Status Review of Chesapeake Bay Marsh Lands and Breeding Marsh Birds

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Abstract.—Emergent tidal marshes are a dominant feature of the Chesapeake Bay's estuarine environment and account for an approximate 123,100 ha of the 185,870 ha (66%) of classified wetlands. Tidal marshes vary in salinity, structure, and plant composition according to their geographic position in the Bay. Chesapeake Bay marshes support breeding bird populations that are of regional or national conservation significance. Marsh bird communities vary with marsh type, geographic position, salinity, patch size, and landscape context. Marsh loss has been significant over the past two hundred years primarily as a result of urban, industrial, and agricultural development. Protective legislation enacted in the 1970s has slowed the rate of loss but marshes continue to be degraded and population of marsh birds continue to decline from the invasion of exotic species, ground predators, poor management practices, encroachment by development, and sea-level rise. Despite these concerns, there is still relatively little information on the population trends of most marsh birds or on the distribution of some of the Bay's highest species of concern such as Black Rails (*Laterallus jamaicensis*), King Rails (*Rallus elegans*), Saltmarsh Sharp-tailed Sparrows (*Ammospiza caudacuta*), and Henslow's Sparrows (*Ammodramus henslowii*). Marshes along the bay's fringe, tributaries, and islands that currently support species at risk of extinction in the Bay are in immediate need of identification and protection. High marshes on the Delmarva peninsula, support greatest concentrations of species at risk and are marshes among the most at risk of loss and degradation. Management to reduce or abate threats to marsh birds is critical to their long term survival.

Key words.—Chesapeake Bay, marsh birds, wetlands, salt marsh, brackish marsh, freshwater marsh, population estimate, habitat requirements, sea-level rise.

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The Chesapeake Bay is the largest estuary in the United States and one of the most biologically productive ecosystems in the world. A prominent feature of the estuary is the extensive complex of emergent tidal marshes that cover 123,100 ha of the total 185,870 ha of tidal wetland area (Field *et al.* 1991). Tidal marshes are indispensable to the overall health of the Chesapeake Bay. They provide a substantial amount of trophic production, regulate nutrient cycles, and enhance water quality by filtering pollutants. These ecological services have obvious biological (e.g., diversity), social (e.g., human health), and economical (e.g., seafood fisheries, recreation) consequences. A significant number of marshes have been lost or degraded over the last 200 years as a result of urban, industrial, and agricultural development. The Chesapeake Bay region is experiencing one of the fastest growing human populations in the nation forecasting continued degradation of marsh habitats into the future (Ernst 2003). Some portions of Chesapeake Bay are also undergoing elevations in sea-level at twice the global rate that is predicted to consume vast quantities of marsh habitat (Kearney *et al.* 2002) Information on the status and distribution of the Bay's living resources, including tidal marshes, are critical in plotting a course for future conservation and management.

Chesapeake Bay tidal marshes provide essential habitat for a diverse assemblage of avian species during breeding, winter, and migration seasons. This includes numerous species of waterfowl, waterbirds, shorebirds, and landbirds that breed here or emanate from different geographic locations. Among these are a specific set of avian taxa that are entirely restricted to marshes throughout the annual cycle (hereafter "marsh birds"). Marsh bird communities are comprised of species or morphologically distinct forms that rely exclusively on marsh vegetation or the underlying substrate of marsh habitats. Obviously, the ecological role that marshes play on the population status and distribution of marsh birds is greatly enhanced compared to other species because of their habitat specificity. Because the Chesapeake Bay contains an outstanding breadth of marsh habitats, their overall condition can modify marsh bird population levels throughout the Atlantic coastal region. The Chesapeake Bay harbors approximately 41% of all tidal marshes along the United States' Atlantic coast (Field *et al.* 1991) and therefore may support a commensurate proportion of the breeding population. Additionally, the geographic position of these marshes along the Atlantic Flyway migration corridor, and within the winter ranges of marsh bird populations that breed at more northern latitudes, suggests that the condition of Chesapeake Bay marshes have far-reaching geographic consequences on population levels.

Despite the relative importance of the Chesapeake Bay for marsh bird communities, information on population research and monitoring has lagged behind other species groups. This is partly due to the difficulty in surveying marsh birds and accessing habitats where they breed. As an indication of the problem, a large number of species are referred to as "secretive marsh birds" because of their infrequent detection and use of inaccessible areas. One of the gaps in information is an assessment of marsh bird population status. This information is needed to prioritize conservation needs and formulate management recommendations. In this paper, we describe the distribution, diversity, and ecological modifiers of Chesapeake Bay marshes and their marsh bird communities. We also provide a population-level assessment for selected species. We restrict our focus throughout to those species that are restricted to breeding in marsh habitats of the Chesapeake Bay.

CHESAPEAKE BAY MARSH SYSTEMS

Emergent tidal marshes are found throughout the intertidal zone and form a boundary between the terrestrial and open water systems. Tidal marshes are typically formed along low to medium energy shorelines where sediment deposits can provide substrate for the colonization of hydrophytic vegetation (Cowardin *et al.* 1979). The Delmarva peninsula protects nearly all of the Chesapeake Bay shoreline from high oceanic wave energy and is one reason for the relatively large number of marshes in this region.

Marsh elevation and hydrology are the outcome of a long history of sediment deposition, water-levels, and biological interactions. Marshes can only increase in elevation where the vertical accretion of sediments on their surface is greater than the rate of sediments lost from erosion (Stevenson *et al.* 1988; Nebauer *et al.* 2002). Deposition onto the marsh surface occurs when sediments are transported during marsh flooding or by the accumulation of autochtonous plant material. Marshes that are frequently inundated accumulate most of their sediment from tidal flooding, river flooding after heavy rainfall, or terrestrial runoff when near upland borders. Suspended silt and clay are able to drop from the water column when flood waters span across land and decrease in velocity. This generally results in greater deposition rates away from the water channel. Sediment deposition can be facilitated further when trapped by emergent plants. Marshes that are infrequently inundated receive a large bulk of deposition from *in-situ* sediment production. Over time, marshes begin to form elevated terraces sloping upwards from the water edge and towards the terrestrial border. As marshes become elevated, plant species less tolerant of inundation begin to colonize. The final outcome of this process is the development of two distinct elevational wetland plant zones, low and high marsh, that are distinguished by the frequency and duration of tidal flooding (Cowardin *et al.* 1979).

Tidal marshes also vary in salinity, structure, and plant composition according to their geographic position in the Chesapeake Bay. Although these conditions occur as a continuum, marshes can be broadly classified into three categories based on their underlying salinity; salt marsh, brackish marsh, and freshwater/oligohaline marsh (see Fig. 1). Salt marsh occurs along lower portions of the Chesapeake Bay's polyhaline shoreline. These marshes ultimately give way to brack-

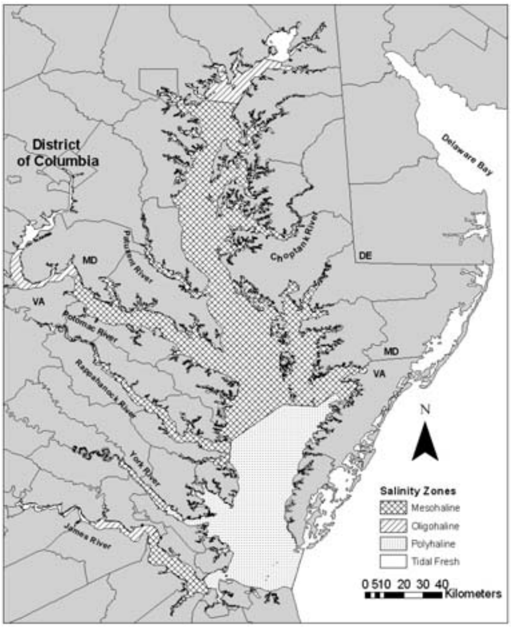

Figure 1. Map of Chesapeake Bay and salinity zones. Salinity zones based on Chesapeake Bay Program Analytical Segmentation Scheme (Data Analysis Work Group 1997).

ish and fresh water marshes in the lower salinity waters of the upper Chesapeake Bay and its tributaries.

Although tidal marshes produce large amounts of biomass, they are simple in structure and a harsh environment for organisms to colonize. Salinity is the principal factor that governs plant and animal distributions in tidal marsh systems. There are very few plant species that can tolerate high salinities. As a result, plant and animal diversity in salt marshes are generally low in diversity compared to brackish and fresh water marshes.

Salt Marsh

Salt marsh is the most abundant type in the lower Chesapeake Bay and covers approximately 7,163 ha (Stevenson *et al.* 2000). It is distributed along the immediate shoreline of the lower Chesapeake Bay and on the Chesapeake Bay Islands (both areas south of 36°30'N) (Fig. 1). Salt marshes are characterized by the presence of plant communities tolerant of salinity values of 18-30 ppt. Plant communities within salt marshes are distributed into two distinct elevation zones (low marsh and high marsh) based on tidal flood frequency and duration. The low marsh is inundated daily by normal high tides and dominated by the short form of Saltmarsh Cordgrass (*Spartinia alterniflora*) (ten cm height) and Black Needlerush (*Juncus roemerianus*). Tall forms of Saltmarsh Cordgrass (one to two m height) grow along tidal creeks and where the marsh is actively accumulating sediments. The high marsh is flooded infrequently by high spring tides and storms that create a boundary between the terrestrial shoreline and the low marsh zone. The high marsh may also be found as elevated hummocks in interior portions of larger marshes. High marsh is dominated by Salt Meadow Hay (*Spartina patens*), Olney's Three-square (*Scirpus americanus*) and Salt Grass (*Distichlis spicata*), or Glasswort (*Salicornia* spp.), often interspersed with shrub species such as Marsh Elder (*Iva frutescens*) or Saltbush (*Baccharis halmifolia*). Most of the high marsh zone can be characterized as a grass-like savannah but can also contain sparsely vegetated areas on hypersaline depressions known as salt pannes. The low marsh is relatively more abundant and widespread throughout the Chesapeake Bay. By comparison, significantly sized patches of high marsh (>50 ha) are uncommon but found in large concentrations on the lower western shore of the Chesapeake Bay and within the middle reaches of the eastern shore (i.e., bayside of Delmarva peninsula) from Dorchester County, Maryland through Accomac County, Virginia.

Brackish Marsh

Brackish marsh occurs primarily within the mesohaline zone of tidal tributaries where salinity ranges from 5.0 to 18.0 ppt. Stevenson *et al.* (2000) estimates that brackish marshes cover approximately 43,953 ha. This generally occurs throughout the upper portions of the Chesapeake Bay (Maryland) and lower portions of tributaries in Virginia. Vegetation within brackish marshes is often more diverse than salt marshes and dominated by dense stands of Giant or Tall Cordgrass

(*S. cynosuroides*) with Salt Meadow Hay, Olney's Three-square, and Salt Grass in the high marsh zone and a narrow fringe of Saltmarsh Cordgrass in the lower marsh zone. Black Needlerush is also a common associate of the low marsh. In many situations, the lower marsh fringe is eroded away leaving an overhanging shelf of peat and remaining Tall Cordgrass. This configuration is common along shorelines of tributaries and tidal creeks.

Oligohaline and Tidal Fresh Marshes

Oligohaline and freshwater marshes are distributed along shorelines of the most upper reaches of the Bay's tributaries where salinity is 0.5 to 5.0 ppt and below 0.5 ppt respectively. Freshwater and oligohaline marshes cover approximately 26, 245 ha (Stevenson *et al.* 2000). On average, patch sizes are much smaller than salt marsh and brackish marsh counterparts. Oligohaline marshes are dominated by Tall Cordgrass but also are associated with plants characteristic of both brackish and freshwater marshes. Arrow-arum (*Peltandra virginica*) is a dominant plant of the lower marsh zone as is species more tolerant of higher salinities and flooding, such as Marsh Hibiscus (*Hibiscus* spp.) and Marsh Mallow (*Kosteletzkya virginica*). High marsh zones may be comprised of salt meadow hay and salt grass and are often interspersed with saltbush or marsh-elder particularly near the upland shoreline. Some oligohaline marshes contain dense colonies of Shoreline Sedge (*Carex hyalinolepis*) or Narrow-leaved Cattail (*Typha angustifolia*) (Odum *et al.* 1984).

Freshwater marshes support the highest diversity of plant species in the Chesapeake Bay marsh system (Odum *et al.* 1984). One simple character of these marshes is a dominance of broad-leaved plants such as Arrow-arum and Pickerelweed (*Pontederia cordata*). Other common plants Wild Rice (*Ziania aquatica*), Southern Wild Rice (*Zizaniopsis miliacea*), Rice Cutgrass (*Leersia oryzoides*), various sedges (*Carex* spp.) rushes (*Juncus* spp.) and cattails (*Typa* spp.). Spadderdock (*Nuphar advenum*) and Yellow Pond Lily (*N. luteum*) can form extensive mats in areas that are inundated for long periods.

Marsh Status and Trends

A significant number of marshes in the Chesapeake Bay have been lost over the past two hundred years primarily as a result of urban, industrial, and agricultural development. The Chesapeake Bay was the earliest site of European colonization and has endured over three centuries of human disturbance. Over this time period, the Chesapeake Bay is estimated to have lost 50% of its wetland cover (Dahl 1990). Marshes were historically viewed as wastelands and rapidly converted to other uses. Most Atlantic coastal marshes were also regularly drained as a means of mosquito control. Protective legislation enacted in the 1970s has slowed the rate but losses continue. During the period from the mid-1950s through the early 1980s, approximately 9% of the Chesapeake Bay's salt marshes were lost to dredging, impoundment, and filling (Dahl 1990). This represents a loss rate of nearly 203 ha per year. During the 1980s an estimated 0.5% of estuarine wetlands in the Chesapeake Bay were still being lost annually (Dahl 1990).

While most of the historic loss in marsh area can be attributed to direct anthropogenic conversion, contemporary losses have other explanations. The combination of sea-level rise and terrestrial land use practices are emerging as the predominant causes of present day marsh loss. The Chesapeake Bay is undergoing a rise in sea-level at twice the global rate (Kearney 1996). Rapid changes in water levels disrupt the balance between marsh deposition and elevational growth. Marshes unable to accrete sediments at the pace of sea-level rise risk becoming submerged. Tiner (1987) reported that 60% of the present day loss of coastal wetlands in the Chesapeake Bay was a result of sea-level rise. Much of the low lying Chesapeake Bay shoreline is considered extremely vulnerable to changes in sea level (Titus and Richman 2001) and at least 50% of the entire Chesapeake Bay marsh surface has been degraded (Kearney *et al.* 2002). Some of the most ecologically important marshes have not kept pace with sea-level rise for over a century (Kearney and Stevenson 1991). For example, the extensive complex of marshes Dorchester County, Maryland has been recognized as the most affected by sea-level rise in the Bay (Kearney and Stevenson 1991; Kearney *et al.* 2002); it also has the most marsh area vulnerable to future losses (Titus and Richman 2001). In addition, high marshes throughout the Bay's margins and its islands are exceptionally vulnerable. Sediments needed to elevate the high marsh require considerably more time to accrete than the low marsh. As water levels continue to rise, the most vulnerable high marshes will be quickly submerged and converted to low marsh. Likewise, the Chesapeake Bay islands have taken hundreds of years to form and rely on much longer deposition rates compared to marshes that fringe the upland. Their relative isolation from the mainland and from the mouth of rivers are two reasons they have difficulty in receiving enough sediment for deposition. Some of these islands are losing three meters of shoreline each year to rising waters.

There is also considerable spatial variation in the amount of marsh submergence suggesting that factors in addition to sea-level rise are responsible for current loss rates. Some marshes have become quickly submerged others have only shown minor signs of submergence (Kearney *et al.* 1988, 2002). In general, salt marshes appear to be more susceptible than freshwater marshes (Kearney and Stevenson 1991; Neubaer *et al.* 2002). Several investigations have concluded that based on historical accretion rates, most marshes should be capable of keeping pace with observed changes in sea-level (Kearney and Stevenson 1991; Neubauer *et al.* 2002). This implies an imbalance in the delivery and supply of sediments for deposition. There are a number of anthropogenic disturbances that likely contribute to this imbalance. Dredging of shipping canals has altered tidal flows, disrupted regular sediment delivery, and has increased the water's erosion energy. Additionally, urbanization of the Chesapeake Bay watershed has converted large amounts of land to impermeable surfaces. This has curbed the amount of available sediments from upland sources and in effect has starved marshes of materials for accretion. Loss of marsh area has also been attributed to subsidence. Most cases of marsh subsidence are due to large withdrawals of groundwater, oil, and natural gas from directly under marshes that has emptied these reservoirs causing compaction of marsh and underlying soils (Kennish 2001).

As sea levels rise, one way marshes can keep pace with rising waters is by progressively moving landward, a process known as transgression. There are a number of locations in the Chesapeake Bay where marshes have essentially "claimed" adjoining upland areas. Although this appears as a viable resolution to the problem of sea-level rise and marsh loss, urbanization and erosion control along the shoreline restrict this landward migration and eventually squeeze marshes out of existence. The hardening of shorelines with bulkheads, rip-rap, and revetments are becoming more common in the Chesapeake Bay (Hardaway and Byrne 1999). Between 1978 and 1997 nearly 500 km of Maryland's bay shoreline became armored with erosion control structures (Titus 1998). In Virginia, nearly 400 km of shoreline (4.3%) was newly armored between 1993 to 2004 (Hardaway and Byrne 1999). In addition to the squeezing effect, these structures disrupt longshore sediment delivery and increase wave energy and erosion of adjacent shoreline areas.

Another source of marsh degradation is the rapid and widespread invasion by exotic species. One of the most recognized and pervasive exotic species in the Chesapeake Bay is *Phragmites australis* (Marks *et al.* 1994; Rice *et al.* 2000). *Phragmites* is a noxious, fast growing plant that can quickly dominate marshes after invasion by usurping native marsh plants for space and nutrients. *Phragmites* invasion is commonly associated within disturbed marshes, dredge material areas, or artificially constructed wetlands. It aggressively colonizes the ecotone between the high marsh and terrestrial shoreline. However, because marshes are intrinsically disturbance-prone habitats, *Phragmites* has been successful in invading nearly all areas of the Chesapeake Bay. By the late 1990s, *Phragmites* was estimated to have invaded 4,000 ha of marsh area in the Chesapeake Bay (D. Forsell and Gerlich, U.S. Fish & Wildlife Service Chesapeake Bay Field Office, unpubl. data).

The negative impacts of invasive exotic species are not limited to plants. One exotic animal that can severely degrade marshes is the Nutria (*Myocastor coypus*). This semi-aquatic rodent was intentionally introduced to Maryland in 1950 to augment the fur industry. Collapse of the fur trade and subsequent release and escape of farm raised nutrias has resulted in a critical problem for some areas. Nutria forage directly on the roots of marsh vegetation, loosening the soil and accelerating erosion (Willner *et al.* 1979). In areas of high Nutria density, foraging destruction can transform marshes into mudflats in short periods of time. For example, in Dorchester County, Maryland nutria populations have grown to an estimated 50,000 animals (Haramis and Colona 1999). Observations from the Blackwater National Wildlife Refuge (NWR) within this region has indicated that nutria were impacting 100-400 ha of marsh per year. Dedicated eradication programs on the Blackwater NWR have proved successful but these may difficult to implement over larger spatial and time scales.

CHESAPEAKE BAY MARSH BIRD COMMUNITIES

Breeding bird communities of tidal marshes are generally less diverse than those in forest and shrublands. This is partly due to the fact that marsh habitats are relatively lower in complexity, contain less vertical structure, and are generally two-dimensional environments, resembling grasslands. However, in the Chesapeake Bay region, marsh bird communities are more diverse compared to this grassland counterpart. One reason for this pattern is the relatively greater horizontal heterogeneity associated with marsh habitats. There are a number of intrinsic components of marshes that greatly influence marsh bird distribution and community structure. Most of these components are related to changes in vegetation that co-occur with gradients of hydrology, salinity, and topography. Marsh bird communities can be generally categorized into three groups based on salinity; 1) salt marsh, 2) brackish marsh, and 3) freshwater/oligohaline marsh (Table 1). Similarly, marsh birds are segre-

Table 1. Salinity and elevational associations of marsh birds in the Chesapeake Bay. Abbreviations for salinity are; s = salt marsh, br = brackish marsh, and fr = freshwater/oligohaline marsh. Abbreviations for elevation are; h = high marsh and l = low marsh. Species with more than one association have abbreviations listed in rank order of affinity.

Species	Scientific name	Salinity association	Elevational association
Pied-billed Grebe	*Podilymbus podiceps*	br, fr	l
American Black Duck	*Anas rubripes*	s, br, fr	h
American Bittern	*Botaurus lentiginosus*	fr	l
Least Bittern	*Ixobrychus exilis*	fr, br	l
Common Moorhen	*Gallinula chlorpus*	fr	l
Virginia Rail	*Rallus limicola*	fr, br, s	l, h
Clapper Rail	*Rallus longirostris*	s, br	l, h
King Rail	*Rallus elegans*	fr, br	l
Sora	*Porzana carolina*	fr, br	l
Black Rail	*Laterallus jamaicensis*	s, br	h
Willet	*Catoptrophorus semipalmatus*	s, br	h, l
Northern Harrier	*Cirus cyaneus*	s, br	h
Sedge Wren	*Cistothorus platensis*	s, br	h
Marsh Wren	*Cistothorus palustris*	fr, br, s	l
Henslow's Sparrow	*Ammodramus henslowii*	s, br	h
Coastal Plain Swamp Sparrow	*Melospiza georiana nigrescens*	fr	h
Saltmarsh Sharp-tailed Sparrow	*Ammospiza caudacuta*	s, br	h
Seaside Sparrow	*Ammospiza maritime*	s, br	l, h

gated into two groups between low and high marsh. Marsh species also respond, based on their individual requirements, to the conditions of other physical components such as wet sloughs, mudflats, tidal creeks, floristic composition, and the upland habitat matrix.

Marsh bird communities are also organized by marsh size. In general, marsh bird diversity is positively related to marsh area (Brown and Dinsmore 1986; Craig and Beal 1992; Watts 1992, 1993; Benoit and Askins 2002). The strength of this relationship varies between species according to their individual area requirements. However, groups of species that share similar area requirements are systematically lost in a nested fashion with reductions in marsh size (Watts 1992). Large marshes (>50 ha) are able support the entire regional suite of breeding salt marsh species. However, marshes from one to five ha may only support 50% of the breeding species. Marshes <1 ha in size are not able to support any salt marsh bird species (Watts 1992).

The reasons for area-sensitive patterns of marsh birds are unknown. However, research on grassland birds and forest birds indicate has suggested that area requirements may be mediated by population levels (Rosenberg *et al.* 1999; Johnson and Igl 2001; Bourque and Desrochers 2006). In the Chesapeake Bay, marsh species with relatively small regional populations appear to have much larger area requirements than species with relatively larger regional populations (Watts 1992). Even so, even relatively common and abundant species have minimum area requirements much larger than an individual's territory. This is particularly true for passerine marsh birds (Watts 1992; Benoit and Askins 2002). For example, the territory sizes of Seaside Sparrows (*Ammodramus maritimus*) range from 0.12 to 0.4 ha (Post and Greenlaw 1994, 1975; Marshall and Reinert 1990). However, in the Chesapeake Bay, Seaside Sparrows are rarely present in marshes smaller than five ha (Watts 1992). Bourque and Desrochers (2006) have shown that populations of some forest birds aggregate their territories in a few patches while other nearby patches of adequate size and similar structure that do not contain conspecifics are not colonized. This implies that individuals have the tendency to establish territories near other conspecifics. It further implies that area-sensitive patterns on a local scale are not mediated by habitat availability. Most importantly, for marsh birds, area-requirements indicate that marsh area is an overwhelmingly important factor to consider for marsh bird conservation and management.

Salt Marsh Breeding Bird Communities

The salt marsh breeding community is distinguished by a set of species that are restricted to the high marsh and a set of species that can utilizes both low and high marsh (Table 1). High marsh species of salt marshes include the American Black Duck (*Anas rubripes*), Willet (*Catoptrophorus semipalmatus*), Black Rail (*Laterallus jamaicensis*), Sedge Wren (*Cistothorus platensi*), Saltmarsh Sharp-tailed Sparrow (*Ammospiza caudacuta*), and Henslow's Sparrow (*Ammodramus henslowii*). In the Bay, Clapper Rails (*Rallus longirostris*), Virginia Rails (*Rallus limicola*) and Seaside Sparrows utilize both marsh zones but reach their highest density in the low marsh (Watts 1992). Most of these species nest on or near the ground so they require areas for nest placement above the high tide line for to avoid submergence. The Marsh Wren (*Cistothorus palustris*) is restricted entirely to the low marsh. This is because Marsh Wrens nest in taller vegetation, typically 1.0-1.5 m or above the marsh substrate (Kale 1965; Verner 1965), therefore are limited to tall stands of Saltmarsh Cordgrass that only form in the low marsh zone.

The Northern Harrier (*Cirus cyaneus*) utilizes both low and high marshes for foraging. Although Northern Harriers also use grasslands throughout most of their geographic range, we classified this species as a marsh bird in this paper because they breed almost exclusively in marshes within the Chesapeake Bay region. Likewise, Sedge Wrens use a variety of grassland types but are only known to breed in marshes when in this region. Finally, the Henslow's Sparrow breeds in grasslands, clear-cuts, and marshes. However, breeding populations in Chesapeake Bay marshes are considered a distinct eastern subspecies, *A. h. susurrans*, that were restricted to marshes and previously isolated from the upland breeding western subspecies, *A. h. henslowii* until that form expanded its range eastward into the mid-Atlantic in the 1800s.

The distribution of some high marsh species are restricted by their specifically large area requirements and high marsh availability. Black Rails, Sedge Wrens, Saltmarsh Sharp-tailed Sparrows, and Henslow's Sparrows are generally limited to marshes greater than 50 ha (Weske 1969; Brinker and Therres 1992; Watts 1992; Benoit and Askins 2002). Only the largest concentrations of marshes in the Bay support high marsh patches of appropriate area (Watts 1999). Moreover, each of these species requires slightly different vegetation requirements. Black Rails require dense stands of Salt Meadow Hay and Saltgrass interspersed with Black Needlerush (Weske 1969; Brinker and Therres 1992). Shallow water ponds and wet areas are also considered important for foraging needs (Brinker and Therres 1992). Despite their relatively large population-level area requirements, individual territories are considered to be <4 ha (Davidson 1992). Saltmarsh Sharp-tailed Sparrows require extensive stands of salt-meadow hay near shrubby edges (Watts 1992). They are often found in elevated hummocks of large marshes. Sedge Wrens and Henslow's Sparrows nest in the marsh-upland ecotone and specifically require dense shrubs. The area requirements of Willets are much less restrictive and regularly found in marshes >4 ha (Watts 1993). Willets require high marshes for nesting that are also in close proximity to open foraging areas such as tidepools, salt pannes, and tidal creeks (Douglas 1996). Likewise, the American Black Duck uses high marsh for nesting but requires open water for foraging (Longcore *et al.* 2000).

Most species that use the low marsh have relatively smaller area requirements (Watts 1992, 1993). Watts (1992, 1993) reported that Clapper rails and Virginia Rails reached a 50% incidence rate in marshes of one ha and five ha, respectively. Watts also reported that Seaside sparrows and Marsh Wrens reach 50% incidence in marshes three to four ha and four to five ha, respectively. Clapper rails and Virginia rails require shallow, open water for foraging so they typically nest within close proximity of a shoreline (Eddleman and Conway 1998). Both of these species use areas with extremely high stem density or large amounts of residual vegetation (Conway 1995; Johnson and Dinsmore 1995). Virginia rails and Marsh Wrens are widespread throughout the Chesapeake Bay marsh system (Robbins and Blom 1996; Trollinger and Reay 2001; Brinker *et al.* 2002) and generally more abundant in brackish and freshwater marshes. Seaside Sparrows are able to use the high and low marsh more extensively than any other marsh species. They also breed in extremely high densities, thus taken together; they are probably the most abundant marsh bird species in the Chesapeake Bay.

Brackish Marsh Breeding Bird Communities

Brackish marsh communities represent a transition between breeding bird communities of salt marshes and freshwater/oligohaline marshes. This assemblage contains many of the same species that breed in salt marshes and a number of species that breed in freshwater/oligohaline marshes (Table 1). Distribution of individual species in brackish marshes reflects the differential tolerance to salt and associated halophytic vegetation. The exact combination of species that co-occur in any one marsh depends on marsh size, geographic location, salinity, and available vegetative components.

Most of the species that depend on high marsh within the brackish zone are limited to the mainstem of the upper Chesapeake Bay. This reflects the distribution of significantly large high marsh patches as restricted to this area. The Willet, Black Rail, Northern Harrier, Saltmarsh Sharp-tailed Sparrow, and Sedge Wren rarely occupy brackish marshes in Virginia. However these species use brackish marshes of the mainstem of the Bay in Maryland and a few tributaries.

Dominance of Tall Cordgrass in brackish marshes provides greater vertical structure and more homogeneous horizontal cover compared to salt marshes. Species that respond positively to these changes and a reduction in salinity include the Least Bittern (*Ixobrychus exilis*), Virginia Rail, King Rail (*Rallus elegans*), Common Moorhen (*Gallinula chlorpus*), and Marsh Wren (Stewart and Robbins 1958; Johnson and Dinsmore 1985; Frederick *et al.* 1990; Kroodsma and Verner 1997). Seaside Sparrows and Clapper Rails begin to decline in abundance and incidence within brackish marshes. Both of these species are found infrequently in marshes dominated by Tall Cordgrass.

Populations of Clapper Rails and King Rails often overlap and hybridize within brackish marshes (Meanley and Weatherbee 1962). Hybrids of the two species can show a wide range of plumage conditions mediated by the appearance of the two species. The overall frequency of occurrence and exact distribution of hybrids in the Bay are unknown.

Freshwater/Oligohaline Marsh Breeding Bird Communities

The freshwater/oligohaline marsh bird community in the Chesapeake Bay is characterized primarily by species such as the Pied-billed Grebe (*Podilymbus podiceps*), American Black Duck, King Rail, Virginia Rail, Sora (*Porzana carolina*), American Bittern (*Botaurus lentiginosus*), Least Bittern, Marsh Wren, and the Coastal Plain Swamp Sparrow (*Melospiza georiana nigrescens*). Some of these species breed in higher saline marshes but reach their highest abundance within marshes of this type. The Chesapeake Bay is at or near the southern range limits for breeding Soras, American Bitterns, and Coastal Plain Swamp Sparrows. The Coastal Plain Swamp Sparrow is a geographically distinct subspecies of Swamp Sparrow that breeds exclusively in oligohaline marshes of the Chesapeake Bay and Delaware Bay (Bond and Stewart 1951; Beadell *et al.* 2005; Watts *et al.* 2006 and unpubl. data).

Area requirements of freshwater marsh birds have not been systematically studied in the Bay and seldom elsewhere (Brown and Dinsmore 1986). In general, certain species that use tidal fresh habitats also use non-tidal emergent wetlands, impounded areas, and even wet ditches so appear to have smaller area requirements than salt marsh species. The King Rail, Virginia Rail, American Bittern, and Least Bittern use tall, dense vegetation such as Cattails, Tall Cordgrass, and Rice Cutgrass for nesting and forage in shallow water (Stewart and Robbins 1958; Frederick *et al.* 1990; Meanley 1992). Pied-billed Grebes and Common Moorhens build floating nests concealed by dense vegetation. They typically forage in water depths of 0.3 m or greater (Strohmeyer 1977). Marsh Wrens are generally more abundant in freshwater/oligohaline and brackish marshes because of greater cover of taller marsh grass species. The Coastal Plain Swamp Sparrow requires a specific combination of habitats near the marsh-upland ecotone (Beadell *et al.* 2003; Watts *et al.* unpubl. data). This consists of complexes of dense shrubs or small trees positioned directly adjacent to high marsh habitat. In the Chesapeake Bay, these complexes typically contain shrub species such as Wax Myrtle (*Myrica cerifera*), Marsh Elder, or Saltbush and grass-like species such as Salt Meadow Hay, Olney's Three-square, or Tall Cordgrass.

Marsh Bird Status and Trends

Tidal marsh bird populations have undoubtedly suffered drastic declines since European colonization. Based on habitat loss alone (Tiner 1987), population levels of certain species may be 50% of what they once were three centuries ago. Population declines have most likely continued with constant rates of marsh loss and degradation. Reliable quantitative population trends for marsh species do not exist. Tidal marsh habitats are poorly sampled by large scale monitoring programs such as USGS Breeding Bird Survey and results for marsh birds from this roadside-based program are unreliable (Sauer *et al.* 2006). Describing modern day changes in marsh bird abundance are generally restricted to comparing anecdotal historic accounts (e.g., Stewart and Robbins 1958), to individual studies (Watts 1992, 1993; Brinker *et al.* 2002), breeding bird atlases and personal observations. The qualitative nature of early records for marsh birds is sometimes difficult to interpret. Throughout the region's early ornithological history, most species are described as being common, uncommon, or rare. Inconsistencies between qualitative descriptions can exist simply by the arbitrary use of these terms. Differences between historical and contemporary records can sometimes be attributed to the secretive nature of most marsh species and lack of systematic survey effort more or less that any actual change in abundance. This restricts credible comparisons on simple presence or absence. These comparisons clearly indicate that many marsh birds have undergone reductions in population size and distribution since the early 1900s. Perhaps the best examples are historical comparisons from areas near Washington, D.C., that at one time supported marsh birds such as King Rails, but can no longer since the wetland habitat was largely destroyed (Smith 1902).

A large proportion of the breeding marsh birds in the Chesapeake Bay are considered to be of high conservation concern (Watts 1999). Based on a relative ranking of vulnerability (Watts 1999; Carter *et al.* 2000), the suite of species that use high marsh habitats are among the most imperiled. Among these are the American Black Duck, Black Rail, Saltmarsh Sharp-tailed Sparrow, and Henslow's Sparrow. These species have small populations and breed at relatively few sites in the Chesapeake Bay. Their breeding habitats are also among the most at risk of loss and degradation.

Brinker *et al.* (2002) conducted the most comprehensive survey for breeding rails in the Chesapeake Bay and used their findings for comparison to historical accounts. The most prominent change they reported was a sharp King Rail decline. Based on their surveys, King Rails were absent or only detected in low abundance from areas where they were historically considered common. In Dorchester and Somerset counties Clapper Rails even replaced King Rails in order of abundance. Although reasons for these shifts remain unknown, two plausible explanations provided were the direct displacement of King Rails by Clapper Rails or changes in habitat conditions that favor Clapper Rails. The latter explanation could be a result of saltwater intrusion of freshwater habitats which is an unfortunate result of sea-level rise. Like many other areas, King Rails are reported to be declining throughout its range for reasons unknown (Meanley 1992).

The distribution of Black Rails, Saltmarsh Sharp-tailed Sparrows, and Henslow's Sparrows reflect the both the availability and distribution of high quality, high marsh habitat. Brinker *et al.* (2002) conducted the only systematic survey of Black Rails within the Chesapeake Bay. Based on this and unpublished records in Virginia, the bulk of the species population resides in the middle reaches of the eastern shore from Dorchester County, Maryland through Accomac County, Virginia. Other populations may exist on the western shore in Virginia due to the presence of large high marshes, but this speculation requires a targeted survey effort. The bulk of Henslow's Sparrow populations also coincide with the concentration of high marsh on the Delmarva peninsula (Boone and Dowell 1996; Trollinger and Reay 2001; MDW, unpubl. data). Historically, there are only a few observations of Henslow's Sparrows from this area, suggesting only a small population has existed. One small population was consistently reported in Virginia at Saxis marsh, Accomac County through 1999 but has now disappeared (D. Schwab, Virginia Dept. of Game and Inland Fisheries, pers. comm.). Currently, there are no consistent breeding populations identified in the Chesapeake Bay. Saltmarsh Sharp-tailed Sparrows breed regularly throughout high marshes from Dorchester County, Maryland through Accomac County, Virginia (O'Brien 1996; Trollinger and Reay 2001; MDW, unpubl. data), the Chesapeake Bay islands (BDW, unpubl. data), and small populations on the western shore of the Bay in Gloucester County, Virginia (Watts 2004). Historical accounts indicate that this species once bred more extensively on the western shores of Virginia (Bailey 1913) and Maryland (Stewart and Robbins 1947, 1958). Reasons for local extirpations on the western shore are unknown, but habitat degradation may be a likely factor. Like other high marsh species, targeted surveys are needed to determine the population status of this species and reasons for their decline.

The American Black Duck is widespread throughout the Bay but breeds locally in low numbers. Populations have declined 64 and 53% in Maryland and Virginia, respectively over the past ten years (Costanzo and Hindman 2007). Nest predation may be the primary cause of population declines (Stotts and Davis 1960; Stotts 1987). Common nest predators are Red Foxes (*Vulpes vulpes*), Racoons (*Procyon lotor*), crows (*Corvus* spp.) and gulls (*Larus* spp.).

The Coastal Plain Swamp Sparrow has not received sufficient conservation concern in the Chesapeake Bay. This is likely due to its uncertain status and poorly known distribution. The subspecies was only described in 1951 by Bond and Stewart (1951) but has not drawn much attention until recently (Greenberg and Droege 1990). Comparisons between contemporary and historical records suggest that Coastal Plain Swamp Sparrows have declined dramatically in the Chesapeake Bay (Bailey 1913; Beadell *et al.* 2003; BDW, unpubl. data). Stewart and Robbins (1958) documented the species in coastal Maryland at only three sites within two counties. The Maryland breeding bird atlas project, conducted from 1983 to 1987, documented twelve confirmed breeding sites, 17 probable breeding sites, and 32 possible breeding sites distributed across eleven bay counties (Droege and Blom 1996). Beadell *et al.* (2003) conducted a targeted survey in Maryland and detected birds in only five of 70 (7%) historically reported locations. Swamp Sparrows were only found from these surveys in the upper bay reaches of Maryland and the Nanticoke River. No birds were detected at historical locations in the lower bay portions of Maryland including previously known sites along the northern shoreline of the Potomac River. The contemporary distribution in Virginia is poorly known. Bailey (1913) described this species as a common breeder in Virginia in the early 1900s. However, the first breeding record in Virginia was only documented in 2005 and currently this subspecies is only known to occur in three marshes on the Rappahannock River in Richmond County (BDW, unpubl. data). More investigation in Virginia is needed in areas of appropriate habitat. Based on what is currently known, Coastal Plain Swamp Sparrows have a limited distribution, small bay-wide population size, suffered drastic population declines, and very specific habitat requirements. The Chesapeake Bay population of Swamp Sparrows is an immediate candidate for special conservation status (Beadell *et al.* 2003). This subspecies requires targeted surveys to document Chesapeake Bay breeding populations and focused management of existing populations.

Conservation concerns have been elevated also for some of the more abundant, widely distributed species in the Bay. The King Rail, Clapper Rail, Willet, and Seaside Sparrow have been recognized by some conservation efforts as needing special attention (Watts 1999). We estimated population sizes of these and other widespread tidal marsh birds in the Chesapeake Bay using a model of density, habitat associations, area requirements, and habitat availability (Table 2, see Appendix for calculation method). Population estimates such as these provide a benchmark for spatial and temporal comparisons. Because these estimates are based on modeling the relationship between density and habitat availability, they can be used to represent the amount of habitat needed for restoration and/or protection to produce future desired population levels. Moreover, these simple models can be used to hindcast population sizes to examine population trends based on past habitat conditions. Currently, the Chesapeake Bay supports approximately 80% of tidal marshes in the Mid-Atlantic region and 65% of tidal marshes along the entire Atlantic Coast (Dahl 1980). Based on this, it is obvious that the Bay supports a significant portion if of the eastern populations of common marsh species.

Breeding populations of Pied-billed Grebes, American Bitterns, and Soras in the Chesapeake Bay are near the edge of these

Table 2. Population estimates (# of pairs) for selected tidal marsh species in the Chesapeake Bay. Density range is the span of values observed across a gradient of patch sizes (Watts 1992, 1993). Total available habitat for each species is the area of usable marsh after being filtered by the species habitat associations and incidence rates within patch size categories. Size class at 50% incidence is to illustrate variation in area requirements (Watts 1992, 1993). See Appendix for method of calculation.

Species	Size class (ha) with 50% incidence	Density range (males/ha)	Total available habitat (ha)	Population size (numbers of pairs)
Clapper Rail	>1.0	0.62-1.32	84,246	61,270
Virginia Rail	1.0-5.0	0.19-0.43	99,986	24,452
King Rail	0.1-1.0	0.62	31,689	19,805
Willet	1.0-5.0	0.79-1.91	71,575	68,306
Marsh Wren	0.1-1.0	0.32-2.75	120,988	123,026
Seaside Sparrow	1.0-5.0	3.4-4.0	71,870	271,323

species' ranges. Populations of these species appear to be primarily scattered in small numbers along the Patuxent and Choptank rivers in Maryland (Stewart and Robbins 1958; Meanley 1975; Davidson 1992; Brinker *et al.* 2002). These species are rarely detected in Virginia and present at only a few sites (Trollinger and Reay 2001). Further, populations of these species have probably always been low and scattered, but anecdotal comparisons with historical accounts suggest they have also declined (Stewart and Robbins 1958).

SUMMARY OF MARSH BIRD THREATS

Species that use the high marsh are probably the most threatened in the Chesapeake Bay. The most significant threat to these habitats is sea-level rise. High marsh habitats have the greatest difficulty accreting sediments to keep pace with rising waters and will likely be squeezed out of existence. This threat is coupled with the fact that the shoreline armoring and upland development continue to rise creating a barrier to marsh transgression.

The rapid spread of *Phragmites* is another leading threat to high marsh species. The tall reed-like structure of *Phragmites* creates markedly contrasting environmental conditions compared to the grass-like savannahs of high marshes. Marsh bird abundance and diversity responds negatively when *Phragmites* invades a marsh (Benoit and Askins 1999; Paxton and Watts 2002). *Phragmites* also negatively affects widespread species such as Marsh Wrens (Paxton and Watts 2002) that require taller marsh grasses suggesting that habitat modification is greater than structural changes alone. Based on the rate of *Phragmites* expansion (Rice *et al.* 2000), significantly large portions of high marsh could be transformed with the next few decades. In addition, the center of the Bay's Nutria problem overlaps and directly affects the most significant stronghold of high marshes and high marsh birds in Maryland.

Urbanization is a significant threat to all marsh birds. The Chesapeake Bay has one of the fastest growing human populations in the United States and a large number of new inhabitants are choosing to live near the shoreline. Urban development has been primarily responsible for marsh loss and degradation. Marshes surrounded by urban development support lower marsh bird diversity and abundance (DeLuca *et al.* 2004; Shriver *et al.* 2004) suggesting that urbanization has many indirect influences beyond direct loss or conversion to other habitats. Without modifications to urban development patterns, conflicts between humans and marsh birds will continue into the future.

The effect of nest predators on reproductive rates of marsh birds in the Chesapeake Bay is poorly known but its effects are believed to be significant. Nest predation is considered the leading factor for declines in American Black Ducks (Stotts 1987; Longcore *et al.* 2000) and remains a need of study for other species. Species that use the high marsh may be most susceptible to nest depredation due to the close proximity of their habitats to upland populations of predators.

Table 3. Species habitat assignments into classified GIS marsh data. Marsh habitat classifications are based on Maryland DNR (2003) and Center for Coastal Resource Management (1992).

Species	MD DNR classification[a]	VA CCRM classification
Clapper Rail	E2EM1N6, E2EM1Nh, E2EM1Nh, E2EMP, E2EM1n	brackish water mixed, saltmarsh cordgrass, saltmeadow hay, black needlerush
Virginia Rail	E2EM1P, E2EM1P6, E2EM1P6d, E2EM1Pd	freshwater mixed, arrow arum-pickerel weed, cattail, big cordgrass, brackish water mixed, saltmarsh cordgrass, saltmeadow hay, black needle rush
King Rail	E2EM1N6, E2EM1P6, E2EM1P6d, E2EM2N6	freshwater mixed, arrow arum-pickerel weed, cattail, big cordgrass, reed grass
Willet	E2EM1Nh, E2EM1P, E2EMiP, E2EM1n	brackish water mixed, saltmarsh cordgrass, saltmeadow hay, black needlerush
Marsh Wren	E2EM1N6, E2EM1Nh, E2EM1P, E2EM1P6, E2EM1P6d, E2EM1Pd, E2EM1Px, E2EM2N, E2EM2N6, E2EMP, E2EM1n, E2EM1Nd	Freshwater mixed, arrow arum-pickerel weed, cattail, big cordgrass, brackish water mixed, saltbush, saltmarsh cordgrass, saltmeadow hay, black needlerush, reed grass
Seaside Sparrow	E2EM1Nh, E2EM1P, E2EMiP, E2EM1n	brackish water mixed, saltmarsh cordgrass, saltbush, saltmeadow hay, black needlerush

[a]E = Estuarine systems, 2 = intertidal, EM = emergent: 1 = persistent or 2 = nonpersistent, Tidal Class: N = regular or P = irregular, Coastal salinity: 1 = hyperhaline, 2 = euhaline, 3 = mixohaline (brackish), 4 = polyhaline, 5 = mesohaline, 6 = oligohaline, 0 = fresh, Soil: g = organic or n = mineral; Other categories: b = beaver-altered, d = partially drained/ditched, f = farmed, h = diked/impounded, r = artificial, x = excavated.

The effect of poor management practices on marsh birds has received the least amount of conservation recognition. However, many management tools can adversely impact marsh birds and their habitats without proper guidance. For instance, impounding wetland areas and burning marshes for game management and other uses are common and growing practices. Impoundments directly eliminate habitats for marsh birds by drowning sections of marsh that are typically shallow water and increase erosion within ponded areas. The use of fire to control marsh vegetation is used regularly in some locations. Incompatibility of the frequency, timing, and magnitude of marsh burns with marsh birds are the greatest threat. Burning during the breeding season can destroy nests and young. Marsh burning just prior to the breeding season removes critical nesting and foraging cover. Most marsh grasses regrow quickly after burning but regrowth of shrubs may take an entire season or longer. Extensive and severe burning of the high marsh removes shrubby cover required by high marsh species such as Sedge Wrens, Coastal Plain Swamp Sparrows, Saltmarsh Sharp-tailed Sparrows, and Henslow's Sparrows (Mitchell *et al.* 2006).

Wetland mitigation is a management technique to create or restore wetlands for compensation of impacts to wetland resources at another area (National Resource Council 2001). However, there are currently no explicit policies for mitigation that properly consider marsh bird habitat requirements. Since many marsh birds have large area requirements, mitigating a large marsh for the construction of smaller marshes, is not commensurate compensation. In addition, there is a growing body of evidence that suggests artificially constructed marshes do not provide similar values to biological communities as natural marshes (Zedler 1993; Zedler and Callaway 1999; Havens *et al.* 2002; Seluck-Race and Christie 2005). This may be due, in part, because artificial marshes are often constructed of dredge material that provides different underlying substrates than natural marshes. These artificial marshes support different plant communities and invertebrate infauna, are often lower in energy output and nutrient availability (Zedler and Callaway 1999), and consequently receive lower bird use than natural marshes (Havens *et al.* 2002). The false perception that mitigating marshland is a one-to-one trade-off for biological value must be made dutiful to managers and policy makers. Specific habitat requirements of marsh birds must be implemented into wetland mitigation policies. Finally, marshes of specific critical value for the bird species most at risk should be protected.

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Appendix. Calculation of estimated of population sizes of marsh bird species in Maryland and Virginia portions of the Chesapeake Bay.

Population sizes of selected species were calculated by projecting values of bird density and incidence rates from data collected in the Chesapeake Bay (Watts 1992, 1993; Paxton and Watts 2002) over corresponding amounts of habitat from GIS coverage in Maryland (Maryland DNR 2003) and Virginia (Center for Coastal Resources Management 1992). Incidence rates were calculated as the percentage of patches occupied. We assume total population sizes represent number of breeding pairs because bird densities were obtained by surveys that are biased for detecting vocalizing males. We also then assume a 100% pairing success rate among for species examined. Population estimates were obtained by the summation:

$$\sum_{x \in S} f(x)$$

where: S = the set of marsh patch size classes for habitats assigned to a species; 1) <1 ha, 2) 1-5 ha, 3) 5-10 ha, 4) 10-50 ha, and 5) >50 ha and $f(x) = d_i((r_i * n_i)\ (s_i))$

where d_i = bird density (males/ha) for patch size class i
r_i = incidence rate for patch size class i
n_i = number of patches for patch size class i
s_i = patch size for patch size class i

To obtain population numbers that could be moderated by patch size, existing GIS coverage of marsh habitats was re-sampled by spatially aggregating patches of similar habitat with boundaries that were within 50 m of one another into a contiguous patch. Conversely, two patches separated by >50 m remained as two individual patches. Each species was assigned to a possible set of habitat types based on author's personal observations (Table 3).