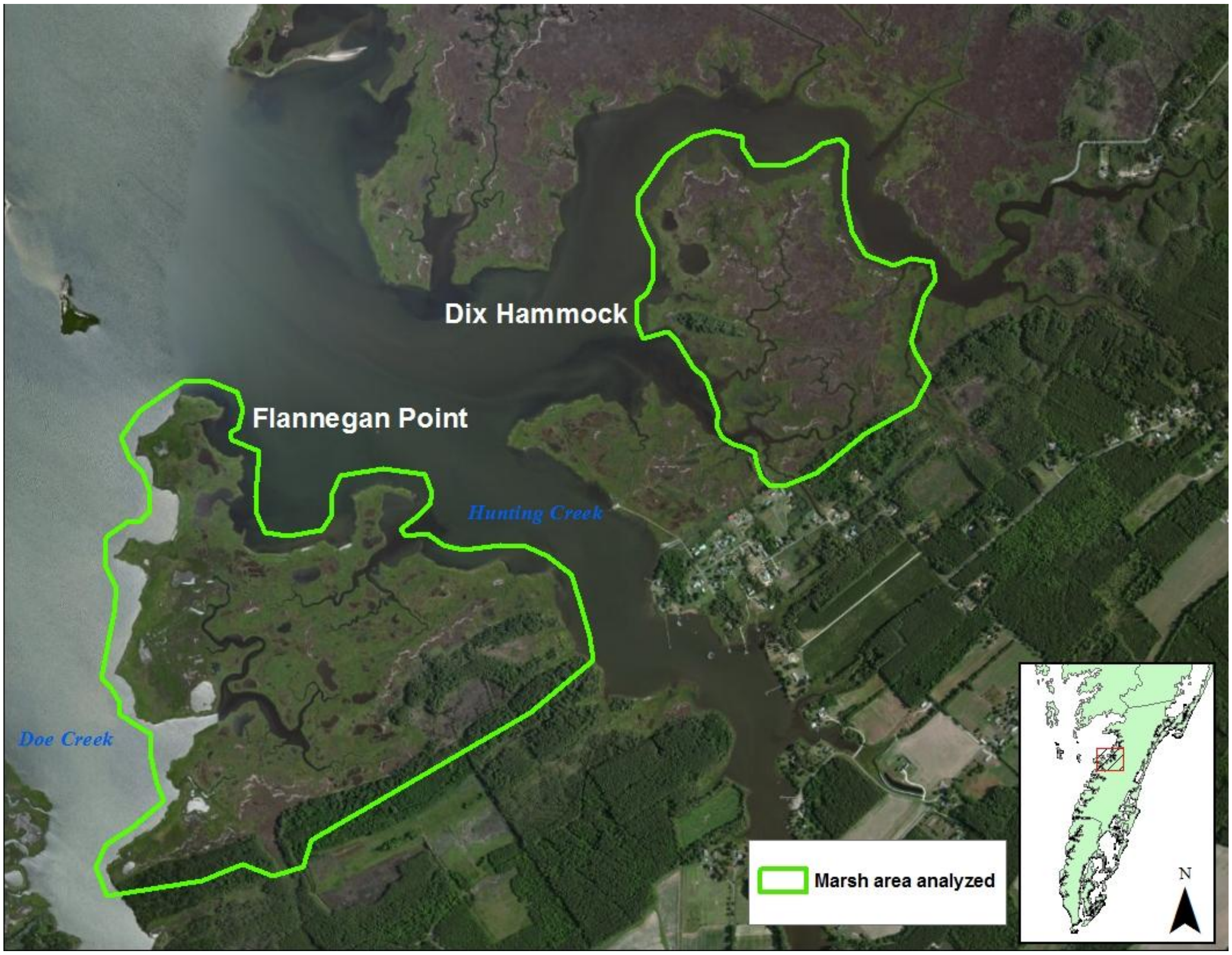
Flannegan Point

Flannegan Point and associated marsh is bordered by Hunting Creek to the northeast and Doe Creek to the southwest (Figure 3). Rottenborn (unpublished data, Armistead 1991) detected a Black Rail in this marsh in 1991, although its exact location is unknown. One survey point was placed on opposite sides of this marsh in 2007 where one Black Rail was detected. We summarized the marsh vegetation over this entire marsh because of the unknown whereabouts of the 1991 detection and the fact that the 2007 detection was >300m away from the sampling station. Overall, the marsh vegetation patterns remained relatively similar between 1994 and 2010 (Table 6 except for a notable loss of pine hammock

Table 6. Vegetation comparisons for Flannegan Point between 1994 and 2010.

Vegetation	Hectares (% cover) 1994	2010
Low Marsh	40.3 (34 %)	31.9 (29 %)
Black Needlerush	12.6 (11 %)	13.1 (12 %)
High Marsh	57.0 (48 %)	58.3 (53 %)
Shrub	1.6 (1 %)	3.0 (3 %)
Pine Hammock	7.8 (7 %)	3.5 (3 %)

Figure 3. Dix Hammock and Flannegan Point marshes. Vegetation composition was examined over the entire marsh surface.



Dix Hammock

Dix Hammock, the first marsh north of the Flannegan Point Marsh (Figure 3), is another location where Rottenborn detected Black Rails in 1991 (Armistead 1991) and no birds were detected during the 2007 survey. In 2007, one survey point was placed in the vicinity of this historical detection, and 3 others were added and accessed by boat. We summarized vegetation within all 2007 survey points within this marsh (Table 7). There was a substantial increase in the percentage of black needlerush between 1994 and 2010, accompanied by a loss of high marsh (-13%).

Table 7. Vegetation comparisons for Dix Hammock Marsh between 1994 and 2010.

	Hectares (% cover)	
Vegetation	1994	2010
Low Marsh	12.0 (27 %)	11.0 (28 %)
Black Needlerush	6.0 (13 %)	8.9 (23 %)
High Marsh	25.3 (57 %)	17.3 (44 %)
Shrub	1.3 (3%)	1.4 (3 %)

Discussion

The limiting factors that influence a species population can be broadly categorized as having an underlying habitat or demographic basis. The availability of suitable habitat is the most obvious factor that can limit a species distribution and abundance. Although there were differences in vegetation parameters between occupied and non-occupied points during the 2007 survey, the large variance among these data indicate that Black Rails are occupying a wide variety of conditions. This suggests that there may be a large quantity of marsh available for this species with many suitable areas remaining unoccupied. Therefore, it is difficult to suggest that the low occupation rate of marsh patches and the disappearance of individuals from historic strongholds are based on habitat changes alone. The low number of Black Rails breeding in Virginia and lack of regular systematic survey effort also prevents us from understanding which factors are driving population declines. However, despite the fact that the results are largely qualitative, there does seem to be a consistent pattern which suggests that locations where Black Rails have disappeared since the 1990s are the same places that have undergone the most relevant changes in habitat composition. The best possible examples of habitat-mediated population losses are found at Pig Point and Dix Hammock. Both of these marshes have experienced the greatest turnover of high marsh to low marsh. The transformation of high marsh to low marsh may have several hydrologic explanations, but is most indicative of areas receiving greater tidal inundation (i.e., longer hydro-periods). The replacement of high marsh with low marsh is the type of perturbation that would be expected to cause a negative response by Black Rails based on their habitat needs. Black Rails use high marshes for both foraging and nesting but their specific requirements within this marsh category remains unknown.

The transformation of high marsh to low marsh in areas we studied is indicative of a system-wide change occurring across the Chesapeake Bay. Because of their low position on the landscape, saltmarshes are one of the first habitats to be lost or altered by rising seas. The Chesapeake Bay is currently experiencing the most accelerated level of sea-level rise in the world (Douglas 1991, Zervas 2001). This unusually high rate results from a combination of both eustatic changes found globally and a unique down-warping of the Bay's crust. Taken together, sea-level rise and subsidence are expected to produce a massive state change in the Bay's wetland habitats. The most pronounced change expected in the Bay over the next 100 years is a transformation of an estuary currently dominated by high marsh into an estuary dominated by low marsh (Glick et al. 2008). In a separate study, we examined the expected loss of Black Rail habitat from sea-level rise by examining the pattern of marsh loss and transformation over time (Wilson and Watts 2013, in review). Results of that comparison forecasted that 95% or more of the high marsh patches suitable for Black Rails in the Chesapeake Bay will be lost or transformed to low marsh over the next 100 years. This forecast places the Black Rail in jeopardy of entirely disappearing from the Bay, an outcome that may be inescapable without management intervention.

In general, landscapes supporting seemingly suitable habitat that are not filled to capacity by individuals may be an indication of underlying demographic problems. This notion suggests that the low percentage of occupied marshes by Black Rails in the Chesapeake Bay may also be a result of poor demographic rates such as low breeding productivity or adult survival. Rising sea levels not only reduce the amount of habitat for Black Rails, but also lower the demographic value of existing patches as well. An increase of tidal flooding above historic tide lines can inundate areas used for nesting and drown eggs. Black Rails likely have evolved behaviors that have shaped their current timing and placement of nests above high tide lines within high marshes. The amount and duration of flooding across the marsh surface has continued to increase and is expected to accelerate as water continues to rise relative to the land. Episodic flooding of high marshes at heights greater than historic values is not likely to produce noticeable changes in marsh composition over the short-term, but its effect on Black Rail breeding should be assessed. The possibility of the "silent killing" of Black Rail populations by an increase of tidal flooding suggests that populations will continue to decline faster than we would expect due to habitat loss alone.

Another factor that can limit Black Rail demographic rates is nest predation. Black Rails occupy drier marsh habitats that are adjacent to uplands from where predators emanate. In a separate study, we attempted to determine the constraints on birds nesting in high marshes by examining predation rates on artificial nests (Wilson et al. 2014). Results of this study revealed that nest predators have the potential to lower nest survival rates to less than 7% for species with long incubation periods such as Black Rails.

Population declines of Black Rails are widely believed to be consequences of habitat change and degradation. In this case, habitat degradation may not only include physical changes in habitat availability, but also suitability. Suitable habitats may experience frequent tidal inundation and/or support large numbers of nest predators. Overall, the low number of breeding rails in the Chesapeake Bay and extirpation of the species from the seaside of the Delmarva Peninsula indicates that Virginia's natural marshes are no longer able to support a viable breeding population. Therefore, focusing management actions on existing habitats may have a low probability of success. It is unreasonable to expect that the loss of high marsh habitats from sea-level rise will end in time to recover the species in Virginia. Furthermore, nest predators may be distributed too widely and exist in numbers too high to manage effectively. One potential management action that may benefit Black Rails is to create habitats that are not influenced by sea-level rise and are free of nest predators. Artificial habitats such as managed impoundments offer the best opportunity to fit these demands. Impoundments could be placed inland to avoid rising seas and could be fenced to exclude ground predators Avian nest predators could remain as a threat with this design. A broad strategy and site-specific recommendations for managing impoundments to benefit Black Rails still need to be developed. Basic requirements include dense grasses that offer adequate cover and very low water levels (i.e, several centimeters in depth).

This would require specific flooding and draw down regimes timed specifically to produce optimal conditions for Black Rails.

Acknowledgements

This publication was completed with funds provided by the Virginia Department of Game and Inland Fisheries through a Federal Aid in Wildlife Restoration grant from the U.S. Fish and Wildlife Service. We thank Ruth Boettcher from DGIF for administrative oversight throughout the length of the project. We also thank Erica Lawler, Jane Lopez, and Michael Cole from the William and Mary Sponsored Programs office for fiscal and administrative assistance.

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