Studies in Avian Biology No. 32:141–154

BREEDING BIRDS OF NORTHEAST SALTMARSHES: HABITAT USE AND CONSERVATION

Alan R. Hanson and W. Gregory Shriver

Abstract. Saltmarshes and associated wildlife populations have been identified as priorities for restoration and conservation in northeastern North America. We compare results from a recent study on habitat requirements of saltmarsh-breeding birds in the Maritime Provinces of Canada to those from recently published studies for the New England Gulf of Maine, and the southern New England shore. Differences in geologic history, sedimentation rates, tidal amplitude, ice cover, sea-level rise, climate, and human activity have influenced the ecology, extent, and distribution of saltmarsh habitat among these regions. In Canada, Bay of Fundy saltmarshes studied were larger and less isolated compared to marshes in the Gulf of St. Lawrence or those along the Atlantic Coast of Nova Scotia. Saltmarshes in the Maritimes and the New England Gulf of Maine were large compared to those along the southern New England shore. In all study regions, species richness was greater in larger saltmarshes. In the Maritime Provinces, marsh area was an important determinant of the density of Nelson's Sharp-tailed Sparrows (*Ammodramus nelsoni*) and Savannah Sparrows (*Passerculus sandwichensis*). Willet (*Catoptrophorus semipalmatus*) density was not influenced by marsh area but was positively influenced by pond area. Proximity to other marshes, or the number of dwellings within 500 m of the study marsh did not affect any aspect of bird use. Nelson's Sharp-tailed Sparrow density was positively influenced by the presence of adjacent dike land. In the Maritimes, common reed (*Phragmites australis*) is not widespread and therefore not a useful predictor of avian habitat use in contrast to New England where studies have documented lower species richness where *Phragmites* is abundant. Based on findings from studies across the Northeast we conclude that: (1) habitat area is an important parameter for determining the occurrence of many species of saltmarsh-breeding birds, (2) habitat quality for saltmarsh-breeding birds is dependent on multiple spatial scales, and (3) wetland protection policies and conservation-restoration activities need to specifically address the collective habitat requirements and conservation concerns for individual bird species within locales.

Key Words: birds, Canada, conservation, isolation, Maritimes, New England, saltmarsh.

AVES REPRODUCTORAS DE MARISMAS SALADAS DEL NORESTE: UTILIZACIÓN DEL HABITAT Y CONSERVACIÓN

Resumen. Marismas saladas y poblaciones de vida Silvestre asociadas han sido identificadas como prioritarias para la restauración y conservación en el noreste de Norte América. Comparamos resultados de un estudio reciente sobre requerimientos del hábitat de aves reproductoras de marisma salada, en las Provincias Marítimas de Canadá, con aquellos estudios publicados recientemente para el Golfo de Nueva Inglaterra de Maine, y la costa sureña de Nueva Inglaterra. Diferencias en historia geológica, tasas de sedimentación, amplitud de marea, cubierta de hielo, levantamiento del nivel del mar, clima y actividad humana, han influenciado la ecología, el alcance y la distribución del hábitat de marisma salada entre estas regiones. En Canadá, las marismas saladas estudiados de la Bahía de Fundy fueron más grandes y menos aisladas, en comparación a las marismas en el Golfo de San Lawrence o a aquellas a lo largo de la Costa del Atlántico de Nova Scotia. Las marismas saladas marítimos en el Golfo de Nuevo Inglaterra de Maine, fueron más grandes comparadas con aquellas a lo largo de la costa sureña de Nueva Inglaterra. En el área marítima, el área de marisma fue un importante determinante de la densidad de Gorriones Cola Aguda Nelson (*Ammodramus nelsoni*) y de Gorriones Sabana (*Passerculus sandwichensis*). La densidad del Playero Pihuiui (*Catoptrophorus semipalmatus*) no fue influenciada por el área de marisma, pero fue positivamente influenciada por el área del charco. La proximidad a otros marismas, o el número de viviendas dentro de los 500 m del estudio, la marisma no afecto ningún aspecto de la utilización del ave. La densidad del Gorrión Cola Aguda Nelson estuvo positivamente influenciada por la presencia de tierra del canal adyacente. En el área marítima, el carrizo (*Phragmites australis*) no es dispersado y por ello no es un vaticinador útil de la utilización del hábitat de aves, en contraste con Nueva Inglaterra donde estudios han documentado menor riqueza de la especie en donde *Phragmites* es abundante. Basándonos en hallazgos de estudios a través del Noreste, concluimos que: (1) el área del hábitat es un parámetro importante para determinar la aparición de muchas especies de aves reproductoras de marisma salada, (2) la calidad del hábitat para aves reproductoras de marisma salada depende en escalas espaciales múltiples, y (3) políticas de protección de humedales y actividades de conservación-restauración necesitan ser dirigidas específicamente a los requerimientos colectivos del hábitat y a preocupaciones de conservación para especies individuales de aves dentro de las locales.

Saltmarshes are unique ecosystems resulting from complex interactions between hydrology, sedimentation, salinity, tidal amplitude and periodicity, and primary productivity at the interface between terrestrial and marine ecosystems (Bertness 1999). The same physical and biological features that make saltmarshes some of the most productive ecosystems in the temperate zone, also supported European settlements during colonization of northeastern North America (hereafter Northeast). The history of human settlement patterns and use of saltmarsh ecosystems in the Northeast is an important factor in determining the present condition of saltmarshes. Human use of saltmarshes for agricultural purposes was widespread throughout the Northeast during the 1600–1900s. Ditching, draining, and infilling of saltmarshes occurred throughout the region and included diking in the Canadian Maritime Provinces (hereafter Maritimes). Since European settlement, increasing human populations and expanding cities and towns have resulted in the continued draining, infilling, and alteration of saltmarshes (Bertness et al. 2004). Loss of coastal wetlands in the US has been substantial, ranging from 30–40% (Horwitz 1978) with saltmarsh habitat in New England being particularly imperiled (Tiner 1984). In Canada, the amount of saltmarsh lost in some local areas is upwards of 85% (Reed and Smith 1972), although national statistics are not available (Glooschenko et al. 1988). Although much research has occurred on saltmarshes in the eastern US there have been few attempts to collectively assess saltmarsh forms, land-use histories, and wildlife communities in the Northeast (Bertness and Pennings 2000).

Despite the magnitude of habitat change, only recently have agencies concerned with wildlife conservation begun to systematically survey saltmarsh avifauna in the Northeast. Most of the research on the habitat function of saltmarshes in the Northeast has focused on fish (Weinstein and Kreeger 2000). Therefore, quantitative information about species occurrence, relative abundance, and density of key wildlife species is often unavailable. Inadequate information on the status and distribution of saltmarsh-bird populations limits the utility of North American Bird Conservation Initiative prioritization, and is the primary reason for many saltmarsh bird species being listed as species of high conservation concern (Pashley et al. 2000). In the Northeast, species such as Nelson's Sharp-tailed Sparrow (*Ammodramus nelsoni*), Saltmarsh Sharp-tailed Sparrow (*A. caudacutus*), Seaside Sparrow (*A. maritimus*), and Willet (*Catoptrophorus semipalmatus*) have been identified as species of concern by state, provincial, and federal agencies.

Saltmarshes are important landscape features for many bird species in the Northeast during all stages of the annual cycle (breeding, migration, and wintering). Despite their low floristic diversity, saltmarshes provide a continuum of habitat from terrestrial grassland to open water, heterogeneous distribution of micro-scale habitat features, and relatively high productivity. Habitat suitability studies have indicated that for wading and water birds the presence and configuration of open-water habitat is important (Burger and Shisler 1978, Hansen 1979) while many breeding passerines are sensitive to vegetation composition, structure, and configuration, as well as tidal inundation patterns (Marshall and Reinert 1990, Reinert and Mello 1995, DiQuinzio et al. 2002).

Understanding the conservation needs of saltmarsh-breeding birds requires knowledge of habitat requirements at multiple spatial scales, including within-patch habitat variables and the landscape configuration of patches. This knowledge is also critical in evaluating the effects of conservation and restoration activities (e.g., coastal land-use policies and regulations, habitat acquisition, and habitat restoration) as well as anticipating the potential negative impacts (e.g., infilling, drainage, and disturbance) on bird communities. Changes in the landscape configuration of saltmarsh patches is a likely outcome of increasing sea-level rise and may negatively effect the population viability of Seaside Sparrows in Connecticut (Shriver and Gibbs 2004). Understanding saltmarsh-bird habitat requirements is also critical to estimating the impacts of short-term habitat changes—weather and tidal cycles—on breeding bird distribution, abundance, and population trends. The effects of habitat and landscape features on saltmarsh-bird species richness in one region may not be the same in other regions, making large-scale, multi-region, coordinated studies and syntheses an important component in determining priorities for conservation and management options within regions, as shown for grassland birds by Johnson and Igl (2001).

Herein, we review information on the effects of habitat and landscape variables on saltmarsh bird communities in New England and present new information on these patterns in the Maritimes. We describe differences in saltmarsh distribution and land use among the regions, discuss patterns of saltmarsh-habitat area, isolation, human influence, and vegetative characteristics among distinct regions in the Northeast, and determine whether these variables influence saltmarsh-bird-species richness similarly among regions.

SALTMARSHES IN NORTHEASTERN NORTH AMERICA

Along the coastline of northeastern North America from Connecticut to Prince Edward Island (Fig. 1), five biophysical regions of saltmarshes can be recognized: southern New England shore, New England Gulf of Maine, Bay of Fundy, Atlantic Coast of Nova Scotia, and Gulf of St. Lawrence (Roberts and Robertson 1986, Wells and Hirvonen 1988, Mathieson et al. 1991, Shriver et al. 2004). We recognize that finer-scale spatial differentiation within regions is also possible (Kelley et al. 1988), however, the broad-scale regions we used differ substantially in geology, tidal amplitude, latitude, and human impacts on saltmarsh habitats (Table 1). An overview of climate, physical characteristics, and rocky shore ecology of regions from Cape Cod northward is provided by Mathieson et al. (1991).

Southern New England Shore

We define the southern New England shore as that area from the western edge of Long Island Sound to the southern shore of Cape Cod, Massachusetts. Marshes within this area share a similar geologic history, tidal range, and human land-use patterns. Long Island Sound is one of the largest estuaries along the Atlantic Coast of the US. It is a semi-enclosed, northeast–southwest trending basin which is 150 km long and 30 km across at its widest point. The mean water depth is 24 m with two outlets to the sea. The eastern end of the sound opens to the Atlantic Ocean whereas the western end is connected to New York Harbor through a narrow tidal strait. Fluvial input into the sound is dominated by the Connecticut River (Poppe and Polloni 1998). Long Island Sound is an estuary, with a watershed encompassing an area of more than 41,000 km^2 and reaching into portions of Massachusetts, New Hampshire, Vermont, New York, Rhode Island, and Canada. Long Island Sound is bordered by Connecticut and Westchester County, New York to the north, New York City to the west, and by Long Island, New York, to the south.

In this region, marshes have often formed in drowned river valleys and contain considerable deposits of peat. Most tidal wetlands along the southern New England shore are saltmarshes, and summer salinity averages about 20–30 ppt. Salinity in this region varies seasonally and with proximity to major sources of fresh water such as the Connecticut, Housatonic, and Thames

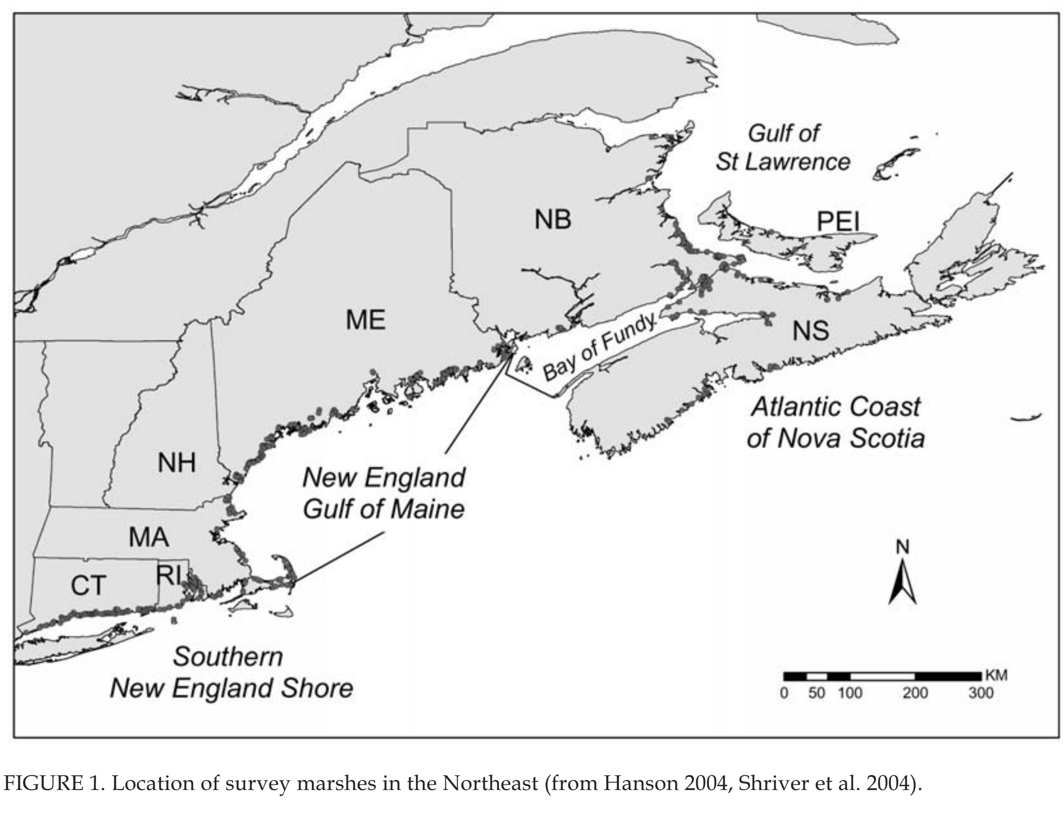

FIGURE 1. Location of survey marshes in the Northeast (from Hanson 2004, Shriver et al. 2004).

TABLE 1. BIOPHYSICAL CHARACTERISTICS OF SALTMARSHES IN THE NORTHEAST INDICATING THE IMPORTANCE OF DIFFERENT FEATURES AND FACTORS IN EACH REGION.

Feature/factor	Southern New England shore	NE Gulf of Maine	Bay of Fundy	Atlantic Coast of Nova Scotia	Gulf of Saint Lawrence
Agricultural diking	Low	Low	High	Low	Low
Tidal barriers	Moderate	Moderate	High	Moderate	High
Sea-level rise impact	Moderate	Moderate	Moderate	Moderate	High
Tidal amplitude	Low	Moderate	High	Moderate	Moderate
Sediment load	Low	Low	High	Low	Moderate
Ice	Low	Moderate	High	Moderate	High
Phragmites abundance	High	Moderate	Low	Low	Low
Low-marsh dominant vegetation	Smooth cordgrass (*Spartina alterniflora*)	Smooth cordgrass	Smooth cordgrass	Smooth cordgrass	Smooth cordgrass
High-marsh dominant vegetation	Saltmeadow cordgrass (*Spartina patens*)	Saltmeadow cordgrass	Saltmeadow cordgrass-saltmeadow rush (*Juncus gerardii*)	Saltmeadow cordgrass-saltmeadow rush	Saltmeadow cordgrass-saltmeadow rush
Upper high-marsh dominant vegetation	Marsh elder (*Iva frutescens*)	Baltic rush (*J. balticus*)	Prairie cordgrass (*S. pectinata*)	Prairie cordgrass-salt marsh sedge (*C. paleacea*)	Prairie cordgrass *C. paleacea*
Breeding bird species diversity	High	Moderate	Low	Low	Low
Breeding bird abundance	High	High	Moderate	Moderate	Moderate
Bird species designated at risk (AOU Alpha Code)	SESP, SSTS, WILL	SESP, NSTS, SSTS, WILL	None	None	None
Impoundment of tidal rivers	High	Low	Low	Low	High
Grazing	None	None	Low	Moderate	Moderate
Haying	Low	Low	Low	Moderate	Low.
Agricultural ditching	None	Moderate	High	Moderate	Moderate
Mosquito ditching	High	Moderate	None	None	None
Infilling	High	Moderate	Low	Low	High
Fragmentation	Moderate	Moderate	Low	Low	High
Historical loss	Moderate–High	High	High	Low	Low
Saltmarsh remaining (hectares)	8,456	3,520	11,599	2,285	11,878
Restoration activity	High	High	Low	Low	Low
Wetland protection laws	High	High	Low	Low	Low

rivers, but is generally between 27 and 32 ppt. The Connecticut River contributes >70% of the fresh water influx, the Housatonic 12%, and the Thames 9% (Thomas et al. 2000). The tidal range of Long Island Sound increases from about 0.7 m in the east to about 2.2 m in the west, and its circulation is dominated by tidal currents (Koppelman et al. 1976). The water temperature of Long Island Sound fluctuates between ~0 C in the winter to >20 C in the summer (Thomas et al. 2000). The basic physical and biological structure of saltmarsh communities in Long Island Sound comes from smooth cordgrass (*Spartina alterniflora*) and saltmeadow cordgrass (*S. patens*).

The first European colonists in New England arrived in the early 1600s and used tidal marshes to graze livestock and provide fodder and bedding (Dreyer and Niering 1995). New England saltmarshes were both hayed and pastured continuously into the beginning of the twentieth century. Farmers began digging shallow ditches to drain standing water to increase yields of hay. By 1900, nearly 50% of the marshes in Connecticut were ditched and virtually all saltmarshes adjacent to the southern New England shore were ditched and altered by a variety of mosquito-control activities by the mid-1900s (Dreyer and Niering 1995). The effects of the ditching projects on saltmarsh ecosystem functions are difficult to determine as all but one marsh in New England has been ditched, leaving limited reference sites for comparison. The direct loss of saltmarsh habitat in New England occurred until the early 1900s through the practice of filling marshes with dredge spoil to create parking lots, industrial parks, airports, and shopping centers (Dreyer and Niering 1995).

Estimates of tidal wetland area presently occurring along Long Island Sound are just over 8,456 ha (Dreyer and Niering 1995), a 30% reduction from the pre-1880 estimates (Rosza 1995). In 1980, Connecticut began a tidal-marsh restoration program targeting systems degraded by tidal restrictions and impoundments (Rosza 1995). Such marshes became dominated by common reed (*Phragmites australis*) or cattail (*Typha angustifolia* and *T. latifolia*; Warren et al. 2002). These dense monocultures of reeds have been rapidly expanding in Connecticut's tidal wetlands with documented declines in avian diversity in plots associated with high density of reeds (Benoit and Askins 1999).

During 1960–1990, the human population along the southern New England shore increased by 40% (U.S. Census 2000). Not surprisingly, the expanding human population required increasing levels of infrastructure, particularly roads. Estimates in 1999 were that 13 roads/km^2 existed in coastal counties on Long Island Sound (Connecticut Department of Transportation, pers. comm.). Roads may reduce regional biodiversity by modifying wetland hydrology (Andrews 1990, Trombulak and Frissell 2000), facilitating invasive species (Cowie and Warner 1993, Lonsdale and Lane 1994, Greenberg et al. 1997), and increasing access to wildlife habitats by humans (Young 1994).

New England Gulf of Maine

The Gulf of Maine watershed encompasses land within Massachusetts, New Hampshire, Maine, Quebec, New Brunswick, and Nova Scotia, an area of 165,185 km^2. Over 5,000,000 people live around the Gulf of Maine. The entire population of Maine, 1,200,000 people, lives within the Gulf of Maine watershed and millions of tourists visit the Gulf of Maine every year. In New England, the Gulf of Maine extends from the tip of Cape Cod, Massachusetts (42°04′N, 70°15′W) to the St. Croix estuary in Calais, Maine (44°54′N, 66°59′W). The coast of Maine has 5,600 km of tidally influenced shoreline and is the third longest shoreline in the US. Tides along the Maine coast are semidiurnal and range from 2.6 m at Kittery to 5.6 m at Calais.

Generally, the amount of saltmarsh habitat in the New England Gulf of Maine decreases with increasing latitude. Saltmarsh alteration has a long history in all of New England including the Gulf of Maine. Saltmarsh habitat for the entire coast of Massachusetts was estimated at 12,600 ha in the 1990s (Koneff and Royle 2004; Koneff and Royle, unpubl. data). The majority of this saltmarsh habitat occurs within the Gulf of Maine. In New Hampshire and Maine, saltmarsh habitat in the 1990s was estimated at 1,900 and 5,200 ha, respectively (Koneff and Royle, unpubl. data). Jacobsen et al. (1987) estimated 7,980 ha of saltmarsh occurred in Maine based on 1960 aerial photographs. The Great Marsh in Massachusetts (>6,800 ha), is the largest marsh complex in New England and encompasses ~54% of saltmarsh habitat from Cape Ann Massachusetts to southern New Hampshire. Most of the other large (>100 ha) saltmarshes in New England occur on the south shore of Massachusetts. In southern Maine between Kittery and Cape Elizabeth, the two largest marshes (>1,000 ha) are at Webhannet Estuary and Scarborough Marsh. Cape Elizabeth, just south of Portland Maine, is a geologic division in coastal habitats for the Gulf of Maine. North of Cape Elizabeth, the Maine coast is dominated by rocky intertidal habitat with limited and patchily distributed saltmarsh habitat while south of Cape Elizabeth, where wave energy and tidal range are lower, the coast is dominated by sandy beaches and saltmarshes (Kelley et al. 1988).

Bay of Fundy

The Bay of Fundy is the northeast extension of the Gulf of Maine, located between the Canadian provinces of New Brunswick and Nova Scotia, and covers an area of 16,000 km^2. The Bay of Fundy is a macro-tidal system with a tidal range of 6 m in the outer bay and 16 m at the head of the Bay in Cumberland and Minas Basins (Desplanque and Mossman 2000, 2004). A single tidal flow into the Bay of Fundy involves 104 km^3 of water. During the day, therefore, the volume of water moving in and out of the Bay of Fundy is equivalent to four times the combined discharge of the world's rivers (Desplanque and Mossman 2004).

Higher elevations in Bay of Fundy saltmarshes are typically dominated by saltmeadow cordgrass (Ganong 1903, Chapman 1974, Van Zoost 1970, Morantz 1976, Thannheiser 1981, Thomas 1983, Chmura 1997, Van Proosdij et al. 1999). Only 3–4% of the tides per year for an average duration of 30 min, flood the high marsh in the upper Bay of Fundy (Palmer 1979, Gordon et al. 1985, Van Proosdij et al. 1999). Low marsh is dominated by smooth cordgrass and can be found at elevations between mean high water (MHW) and approximately 1.2 m below MHW (Van Proosdij et al. 1999). A mid-marsh zone which is a transitional zone between high marsh and low marsh has also been described (Wells and Hirvonen 1988, Van Proosdij et al. 1999) and can be dominated by goose tongue (*Plantago maritime*) in some marshes (Chmura et al. 1997). Another climatic-physical feature of Bay of Fundy saltmarshes is the role of ice in creating saltmarsh pannes, exporting detritus, and importing sediment (Bleakney and Meyer 1979, Gordon and Desplanque 1983, Gordon and Cranford 1994, Van Proosdij et al. 2000). The marshes in the upper Bay of Fundy differ from those in the other regions of the Northeast in that they are influenced by large amounts of available sediments. Water-column sediment concentrations typically range from 50–100 mg/L (Amos and Long 1987) and during fall storms, measurements of 6–7 g/L have been recorded (Amos and Tee 1989). Surface-water salinities are 30–33 ppt, with monthly mean water temperatures being affected by the Labrador Current and ranging from 0.6–13.0 C (Mathieson et al. 1991, Davis and Browne 1996a).

European settlement along the shores of the Bay of Fundy began in 1604. The process of diking and draining saltmarsh for conversion to agricultural fields was initiated in the 1630s along the Annapolis River and in the 1670s in the upper Bay of Fundy, with dikes being maintained to this day (Milligan 1987, Bleakney 2004). By 1920, 80% of all saltmarsh in the Maritimes was converted to agricultural land through diking (Reed and Smith 1972), a land use unique to the Bay of Fundy saltmarshes compared to other regions in the Northeast. The draining of wetlands through the use of dikes and water-control structures created 222,000 ha of agricultural land in Canada (Papadopoulus 1995). Currently 35,000 ha of dikeland are in the Bay of Fundy created through conversion from saltmarsh. In recent years most of the dikeland has been used for forage production or pasture (Collette 1995). This non-intensive agricultural use of the dikeland can provide habitat for grassland birds (Nocera et al. 2005).

Recently, dikeland has reverted back to saltmarsh in the upper Bay of Fundy when dikes and water-control structures failed and were not repaired or replaced. By the 1980s <65% of original saltmarsh area remained behind dikes compared to 80% in the 1920s (Milligan 1987, Austin-Smith 1998). Of New Brunswick's 141 Bay of Fundy saltmarshes, 35% were formerly diked (Roberts 1993). The Maritime Wetlands Inventory (Hanson and Calkins 1996) estimates that in the early 1980s, 7,793 ha of saltmarsh were in the Bay of Fundy (Table 2).

Atlantic Coast of Nova Scotia

The Atlantic Coast of Nova Scotia is a high-energy system, experiencing the effects of ocean swells, with a maximum tidal range of 2 m (Wells and Hirvonen 1988, Davis and Browne 1996b). Monthly mean surface-water temperatures are 0.9–15.0 C with salinities ranging from 32.0–33.5 ppt (Davis and Browne 1996a). The Atlantic Coast of Nova Scotia is a drowned coastline and has been subsiding for 7,000 yr (Fensome and Williams 2001) and is characterized by drumlins and terminal moraines (Roland 1982). Saltmarshes along this coastline are most often small wetlands protected by islands, or part of a few large complexes associated with estuaries (Scott 1980, Chagué-Goff et al. 2001). The vegetative zones in Atlantic Coast saltmarshes consist of smooth cordgrass in low marsh, and saltmeadow cordgrass, saltmeadow rush (*Juncus gerardii*), and Cyperaceae in the high marsh (MacKinnon and Scott 1984, Wells and Hirvonen 1988, Austin-Smith et al. 2000). Historically, little diking has occurred along the Atlantic Coast (Kuhn-Campbell 1979). In southwestern Nova Scotia where the coastal plain gradually slopes to below sea level, saltmarshes were hayed and

TABLE 2. LANDSCAPE LEVEL DESCRIPTORS OF SALTMARSHES IN THE ATLANTIC COAST OF NOVA SCOTIA, BAY OF FUNDY, AND GULF OF ST. LAWRENCE REGIONS.

Maritime wetland inventory data[a]	Atlantic	Bay of Fundy	Gulf of St. Lawrence
Number of saltmarshes	598	574	2,106
Total marsh area	6,091 ha	7,793 ha	11,880 ha
Median marsh size (hectares)	4.3 ha	5.9 ha	2.6 ha
Mean marsh size ± SE (hectares)	10.2 ± 0.83 ha	13.6 ± 0.91 ha	5.6 ± 0.21 ha
Number of marshes <5 ha	330	262	1463
Total area of marshes <5 ha	745 ha	587 ha	2,831 ha
Number of marshes 5–10 ha	125	116	343
Total area of marshes 5–10 ha	875 ha	843 ha	2,410 ha
Number of marshes 10–20 ha	74	90	183
Total area of marshes 10–20 ha	1,033 ha	1,260 ha	2,440 ha
Number of marshes 20–50 ha	47	69	98
Total area of marshes 20 - 50 ha	1,423 ha	2,214 ha	2,813 ha
Number of marshes >50 ha	22	37	19
Total area of marshes >50 ha	2,015 ha	2,889 ha	1,386 ha
Study marshes			
Number	16	72	72
Percent with adjacent dike land	0	29	6
Percent with old dikes in marsh	0	36	14
Percent with old ditches in marshes	0	47	37
Percent with ponds	69	61	85
Percent with reeds (*Phragmites*)	0.0	4.2	5.6
Percent with prairie cordgrass (*Spartina pectinata*)	47	64	74

[a] Maritime Wetland Inventory data obtained from Hanson and Calkins (1995).

grazed without the use of dikes. For much of the Atlantic Coast of Nova Scotia, the land rises steeply from the shoreline and there has been little infilling of saltmarsh for construction of human infrastructure. The Atlantic Coast of Nova Scotia is estimated to have 6,090 ha of saltmarsh (Table 2).

GULF OF SAINT LAWRENCE

The Gulf of St. Lawrence is a low-energy system compared to the Atlantic Coast of Nova Scotia and has a much smaller tidal range compared to the Bay of Fundy region (see Roland 1982). Tidal ranges are 1–4 m with mixed components of semidiurnal and diurnal influences. In the western section the tides are mainly diurnal with a period of 25 hr hence on some days tides can remain high for 12 hr (Davis and Browne 1996a). The shallow waters of the Gulf of St. Lawrence result in surface water temperatures ranging from 1.5–19.7 C, with maxima of >22 C being observed. In coastal areas, salinities of 25.2–28.0 ppt occur above the thermacline (Mathieson et al. 1991, Davis and Browne 1996a). The Gulf of St. Lawrence coast consists of a low-elevation plain (Fensome and Williams 2001) and is influenced by the transport of sandy materials, with many barrier islands, dunes, lagoons, and barachois ponds present (Reinson 1980). Residential development resulting in the infilling of saltmarshes and alteration of adjacent habitat, is the primary land use affecting saltmarsh habitat in the Gulf of St. Lawrence due to the presence of sandy beaches, warm water, and flat topography (Roberts 1993, Maillet 2000, Milewski et al. 2001). Gulf of St. Lawrence saltmarshes were not subject to the intense diking that Bay of Fundy marshes were, although some old hand-dug dikes can still be seen. Coastal marshes were, however, important to early agricultural activities (Hatvany 2001). Marshes were ditched to drain ponds and created drier soils for livestock and equipment as they were grazed and hayed.

The vegetative community of Gulf of St. Lawrence saltmarshes has been described as smooth cordgrass in the low marsh, saltmeadow cordgrass in the middle marsh and saltmeadow rush in the high marsh (Wells and Hirvonen 1988, Roberts 1989). Salt marsh sedge (*Carex palacea*) and prairie cordgrass (*Spartina pectinata*) in the higher elevations of Gulf of St. Lawrence saltmarshes distinguishes them from New England saltmarshes (Gauvin 1979, Olsen et al. 2005). In comparison to Bay of Fundy or New England saltmarshes, the vegetative zones and ecology of Gulf of St. Lawrence marshes have received little study to date. The Gulf of St. Lawrence has 11,880 ha of saltmarsh (Table 2). The combination of relatively low land elevations, small tidal variation, intensive coastal-zone development, and erosive soils makes this area highly susceptible to sea-level-rise damage (Shaw et al. 1994). This seems to be confirmed by comparison of soil accretion rates to recent sea-level rise at some sites, but further study is necessary (Chmura and Hung 2004).

METHODS

Data to estimate avian-species richness, abundance, dominant vegetation, surface water area, previous human activity, adjacent land use, and proximity to adjacent saltmarsh were collected on saltmarshes in the Maritimes using techniques similar to those previously used throughout the Northeast (Benoit and Askins 1999, 2002; Shriver et al. 2004).

Maritime saltmarsh vegetative composition was characterized by estimating the percent areal cover of each macrophyte species in a 5-m radius centered on the survey point, and a 5-m-wide transect to the first survey point, between subsequent survey points, and from the last survey point to the marsh edge. The percent cover of salt-meadow vegetation was calculated by summing the percent cover of saltmeadow cordgrass, prairie cordgrass, salt marsh sedge, and saltmeadow rush. The presence of reeds, no longer maintained (old) ditches, or dikes were noted if they occurred within the marsh. Wetland inventory maps (Hanson and Calkins 1996), National Topographic Series maps (1: 50,000 scale) and the most recent aerial photographs were used to determine landscape level features. Marsh boundaries were determined by paved roads or water channels >100-m wide. These definitions of marsh boundaries ensure that the saltmarsh is a relatively homogeneous patch within the landscape matrix (Forman 1995). A proximity index, similar to Gustafson and Parker (1994), was estimated using wetland inventory maps and derived by summing the ratio of size (hectares) of an adjacent saltmarsh divided by its distance (kilometers) to the study marsh for all marshes within 1 km of the boundary of the study marsh (PI= ∑ [area in hectares] of nearby marsh *i*/[distance in kilometers] to nearby marsh *i*) for all marshes within 1 km of study marsh). This proximity index was based on the total area of an adjacent saltmarsh, not just the area within the 1 km buffer, and hence PI >10 was possible, unlike the proximity index used by Shriver et al. (2004). The number of buildings within a 500-m radius was determined as an index of human disturbance. The number and total area (hectares) of ponds in the marsh, the presence of dikes or ditches in the marsh, and the presence of dikelands within 250 m were determined based on aerial photographs.

To survey resident breeding-bird communities, 100-m-radius point counts (1–46 points/marsh) were established within each marsh and each point was visited at least twice from 10 June–30 July, 2000–2002, with at least 10 d between visits (Ralph et al. 1995). The number of points located in a marsh was determined by marsh size, with more points in larger marshes. We attempted complete coverage of the survey marsh. All point centers were >200 m from any other point center and at least 50 m from an upland edge. For small marshes, where the 100-m-radius point extended into adjoining upland habitat, only birds detected within the marsh were counted.

Observers, including volunteers, sampled for 10 min at each point and recorded all birds seen and heard within 100 m. Surveys were conducted from dawn to 1100 H on days with low wind (<10 km/hr) and clear visibility. All observers had experience in bird identification (by sight and sound) prior to this study, with additional training in identification of saltmarsh bird species if required. Differences among observers in ability to see and hear birds were not quantified.

Species richness in marshes was based on three guilds: (1) obligate wetland birds, (2) wading birds, and (3) passerines, similar to Shriver et al. (2004). Both the total number of species detected per marsh (total species) and the mean number of species detected per survey point in each marsh (species richness) were considered as response variables.

Statistical Analysis

General linear models (GLM) were used to determine which marsh-level and landscape-level features were significantly related to the mean number of birds or number of species observed per survey point in each marsh (SAS 2000). The mean number of individuals per survey point will simply be referred to as density. Separate models were developed for Nelson's Sharp-tailed Sparrow, Willet, and Savannah Sparrow densities, and species richness. Proportional data were arcsine-transformed prior to analysis, count data were square-root transformed, and other variables log-transformed prior to statistical analysis to improve normality, and reduce heterogeneity of variance (Zar 1999). W values indicated normal or near normal distributions (Proc UNIVARIATE, SAS 2000).

RESULTS

Saltmarsh Characteristics

Surveys were conducted on 161 saltmarshes throughout the Maritimes. Saltmarshes in the previously described regions of the Maritimes differed in size distribution, the extent of human disturbance, and vegetative composition (Table 2). Saltmarshes surveyed in the Bay of Fundy were larger compared to saltmarshes surveyed along the Atlantic Coast, consistent with the size distribution of saltmarshes reported in the Maritime Wetlands Inventory (Table 2). Old dikes and ditching, adjacent dikeland, and reeds were not present in Atlantic Coast study marshes but were present in study marshes in the other regions (Table 2). Approximately three-quarters of the surveyed marshes in the Gulf of St. Lawrence had prairie cordgrass present (Table 3).

The mean number of buildings within 500 m for Gulf of St. Lawrence study marshes was 50 compared to 33 and 36 for saltmarshes along the Atlantic Coast and Bay of Fundy, respectively (Table 3). Gulf of St. Lawrence saltmarshes also had a greater number and greater total area of ponds compared to saltmarshes in the other two regions.

Nelson's Sharp-tailed Sparrow density was similar for study marshes among all three regions (Table 4). The density of Willets was higher for Atlantic Coast marshes compared to Gulf of St. Lawrence, and Bay of Fundy marshes (Table 4). Savannah Sparrow density was lower in Bay of Fundy marshes compared to those along the Gulf of St. Lawrence or Atlantic Coast.

Landscape and Patch-level Effects

Individual bird species differed in their response to landscape and patch-level habitat characteristics. Marsh area was an important determinant of Nelson's Sharp-tailed and Savannah sparrow densities and avian-species richness (Table 4). Nelson's Sharp-tailed Sparrow density increased with marsh size up to 10 ha (Fig. 2, Table 5). Nelson's Sharp-tailed Sparrow density in marshes <5.0 ha (0.33 ± 0.07, $\bar{x}$ ± SE) was less than that for marshes ≥5 ha (1.07 ± 0.09, $P < 0.001$), and was less in marshes ≤10.0 ha (0.50 ± 0.095, $\bar{x}$ ± SE) compared to marshes >10.0 ha (1.2 ± 0.096, $P < 0.001$). Willet density was not influenced by marsh area but was positively influenced by pond area. In these study marshes a high correlation occurred between saltmarsh area and pond area ($r^2 = 0.73$) and density of Willets was positively associated with marsh area in models which included marsh area but not pond area (Hanson 2004). Savannah Sparrow density was negatively affected by pond area.

The average amount of saltmarsh-meadow vegetation positively influenced Willet density and species richness (Table 4). The number of dwellings within 500 m was positively correlated with species richness. The proximity index or the number of dwellings within 500 m of the study marsh did not affect any of the species habitat use response variables.

The presence of old dikes and old ditches on the marsh itself did not affect the density of Willets or Savannah Sparrows or species richness. Nelson's Sharp-tailed Sparrow, Willet

Table 3. Summary statistics of study saltmarshes in the Atlantic Coast of Nova Scotia, Gulf of St. Lawrence, and Bay of Fundy Regions.

	Atlantic Coast		Bay of Fundy		Gulf of St. Lawrence	
	Mean	SE	Mean	SE	Mean	SE
Marsh area (hectares)	19.98	4.78	52.75	10.97	24.12	4.68
N ponds	9.56	5.08	12.29	2.34	24.88	5.51
Pond area (hectares)	5.41	1.76	5.91	1.08	9.26	1.54
Proximity index	3.00	0.85	19.18	3.19	10.44	1.57
N dwellings <125 m	6.88	2.22	5.21	1.19	8.47	1.93
N dwellings 125–250m	7.88	1.90	8.38	2.67	10.56	2.51
N dwellings 250–500m	17.88	3.50	22.51	5.46	31.29	6.74
Total dwellings <500m	32.63	5.51	36.10	8.59	50.32	10.03
NSTS[a]/marsh	6.48	2.35	5.74	0.92	4.74	0.84
NSTS per survey point	0.97	0.19	0.85	0.13	0.90	0.09
WILL[a]/marsh	6.63	2.28	0.63	0.25	2.99	0.62
WILL per survey point	1.20	0.22	0.14	0.06	0.69	0.11
SAVS[a]/marsh	7.53	4.35	3.25	0.71	4.17	1.28
SAVS/survey point	0.80	0.37	0.42	0.08	0.89	0.12
Percent cover of salt-meadow vegetation	33.25	4.99	53.86	2.88	52.59	2.53
N passerine species	5.06	0.75	4.19	0.34	5.69	0.40
N wetland species	7.13	1.43	2.97	0.40	5.99	0.51
N wader species	0.94	0.11	0.49	0.07	0.76	0.07
N gull species	1.75	0.17	0.79	0.11	1.18	0.13
Total N of species/marsh	14.88	2.24	8.44	0.79	13.63	0.93
Mean N of species/survey point	7.32	0.85	3.92	0.29	8.40	0.53

[a] NSTS = Nelson's Sharp-tailed Sparrow; WILL = Willet; SAVS = Savannah Sparrow.

TABLE 4. RESULTS FROM GLMS FOR EVALUATING THE IMPORTANCE OF MARSH AND LANDSCAPE LEVEL HABITAT DESCRIPTORS ON THE MEAN NUMBER OF NELSON'S SHARP-TAILED SPARROWS, WILLETS, SAVANNAH SPARROWS AND SPECIES RICHNESS PER SURVEY POINT. RESULTS FROM MULTIPLE PAIR-WISE COMPARISONS AMONG REGIONS ALSO PRESENTED.

	Nelson's Sharp-tailed Sparrow		Willet		Savannah Sparrow		Species Richness	
	F	Pr > F	F	Pr > F	F	Pr > F	F	Pr > F
Model	35.20	<0.01	16.9	<0.01	17.38	<0.01	210.61	<0.01
Marsh area	20.04	<0.01	0.56	0.46	15.75	<0.01	4.22	0.42
Pond area	0.55	0.45	5.08	0.03	15.29	<0.01	0.61	0.44
Proximity index	0.03	0.87	0.55	0.46	0.42	0.52	0.86	0.35
Meadow cover	0.05	0.81	0.20	0.66	2.14	0.15	0.02	0.89
Old ditch	0.01	0.93	0.19	0.66	0.63	0.43	0.20	0.65
Old dykes	1.10	0.30	0.03	0.86	0.06	0.81	0.00	0.98
Dykeland nearby	12.17	<0.01	10.6	<0.01	2.61	0.11	6.91	0.01
Dwellings <500 m	0.04	0.84	0.56	0.45	1.67	0.20	4.01	0.05
Region	3.79	<0.01	26.25	<0.01	12.11	<0.01	32.31	<0.01
Model r^2	0.30		0.33		0.24		0.36	
BOF vs ATL [a]	NS		P < 0.05		NS		P < 0.05	
BOF vs GSL [a]	NS		P < 0.05		P < 0.05		P < 0.05	
ATL vs GSL [a]	NS		P < 0.05		NS		NS	

[a] Results from multiple pair-wise comparisons among regions: BOF = Bay of Fundy; ATL = Atlantic Coast of Nova Scotia; GSL = Gulf of St. Lawrence.

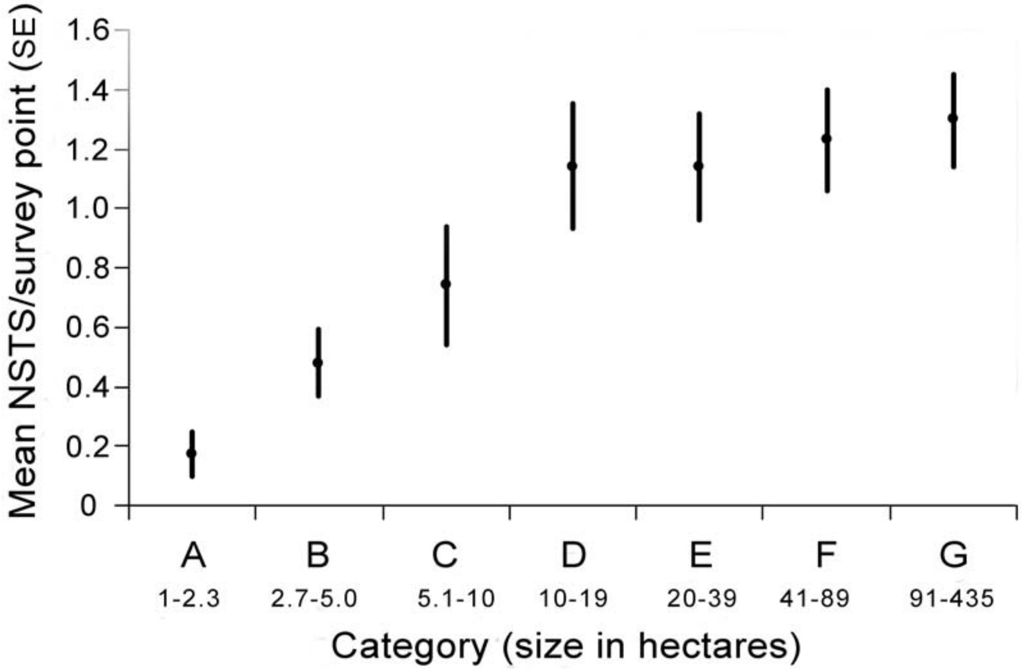

FIGURE 2. Mean (± SE) number of Nelson's Sharp-tailed Sparrows (NSTS) per survey point in relation to marsh size.

TABLE 5. SUMMARY STATISTICS OF STUDY SALTMARSHES ACCORDING TO MARSH SIZE.

	Class A		Class B		Class C		Class D		Class E		Class F		Class G	
Variable	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Pond area (hectares)	0.35	0.13	2.02	0.96	2.66	0.58	4.21	0.78	9.48	1.50	19.16	3.84	20.43	4.57
Marsh area (hectares)	1.55	0.13	3.72	0.19	7.47	0.27	13.96	0.60	28.85	0.85	60.72	3.14	222.85	31.48
Proximity index	4.28	2.15	4.51	1.85	8.19	2.45	16.14	5.48	18.50	4.34	22.00	5.57	25.05	5.65
N dwellings	42.75	11.60	44.43	15.17	43.41	18.36	36.21	12.67	37.62	10.88	27.11	6.46	75.79	35.62
Percent cover salt meadow	59.78	6.64	55.24	7.08	54.86	4.26	53.11	3.57	47.23	3.08	42.43	5.06	43.99	4.55
N NSTS[a] /marsh	0.17	0.08	0.79	0.25	2.00	0.62	3.87	0.88	7.13	1.18	11.85	2.59	16.56	2.36
N NSTS/point	0.17	0.08	0.48	0.11	0.74	0.20	1.14	0.21	1.14	0.18	1.23	0.17	1.30	0.16
N WILL[a] /marsh	0.42	0.19	1.05	0.46	1.36	0.52	1.76	0.35	3.16	1.19	4.87	1.98	4.26	1.69
N WILL/point	0.42	0.19	0.57	0.23	0.56	0.18	0.51	0.10	0.39	0.10	0.68	0.28	0.37	0.17
N SAVS[a] /marsh	0.28	0.13	1.16	0.37	1.88	0.66	1.75	0.53	5.07	1.03	6.51	3.78	17.07	5.92
N SAVS/point	0.28	0.13	0.94	0.31	0.64	0.14	0.62	0.22	0.73	0.13	0.50	0.21	1.06	0.26
N passerine species	3.20	0.56	3.19	0.63	4.17	0.46	5.00	0.65	6.50	0.57	5.22	0.64	7.57	0.76
N wetland species	2.10	0.62	1.62	0.37	4.52	0.89	4.33	0.66	6.38	0.76	7.39	1.19	7.00	1.24
N wader species	0.45	0.11	0.52	0.13	0.62	0.12	0.54	0.12	0.79	0.08	0.83	0.19	0.86	0.18
N gull species	0.60	0.18	0.71	0.18	1.07	0.24	0.75	0.15	1.38	0.19	1.17	0.22	1.86	0.25
Total N species/marsh	6.35	1.28	6.05	1.10	10.38	1.52	10.63	1.34	15.06	1.30	14.61	1.88	17.29	1.97
N Species/survey Point	6.18	1.26	5.19	0.88	6.86	0.82	6.14	0.74	7.19	0.78	5.41	0.76	5.96	0.69
Marsh size	1.0–2.3 ha		2.7–5.0 ha		5.1–10.0 ha		10.1–18.7 ha		20–39 ha		41–89 ha		91–435 ha	
Sample size	20		21		29		24		34		18		14	

[a] NSTS = Nelson's Sharp-tailed Sparrow; WILL = Willet; SAVS = Savannah Sparrow.

densities and species richness were positively associated with the presence of adjacent dike land (Table 4).

DISCUSSION

MARSH AREA

Marsh area had a consistent and positive influence on many breeding bird species occurrences and species richness in all regions of the Northeast. The occurrence of saltmarsh-obligate species was positively related to marsh area in the Maritimes, similar to previous findings for the New England Gulf of Maine and southern New England shore (Benoit and Askins 2002, Shriver et al. 2004). In the Maritimes, Nelson's Sharp-tailed Sparrow density was positively correlated with saltmarsh area. These findings are consistent with the findings for the effect of marsh area on the occurrence of Seaside Sparrows and Saltmarsh Sharp-tailed Sparrows in the New England Gulf of Maine and the southern New England shore (Benoit and Askins 2002, Shriver et al. 2004). Species richness was also greater on larger marshes than smaller marshes in the Maritimes and New England (Shriver et al. 2004). Shriver et al. (2004) observed that 13 of 14 species were more likely to be detected on larger marshes compared to smaller marshes. The number of species in the saltmarsh breeding bird communities declined with increasing latitude. The southern New England shore had the greatest species richness for saltmarsh breeding birds while species richness was lowest in the Bay of Fundy. Most of the wading bird species observed in U.S. saltmarshes are absent from the Maritimes, due to geographic range limits.

Both absolute and relative marsh size may influence bird distribution. Willets in Connecticut were absent in marshes <138 ha (Benoit and Askins 2002), whereas in the Maritimes, Willets were observed in smaller marshes, including a 2.0 ha saltmarsh that contained 0.40 ha of total pond area. Habitat use does not always equate with habitat quality (Van Horne 1983), and these different results may be due to the marsh patch-size distribution or low Willet populations (Benoit and Askins 2002). The affinity of Willets (and other shorebird species) for ponds highlights the importance of including measures of open water, rather than just marsh area, in analyses of habitat use as well as in conservation-restoration activities. Previous analyses indicate that Willets were more likely to occur on larger marshes than smaller marshes in all regions of the Northeast when pond area is not included in the model (Benoit and Askins 2002, Hanson 2004, Shriver et al. 2004). Erwin et al. (1994) observed the highest shorebird densities (including Willets) on ponds >0.10 ha. In the Maritimes, the density of Willets was positively correlated with pond area. In most marshes total pond area will be highly correlated with marsh area, and hence these findings collectively highlight the importance of large marshes as wildlife habitat.

In the Maritimes, marsh size was not important for facultative or opportunistic users of saltmarshes, such as Savannah Sparrow, perhaps because these species are also using several non-saltmarsh habitats, including upland grassland and dune ridges. Differences among species in the importance of marsh area are consistent with findings for grassland (Bakker et al. 2002) and forest birds (Mitchell et al. 2001) where individual species demonstrated scale-dependent differences in how they perceived habitat and landscape structure, and that no single scale was appropriate for assessing habitat. The importance of marsh size in different studies for different species in the Northeast suggests that large coastal marshes should remain intact and that the wildlife habitat benefits of several small saltmarsh restoration projects may not be as great as a single large project.

LANDSCAPE CONTEXT

The effect of marsh isolation on obligate saltmarsh breeding birds differed among regions and species. Marsh proximity was not an important variable in explaining Willet, Nelson's Sharp-tailed Sparrow, or Savannah Sparrow densities in the Maritimes and no difference was found in saltmarsh-breeding bird species richness among isolated or contiguous marshes in this region. This pattern was consistent with findings for Nelson's Sharp-tailed Sparrows in the New England Gulf of Maine where this species was not shown to be influenced by marsh isolation. The effect of marsh isolation on Willets was not consistent among regions. In all regions, except the New England Gulf of Maine, Willet occurrence or density was not influenced by marsh isolation. In the New England Gulf of Maine, Willets were more likely to occur on marshes in close proximity to other marshes (Shriver et al. 2004). The presence of Saltmarsh Sharp-tailed Sparrows, a species present along the southern New England shore and the New England Gulf of Maine, was also influenced by marsh isolation in the New England Gulf of Maine but not along the southern New England shore. Alternatively, Seaside Sparrows were positively associated with the proximity to other saltmarshes along the southern New England shore and only marginally in the New England Gulf of Maine (Shriver et al. 2004). The importance of marsh isolation likely depends on the distribution and characteristics of habitat patches within the landscape and the breeding ecology of the species in question. Patterns of marsh isolation on the saltmarsh breeding birds were not as consistent as the effects of marsh area. If patch size is large in relation to the home range of the species then, all other things being equal, proximity to other habitat patches may not be important. Correlations between the distribution of habitat patches across the landscape and within patch habitat quality will also influence the apparent importance of proximity indices in these analyses. Numerous and dispersed small saltmarshes in the New England Gulf of Maine, especially in northern Maine (Jacobsen et al. 1987), may also influence this relationship.

In comparison to eastern forested landscapes or western grassland landscapes, the tidal wetlands of the Northeast are relatively small, discrete habitats, unevenly distributed along the coast. Saltmarsh birds in many locales may be forced to use only one marsh because others are not available. The discrete, insular nature of saltmarshes may also explain why the number of dwellings near the marsh had no impact on densities of saltmarsh birds in the Maritimes. Shriver et al. (2004) did not observe an effect of road density on species richness in either the southern New England shore or the New England Gulf of Maine. The lack of correlation to these indices of human disturbance does not minimize the importance of the upland edge as nesting cover for species such as Willet and Nelson's Sharp-tailed Sparrow in the Maritimes (A. Hanson, pers. obs.).

Another unique finding from the Maritimes is that although proximity to adjacent saltmarsh habitat did not influence Nelson's Sharp-tailed Sparrow or Willet densities, the presence of adjacent dikeland habitat did. Nelson's Sharp-tailed Sparrows use tall-grass cover in agricultural areas, and riverine floodplains in the Maritimes (Townsend 1912, Conner 2002, Nocera et al. 2005). Willets will also nest in dikeland pasture (A. Hanson, pers. obs.) as well as considerable distances from estuarine feeding areas (Hansen 1979).

Within-Marsh Characteristics

Tidal flooding is an important proximate and ultimate determinant of nest success and hence nest-site selection by ground-nesting birds in saltmarshes (Reinert and Mello 1995, Shriver 2002). Singing male Nelson's Sharp-tailed Sparrows were associated with females who remain relatively close to the nesting area (Shriver 2002). This results in males using the higher elevations of the marsh, and they will use old fence posts, bushes, or spruce trees as singing perches if available adjacent to nesting areas (A. Hanson, pers. obs.). The species of plants associated with higher elevations of the marsh depend on absolute elevations of the marsh compared to water levels. Some marshes have only smooth cordgrass and saltmeadow cordgrass zones, whereas other marshes may also have zones of higher elevations that contain saltmeadow rush, salt marsh sedge, Baltic rush (*Juncus balticus*), or prairie cordgrass. Plant species associated with singing male sparrows may vary across marshes or regions depending on the plant species present in the highest elevations of the marsh. Habitat suitability and abundance of birds in Long Island Sound saltmarshes was largely influenced by birds using marshes with reed*s* less often than other marshes (Benoit and Askins 1999, Shriver et al. 2004). The limited distribution and abundance of reed*s* in the Maritimes presently precludes this relationship.

Implications for Bird Conservation

As described earlier, considerable differences exist in the nature of saltmarshes throughout the Northeast. Saltmarshes have been lost due to drainage or infilling and modified by activities such as ditching. The extent and intensity of such activities varies throughout the Northeast. Remaining saltmarshes may not be representative of past conditions and habitat use can only be based on habitat types currently available. Therefore, the observed differences in habitat use across regions may be due to differences in the amount of various habitat types available and not necessarily due to differences in habitat selection.

Nelson's Sharp-tailed Sparrows seem to be present in all moderately sized marshes in the Maritimes and 48% of saltmarshes in the New England Gulf of Maine. In the Maritimes, they use dykeland habitats and seem to be equally abundant in agricultural fields and floodplain grasslands (Conner 2002, Nocera et al. 2005). The data collected in the Maritimes support the recommendation that Nelson's Sharp-tailed Sparrows be designated as Not at Risk in Canada (Rompre et al. 1998).

Willets were hunted by market hunters almost to extirpation in the Northeast by 1910, with the Willet population north of Virginia reduced to a small breeding population in southern Nova Scotia (Tufts 1986). Willet populations increased throughout Nova Scotia after the 1920s and the passage of the Migratory Bird Convention Act, but were not reported to be nesting again in New Brunswick until 1966 and for Prince Edward Island not until 1974 (Erskine 1992). They returned to the southern New England shore and New England Gulf of Maine during the 1970s and 1980s (Lowther et al. 2001). The absence of Willets from many saltmarshes in the Maritimes, especially the Bay of Fundy, may reflect unsuitable or unused habitat. In Connecticut, it is thought that low population size results in much unused habitat (Benoit and Askins 2002). Low Willet populations or availability of suitable habitat are both cause for concern because of sensitivity to environmental catastrophe or habitat degradation. The lack of ponds on many saltmarshes in the upper Bay of Fundy may be due to vestigial dikes that preclude ice rafting and ditches that promote drainage of ponds. Without an understanding of natural pond-formation processes, direct human intervention to create ponds on saltmarsh by excavation may be considered habitat alteration and not restoration.

Saltmarsh Sharp-tailed Sparrows occur in this region from the Weskeag Marsh in Maine to the southern portion of the Southern New England Shore (Hodgman et al. 2002). This species is a high conservation priority because of its limited breeding distribution, the high proportion of its breeding population that occurs in the Northeast, and the threats to its coastal habitats (Pashley et al. 2000). Saltmarsh Sharp-tailed Sparrows were detected on 70% of the surveyed marshes along the southern New England shore and were less likely to occur on marshes invaded by reeds (Benoit and Askins 1999, Shriver et al. 2004). Conservation of this species in New England will likely be influenced by saltmarsh restoration projects that are designed to reduce invasive plant cover and remove tidal restrictions. The success of these projects in relation to increasing habitat quality for Saltmarsh Sharp-tailed Sparrows may be delayed, however, due to the time lag in vegetative response after initial flooding (DiQuinzio et al. 2002). Even though this species occurs on large percentage of marshes, its promiscuous mating system (Greenlaw and Rising 1994) and potentially male-biased sex ratio (Shriver, unpubl. data) may effectively reduce the number of source populations. Given that these sparrows are obligate saltmarsh birds, consideration of Saltmarsh Sharp-tailed Sparrow reproductive success should be incorporated into saltmarsh restoration projects that are designed to increase or restore marsh integrity.

Seaside Sparrows in the Northeast are distributed from southern New Hampshire (occasionally breeding in Maine) south to the southern portion of the southern New England shore. This species was very sensitive to marsh size along the southern shore of New England (Benoit and Aksins 1999, Shriver et al. 2004) and only occurred on 15% of the surveyed marshes in this region (Shriver et al. 2004). Unlike Saltmarsh Sharp-tailed Sparrows, Seaside Sparrows are monogamous and territorial (Post and Greenlaw 1994), a contrast in behavioral strategies that may explain differences in the effects of marsh size on the occurrence and density of these two species. Seaside Sparrows tend to require larger marshes to establish breeding populations which are less common in the portion of the region where this species occurs. Shriver and Gibbs (2004) modeled the potential effects of sea level on the population viability of this species and found a significant increase in the probability of extinction given three estimates of sea-level rise. The ability of inland saltmarsh expansion with rising sea levels will be necessary in the coming decades if we are to conserve viable populations of saltmarsh breeding birds.

Saltmarsh conservation in New England has been facilitated through the enactment of various federal and state policies and regulations. In Canada, the Federal Policy on Wetland Conservation was implemented in 1991 and provincial governments in the Maritimes have recently passed wetland protection policies. Provincial regulations to protect coastal wetlands are forthcoming and much needed. In the Maritimes, coastal wetlands in the Gulf of St. Lawrence are most threatened due to high recreational use of the shoreline. Coastal wetlands may also be threatened in this region due to potential human responses to sea-level rise impacts on this low-elevation coastline. Studies in the Northeast have indicated the importance of large saltmarshes to bird diversity and density. Maintaining large saltmarshes intact without fragmentation should therefore be a conservation priority in the Northeast under current conditions and anticipated changes in coastal ecosystems due to rising sea levels.

ACKNOWLEDGMENTS

We would like to thank R. Greenberg, S. Droege, and J. Taylor for organizing and supporting the conference that lead to these proceedings. C. Elphick, G. Chumra, R. Greenberg, and L. Benoit provided valuable comments on earlier versions of this manuscript.