CHAPTER 12

AVIAN RESOURCES OF THE NORTHERN GULF OF MEXICO

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12.1 INTRODUCTION

Birds are unique among vertebrates because they can fly long distances in a short period of time, and, with few exceptions, live in three-dimensional spaces. Birds that live in the water-land interface may be equally at home on land, in the air, and in the water. Most other organisms live their entire lives, or phases of their lives, in either water (fish, whales, clams, other invertebrates) or in some other medium (soil or land surface). The ability to switch from one medium to another on a daily basis requires flexibility in physiological and behavioral adaptations. A wide diversity of birds exists in the marine-terrestrial interface at the margins of continents and offshore islands. Seabirds live mainly on the oceans (pelagic), but also nest on offshore islands or along coasts (Schreiber and Burger 2001a). Herons, egrets, and some shorebirds live primarily in the marine-land interface, foraging in coastal bays and estuaries and nesting along beaches on islands, or on adjacent uplands (Burger and Olla 1984; Lantz et al. 2010, 2011; Kushlan and Hafner 2000a, b). Several shorebird species migrate or winter along coasts, but breed in the high Arctic. Many species of ducks winter along coasts but breed in inland habitats, including the prairie pothole region of North America. Other birds live mainly in coastal marshes (rails, some Passerines) and spend most of their time there.

The Gulf of Mexico has several important features for promoting high avian use and diversity: (1) a high diversity of habitats; (2) a direct pathway for Nearctic-Neotropical migrants flying to Mexico, Central America, and South America; and (3) warm coastal waters. The Gulf of Mexico is considered the most important migratory pathway in the world for waterfowl (Gallardo et al. 2004), in North America for Nearctic-Neotropical migrants, primarily songbirds (Rappole 1995; Moore 2000a), and for migrant and wintering shorebirds (Withers 2002). The four flyways of North America join in the Gulf of Mexico. Many migrants pass through central Veracruz, while others from the Mississippi and Atlantic flyways migrate directly across the open waters of the Gulf (Moore 2000a; Gauthreaux et al. 2006).

One indication of the importance of the Gulf of Mexico is the percentage of U.S. breeding populations of several species that it hosts. The U.S. Gulf Coast has a significant portion of the world population of Reddish Egret (*Egretta rufescens*) (Lowther and Paul 2002) and nearly all the Snowy Plover (*Charadrius nivosus*) that breed east of the Rockies (Elliott-Smith et al. 2004; Page et al. 2009). It also has a significant portion of the U.S. breeding populations of Sandwich Tern (*Sterna sandvicensis*), Black Skimmer (*Rynchops niger*), Forster's Tern (*Sterna forsteri*), Laughing Gull (*Larus atricilla*), and Royal Tern (*Sterna maximus*) (Figure 12.1) (Visser and Peterson 1994).

In addition, the southern Gulf of Mexico is the northern limit for many tropical species nesting in Mexico, such as boobies and Magnificent Frigatebird (*Fregata magnificens*), while the tropical Sooty Tern (*Sterna fuscata*) and Brown Noddy (*Anous stolidus*) breed as far north

C.H. Ward (ed.), *Habitats and Biota of the Gulf of Mexico: Before the Deepwater Horizon Oil Spill*,
DOI 10.1007/978-1-4939-3456-0_4

Figure 12.1. A colony of Sandwich Terns, with half-grown young. A royal chick (with a *yellow bill*) is in the center. After hatching, the chicks form crèches as protection against predators. © J. Burger.

as the Dry Tortugas (Tunnell and Chapman 2000). The Laguna Madre region from southern Texas to Tamaulipas is one of the most important shorebird wintering areas (Mabee et al. 2001; Withers 2002). The region from southern Tamaulipas to Campeche contains mainly aquatic species with Nearctic-Neotropical affinities (Correa et al. 2000a, b; Gallardo et al. 2009). Many migrants, some from southern regions, winter or occur in the Yucatán peninsula (Howell 1989; Greenberg 1992; Mackinnon et al. 2011).

12.1.1 Objectives

The purpose of this chapter is to provide an overview of avian status and trends in the northern Gulf of Mexico before the Deepwater Horizon oil spill, with special emphasis on the U.S. Gulf Coast. Specific objectives include examining the avian assemblages in the Gulf generally, exploring how birds use the marine-land interface, describing the major stressors driving avian abundance and distribution, and examining spatial and temporal trends in breeding and migrant bird populations. Depending upon the authority, about 400 species of birds use the Gulf at some time of the year or at some point in their life cycle, including brief but crucial stopovers as migrants (Gallardo et al. 2009).

This chapter mainly tracks bird populations in the northern Gulf of Mexico since the 1930s or later, using indicator species and indicator groups. Prior to this time, there are no time series data on bird populations. This time period was also selected because two of the major data sets (Audubon's Christmas Bird Counts, Bird Banding Laboratory's Breeding Bird Surveys) include data for these periods. Many local and state surveys began in the 1970s. Systematic collection of local and regional data usually spans a shorter period, and often stops before the present. Changes in avifauna undoubtedly occurred with the arrival of people from Europe (clearing of forests), with market hunting (plumes for hats, eggs for food), and the massive use of pesticides such as dichlorodiphenyltrichloroethane (DDT) (King et al. 1977). For a more in depth presentation of status and trends of birds of both the northern and southern Gulf, see Burger (2017).

12.1.2 Methods

This chapter considers birds in the Gulf of Mexico ecosystem, including associated offshore islands, barrier islands, and the complex matrix of backbays, mudflats, mangroves, salt marshes, brackish marshes, and associated freshwater marshes, swamps, and uplands. Coral reefs are located mainly in Mexico, although some reefs extend to the Florida Keys (Stedman and Dahl 2008). The Gulf of Mexico itself is approximately 1,400 kilometers (km) (870 miles [mi]) in diameter and is bordered by the United States in the north, Mexico in the

Figure 12.2. Map of Gulf of Mexico, showing the United States, Mexican, and Cuban Coasts. Photo by Wells 2013.

south, the Eastern coast of Mexico and Texas on the west, and the western coast of Florida and Cuba on the east (Figure 12.2). Three countries border the Gulf of Mexico. For many economic, ecological, ethical, and legal reasons, society should protect biodiversity in the Gulf of Mexico ecosystem (Felder et al. 2009). Understanding avian diversity in the Gulf is part of this mandate.

This chapter is derived primarily from published information in the refereed literature, in state and federal reports, and in the gray literature. All sources used are available to the public. Since it is impossible to examine the status and trends of all these species, this chapter examines selected indicators. A brief discussion of various aspects of the Gulf ecosystem and the factors that affect avian reproductive success, survival, and population dynamics are presented. This is followed by status and trends information of birds in the Gulf by individual species and species groups. Trends information is usually not available for the entire Gulf (or even for the northern coast) from the same time period. However, more complete data exist for some species, such as the Piping Plover (*Charadrius melodius*, Haig et al. 2005; Elliott-Smith et al. 2009), and comprehensive surveys of breeding and wintering Charadriiformes (gulls and terns), Anseriformes (waterfowl), and Gaviiformes through Pelecaniforms (loons through pelicans) were conducted from 1976 to 1978 by the U.S. Fish and Wildlife Service (Clapp et al. 1982a, b, 1983). These databases provide representative status and trends information for indicator species groups.

Many data gaps exist because neither the U.S. Gulf Coast nor the entire Gulf Coast has been surveyed for birds recently or completely. Different data sets are used to examine different questions. Some of these are older than others, and there may have been changes in either species composition or population levels since the data were last gathered. One of the longest-running data sets available for wintering birds is the annual Christmas Bird Counts, conducted by National Audubon Society.

Christmas Bird Counts were used to examine trends to illustrate particular points (e.g., yearly variability, differences among species, or in a given species in different Gulf States)[1] and recent trends (Niven and Butcher 2011). Niven and Butcher's (2011) analysis of the status and trends of wintering birds along the northern Gulf Coast using the Audubon Christmas Bird Counts from 1965 to 2011 is useful because it is extensive, long-term, and includes all five states. They used Christmas Counts that were centered around 7.5 miles from the Gulf coast. During this time period, the number of counts ranged from 10 to 21 (Texas), 1.7 to 6.6 (Louisiana), 2.5 to 4 (Alabama), 0 to 2 (Mississippi), and 13 to 26 (Florida). There were twice as many counts in the period from 2001 to 2010 than during 1965–1970. In general, counts were conducted by any number of people divided into parties that counted all individual birds observed during a variable period of time (limited to 24 hours (h) from mid-December to early January; Butcher 1990). The difficulty of different numbers of people, counting for different time periods, is reduced by reporting number of birds per party hour (after Link and Sauer 1999a, b).

Niven and Butcher (2011) used hierarchical log-linear models fit with Bayesian models to estimate relative abundance, relative density, and trends for the Gulf region as a whole (Sauer et al. 2009; Sauer and Link 2011). They published their findings after the Deepwater Horizon oil spill, but the trends are not reflective of this event because it occurred at the end of the time series (e.g., 2010–2011 Christmas Count); the data reflect regional trends (Niven and Butcher 2011). Christmas Bird Count data are presented, either as yearly patterns or 3-year running averages, which smooths out the temporal data, making it easier to see patterns.

Breeding Bird Surveys (BBS, Sauer et al. 2011) provide useful data for species that nest mainly along the Gulf of Mexico (e.g., Brown Pelican). Surveys conducted in June (early May in some southern states) by volunteers are point counts conducted randomly at 50 stops along preselected roadside routes. Counts start 30 minutes (min) before local sunrise, and stops are 0.8 km apart. At each stop, the observer conducts a 3-min count of all birds seen and heard within 400 meters (m). There are more than 5,000 established routes in North America, and about 2,500 are surveyed each year (Sauer and Link 2011). Data are presented as an index, which represents the mean number of birds counted per route (Sauer and Link 2011). Colonial birds present a challenge because the routes seldom pass colonies, and counts may represent birds flying around or foraging. However, since the methods are the same from year to year, they provide a useful index to assess changes in population numbers. The Bird Banding Laboratory provides information on trends by state for different species, and this information can give an overall picture of changes that can be used in conjunction with other data sets (Sauer et al. 2008).

Other methods are explained in individual sections (Green et al. 2008). The author took all photographs and all tables and figures were developed from the original data sources, unless otherwise noted. This chapter reviews current information, with three caveats: (1) Understanding population status and trends is an on-going process of new assessments, improving methods of assessment, and increasing coverage of the Gulf of Mexico, both temporally and spatially. (2) Selection of topics, indicator species and groups, and trends information was necessary. (3) The emphasis is on the northern Gulf Coast. Indicators were selected to represent avian communities and relationships, as well as different life histories and conservation status. While it is possible to write separate papers on most topics considered, the task was to provide an overview of avian communities in the Gulf of Mexico.

[1] http://audubon2.org/cbchist/table.html.

Finally, over the course of the last half-century, the taxonomy of North American birds has undergone several revisions (American Ornithologists' Union [AOU] Checklists), resulting in different family assignments and changes in nomenclature, particularly at the genus level. The sequence of listing families has also changed. Throughout this chapter, the nomenclature used by the authors cited was retained. The most recent AOU checklist is the 7th edition (1998), and more than 50 supplements have been published in *The Auk* since that time. Changes that are relevant to the Gulf of Mexico can be found in the individual Birds of North America Accounts (Laboratory of Ornithology, Cornell University, Ithaca, NY USA).[2]

12.2 LAWS, REGULATIONS, AND STATUS DESIGNATIONS

Laws and regulations provide the legal basis for environmental protection of birds in the Gulf of Mexico. The Migratory Bird Treaty Act (1918) and the U.S. Endangered Species Act (1973) are the main federal laws that apply to birds in the Gulf. The Migratory Bird Treaty Act protects birds that migrate between and among Canada, the United States, and Mexico. Nearly all birds that occur in the United States and Mexico are protected by this Act. The United States also signed treaties with Mexico (1936), Japan (1972), and the USSR (1976) to protect birds in those countries (Shackelford et al. 2005). The Endangered Species Act protects species listed as threatened or endangered, but the U.S. Fish & Wildlife Service also lists candidate species, those that are being considered for listing. The Convention on International Trade in Endangered Species of Wild Fauna and Florida (CITES), 1973, applies to an established list of birds that are imported, traded or sold, and where such activities threaten their populations.

In addition to international laws, and United States, Cuban, or Mexican laws, each state in the United States has laws and regulations that relate to birds. Most states have an endangered and threatened species list, and many states have a list of species of special concern. Such species are usually so designated because either their populations are in jeopardy or information is insufficient to determine status, but there is concern about their numbers or threats to their populations. Federal and state designations are given in Tables 12.1 and 12.2. Other federally listed endangered or threatened species occur along the coast, although most are

Table 12.1. Federally Listed Birds that Occur Along the Gulf Coast of the United States, Cuba, and Mexico (only non-Passerines are included)

United States
Whooping Crane (*Grus americana*)—endangered
Wood Stork (*Mycteria americana*)—threatened (Alabama, Florida, Mississippi)
Eskimo Curlew (*Numenius borealis*)—endangered
Piping Plover (*Charadrius melodus*)—threatened
Interior Least Tern (*Sterna antillarum*)—endangered
Northern Aplomado Falcon (*Falco femoralis*)—endangered
Cape Sable Seaside Sparrow (*Ammodramus maritimus mirabilis*)—endangered (Florida only)
Everglade Snail Kite (*Rostrhamus sociabilis plumbeus*)—endangered
Cuba (Earth's Endangered Species (Glenn 2006a))
Black-capped Petrel (*Pterodroma hasitata*)

(continued)

[2] Available online at http://bna.birds.cornell.edu/bna/.

Table 12.1. (continued)

Brown Pelican (*Pelecanus occidentalis*)
Cuban Black Hawk (*Buteogallus gundlachii*)
Cuban Kite (*Chondrohierax wilsonii*)
Least Tern (*Sterna antillarum*)
Sandhill Crane (*Grus canadensis*)
West Indian Whistling-duck (*Dendrocygna arborea*)
Ivory-billed Woodpecker (*Campephilus principalis*)
Mexico (Glenn 2006b)
Northern Aplomado Falcon (*Falco femoralis*)
Whooping Crane (*Grus americana*)
Elegant Tern (*Sterna elegans*)
Brown Pelican (*Pelecanus occidentalis*)
Black Rail (*Laterallus jamaicensis*)
Least Tern (*Sterna antillarum*)

Table 12.2. Endangered and Threatened Species by State for Those Breeding or Those Expected to Occur Along the Gulf of Mexico

Texas (TPWD 2004)
Brown Pelican (*Pelecanus occidentalis*)—endangered
Reddish Egret (*Egretta rufescens*)—threatened
White-faced Ibis (*Plegadis chihi*)—threatened
Wood Stork (*Mycteria americana*)—threatened
Whooping Crane (*Grus americana*)—endangered
Swallow-tailed Kite (*Elanoides forficatus*)—threatened
Bald Eagle (*Haliaeetus leucocephalus*)—threatened
Northern Aplomado Falcon (*Falco femoralis*)—endangered
Peregrine Falcon (*Falco peregrinus*)—threatened
Eskimo Curlew (*Numenius borealis*)—endangered (generally considered extinct)
Interior Least Tern (*Sterna antillarum*)—endangered
Piping Plover (*Charadrius melodus*)—threatened
Sooty Tern (*Sterna fuscatus*, now *Onychoprion fuscata*)—threatened
And a few songbirds that may be migrants (e.g., Golden-cheeked Warbler (*Dendroica chrysoparia*, endangered), Rose-throated Becard (*Pachyramphus aglaiae*, endangered), and Black-capped Vireo (*Vireo atricapillus*, threatened)). These are in coastal woodlands.
Louisiana (DWF 2012[a])
Brown Pelican (*Pelecanus occidentalis*)—endangered (also the Louisiana state bird)
Least Tern (*Sterna antillarum*)—endangered
Piping Plover (*Charadrius melodus*)—threatened/endangered
Eskimo Curlew (*Numenius borealis*)—endangered (generally considered extinct)

(continued)

Table 12.2. (continued)

Whooping Crane (*Grus americana*)—endangered
Peregrine Falcon (*Falco peregrinus*)—threatened/endangered
Bald Eagle (*Haliaeetus leucocephalus*)—endangered
Mississippi (USFWS 2012a[a])
Mississippi Sandhill Crane (*Grus canadensis*)—endangered
Least Tern (*Sterna antillarum*) (may not occur coastally)—endangered
Piping Plover (*Charadrius melodus*, except Great Lakes watershed)—threatened
Alabama (USFWS 2012b[a])
Piping Plover (*Charadrius melodus*, except Great lakes watershed)—threatened
Wood Stork (*Mycteria americana*)—endangered
Florida (FFWCC 2010)
Brown Pelican (*Pelecanus occidentalis*)—species of special concern
American Oystercatcher (*Haematopus palliatus*)—species of special concern
Marian's Marsh Wren (*Cistothorus palustris marianae*)—species of special concern
Scott's Seaside Sparrow (*Ammodramus maritimus peninsulae*)—species of special concern
Wakulla Seaside Sparrow (*Ammodramus maritimus juncicola*)—species of special concern
Wood Stork (*Mycteria Americana*)—endangered
Least Tern (*Sternula antilla*rum)—threatened
Roseate Tern (*Sterna dougallii*)—threatened
Snowy Egret (*Egretta thula*)—species of special concern
Reddish Egret (*Egretta rufescens*)—species of special concern
Roseate Spoonbill (*Platalea ajaja*)—species of special concern
White Ibis (*Eudocimus albus*)—species of special concern
Tricolored Heron (*Egretta tricolor*)—species of special concern
Snowy Egret (Egretta thula)—species of special concern
Piping Plover (*Charadrius melodus*)—threatened
Snowy Plover (*Charadrius nivosus*)—threatened
Little Blue Heron (*Egretta caerulea*)—species of special concern
Osprey (*Pandion haliaetus*)—species of special concern
Black Skimmer (*Rynchops niger*)—species of special concern

Listed are all species that could get to coastal environments
[a]Earlier lists are not available
SSC species of special concern

not common in saltwater environments. The Brown Pelican (*Pelecanus occidentalis*) was listed federally until 1998 (Lindstedt 2005; USFWS 2009a). The Bald Eagle was federally delisted August 9, 2007, although they are still protected under the Eagle Act (USFWS 2010a).

Other organizations have conservation ratings or listings for many species. For example, the Audubon Society (2012) lists priority species, and the International Union for Conservation of Nature (IUCN 2011) publishes a Red List of Threatened Species. Their listings are usually similar to federal listings. The Audubon list sometimes includes species before they have been added to the federal lists (Reddish Egret, Red Knot, Marbled Godwit, and Black Skimmer) (Audubon Society 2012).

Finally, it should be mentioned that many states have designations of "species of special concern" for species with some indication that populations may have declined or lack data to indicate status. These species deserve special consideration because some may become threatened if steps are not taken to protect them.

12.3 LAND-WATER INTERFACE

Land-water interfaces usually have high species diversity and high biomass because they contain a range of different habitats. Habitats are intermixed in different patch sizes, and the interface serves as the gateway for movement into both aquatic and terrestrial environments. While it is impossible to clearly define the coastal zone, functionally it is the area on either side of the actual meeting of the land and ocean that is influenced by both marine and terrestrial inputs. The margins themselves are usually narrow, providing an opportunity for animals to move quickly from one habitat to another (Burger 1991a). Since these characteristics apply to both plant and invertebrate communities, the diversity is amplified in higher trophic levels, such as fish, birds, and mammals. The land-water interface also serves as a physical buffer for both the marine ecosystem and for the terrestrial system. Estuarine and coastal environments protect inland terrestrial habitats from excessively high tides, hurricanes, erosion, and other severe storm events, while protecting marine environments from contamination by providing a sink for contaminants. The margin constantly changes due to the effects of wind and water.

Because it is large, the Gulf of Mexico has a long coastline with a wide range of habitats. Because of its geographical position, it has a diversity of habitats that extend from tropical to temperate and from coastal to offshore islands. The Gulf serves as a conduit or migration route to southern wintering grounds between the United States (and more northern Canada) and Mexico, Central America, and South America (Gallardo et al. 2004). The land mass to the north is larger and serves as a funnel point for birds scattered across North America that are migrating to wintering grounds along the Gulf of Mexico or farther south. Most of the birds of the Gulf of Mexico are tied to the coastal zone because of breeding constraints and foraging opportunities.

Gallardo et al. (2009) lists 395 species in 53 families as the number of bird species in the Gulf region. The main families in the Gulf are ducks (Anatidae, 46 species), gulls, terns and skimmers (Laridae, $N = 41$), herons and egrets (Ardeidae, $N = 17$), rails (Rallidae, $N = 16$), warblers (Parulidae, $N = 36$), and flycatchers (Tyrannidae, $N = 17$). The latter two groups are Passerines, but they frequently occur on coastal islands, on marshes, and in coastal forest habitats either as migrants or during the breeding season (Moore et al. 1990; Buler et al. 2007; Buler and Moore 2011). For a full list of the species, see Gallardo et al. (2009).

Coasts are impacted by weather and storm events, as well as anthropogenic factors, such as alteration of hydrological processes, introduction of toxic chemicals and nutrients, increased human population density, increased fishing and other commercial enterprises, development of wind energy, increased numbers of oil and gas platforms, and direct human disturbance. Half of the continental U.S. population resides within 50 mile of the coasts, making them the most rapidly growing areas in the United States. From the 1960s to 2015, the population density of all Gulf coastal counties is expected to increase from 187 to 327 people per square mile (NOAA 1998). Condominiums, resorts, casinos, and other commercial and industrial development already characterize large expanses of the northern Gulf Coast. Development of wind energy is ongoing, both nearshore and offshore, and has the potential to disrupt bird migration across the Gulf (Morrison 2006). Thirty-seven percent (37 %) of the population in the Gulf States lives in the Gulf Coast region (Bildstein et al. 1991; NOAA 2011). Increases in coastal and offshore development will affect birds through decreases in habitat and increased disturbance.

The potential effects of climate change are related to anthropogenic factors (Bradshaw and Holzapfel 2006), such as sea level rise and land subsidence (Daniels et al. 1993; Bayard and Elphick 2011). Increased sea level rise results in increased flooding of nests, eggs, and chicks, as well as rendering habitat on islands, beaches, or salt marshes no longer usable by nesting or foraging birds, such as Brown Pelicans, Piping Plovers, and most terns and skimmers (Daniels et al. 1993). Habitat for salt marsh species, such as Clapper Rails (*Rallus longirostris*) and Salt marsh Sparrows (Sharp-tailed Sparrow, *Ammodramus caudacutus*) (Bayard and Elphick 2011), will also be severely affected by sea level rise.

Studies suggest that habitats and species assemblages will shift considerably over the coming decades (Forbes and Dunton 2006; Greenberg et al. 2006; Day et al. 2008). Some of these changes are due to human population increases and management, and others to sea level rise or subsidence. Management of water levels in marshes can shift the salinity gradient and marsh vegetation, with consequences for marsh-nesting species. Sea level rise, storms, and hurricanes can also influence forested habitats, which in turn affects avian use by both migrants and breeding birds (Gabrey and Afton 2000; Barrow et al. 2005, 2007).

Perhaps the most important features of the Gulf of Mexico for avian populations are related to the complex interaction between natural and anthropogenic factors that result in changes in land available (losses or gains), changes in the relative amount of different habitat types (sandy beaches, marshes, mudflats), and changes in salinity. The northern Gulf coast, especially Louisiana, is losing land at a rapid rate due to complex interactions among subsidence, sea level rise, tropical and other storms, inadequate water supply, and human disturbance (Visser et al. 2005; Valiela et al. 2009). The habitats along the Gulf coast are a shifting mosaic of changing elevation and salinity gradients that result in changes in vegetation species and patterns that affect nesting. Examples of changes are given throughout this chapter, but a few examples are mentioned in Table 12.3. Some habitat shifts result in changes in populations, while others result in changes in the species of birds that are able to use that habitat.

12.3.1 Birds of the Gulf of Mexico as a Whole

There are 395 bird species that reside, migrate, or winter in the Gulf of Mexico and associated coastlines (Gallardo et al. 2009). This number may increase with time because of new information and potential range changes due to global warming. Some neotropical species may move northward into the Gulf coastal habitats (lagoons, marshes, mangroves). Semiaquatic birds (land birds feeding on aquatic species), and all land birds have been reported on islands of the Gulf or crossing its waters (Gallardo et al. 2009). Gallardo et al. (2009) drew the following conclusions: (1) approximately a third of the species occurring in the Gulf of Mexico are breeding residents with no apparent population movements; (2) about 65 % depend upon the Gulf shores for a migratory stopover, or overwintering; (3) 44 % are aquatic species and 27 % are marine; and (4) most feed on invertebrates (55 %) or vertebrates (28 %), while the others eat plants.

The recent avian update included a listing of all species by taxonomy, habitat, range, and location (Gallardo et al. 2009). These data were used to paint a picture of general avian distribution in the Gulf of Mexico, and to create a map that shows the total number of species in each of 12 sectors (Figure 12.3). The percent for each sector is the percent of the total species that is present in that sector (e.g., *N* in the sector/395 for the Gulf species list). This figure makes

Table 12.3. Examples of How Hydrological, Sea Level Changes, or Other Environmental Factors Affect Distribution and Behavior of Birds in the Gulf of Mexico

Feature	Effect on Birds
Low-lying island formations, storms, and hurricanes	Erosion of nesting islands or beach habitats in winter, or wash over of eggs and chicks of Brown Pelicans, Black Skimmers, Least Terns (*Sterna antillarum*) and other terns in colonies in Louisiana and elsewhere (Visser and Peterson 1994). Storms and hurricanes influence habitat use by migrants, as well as habitat availability for migrants and nesting birds (Barrow et al. 2005, 2007; Dobbs et al. 2009)
Changes in water flow pattern and water levels	Changes in the number and amount of shallow pools that flood periodically, and then dry down, thus concentrating prey. Reddish Egrets (*Egretta rufescens*), Roseate Spoonbills (*Platalea ajaja*), and other wading birds require a concentrated food supply of fish and invertebrates (Powell et al. 1989; Lantz et al. 2011). Low water levels limit food resources and delay breeding of Mottled Duck (*Anas fulvigula*) (Grand 1992)
Changes in salinity and influxes of freshwater	Changes in salinity result in halophytic vegetation that alters bird species composition in marshes. Clapper Rails (*Rallus longirostris*) and Seaside Sparrows (*Ammodramus maritimus*) are likely to increase, while Least Bitterns (*Ixobrychus minutus*) and Common Yellowthroats (*Geothlypis trichas*) will decrease (Rush et al. 2009a)
Sea level changes with violent storms	Changes in height of nesting beaches and islands above mean high tide result in greater washovers of beaches, with mortality of eggs and young (Visser and Peterson 1994)
Sea level changes with changes in hurricane timing, frequency, and intensity	Alteration of coastal hydrology, geomorphology, and availability of suitable nesting habitat above storm tides, causing shifts in colony locations, and declines in number of ground-nesting species (Michener et al. 1997). May also shift species composition because of habitat changes

it clear that the highest species diversity is in the southern Gulf, along the Yucatán Peninsula (although not in the sector with Cuba).

A number of non-Passerine species ($N = 93$) occurred in all 12 sectors of the Gulf of Mexico (Table 12.4). Only the non-Passerines are listed because they are more typical of the species that inhabit the coastal and marine areas. The non-Passerines that are distributed throughout the Gulf include ducks, grebes, loons, boobies, pelicans, herons, egrets, ibises, spoonbills, storks, rails, shorebirds, gulls, terns, skimmers, and a kingfisher. As might be expected, shorebirds ($N = 31$ species), ducks ($N = 10$ species), herons and egrets ($N = 10$), and gulls and terns ($N = 13$) are the most diverse groups. Scientific names in Table 12.4 are not repeated in the text that follows this section.

While the non-Passerines are normally considered the key avian component of the Gulf, Passerines are important because millions migrate around or over the Gulf each spring and fall, and others reside in the coastal environment (e.g., Seaside Sparrows, Moore 2000b). Although Gallardo et al. (2009) lists Passerine species found throughout the Gulf, their list is necessarily incomplete because the marsh, shrub, and forest habitats are continuous landward, and it is difficult to draw a suitable line for which species to include. Moreover, the distribution of Nearctic-Neotropical migrants along the southern Gulf of Mexico may be less well known than the distribution along the northern Gulf coast. Some raptors that prey on migrants may be

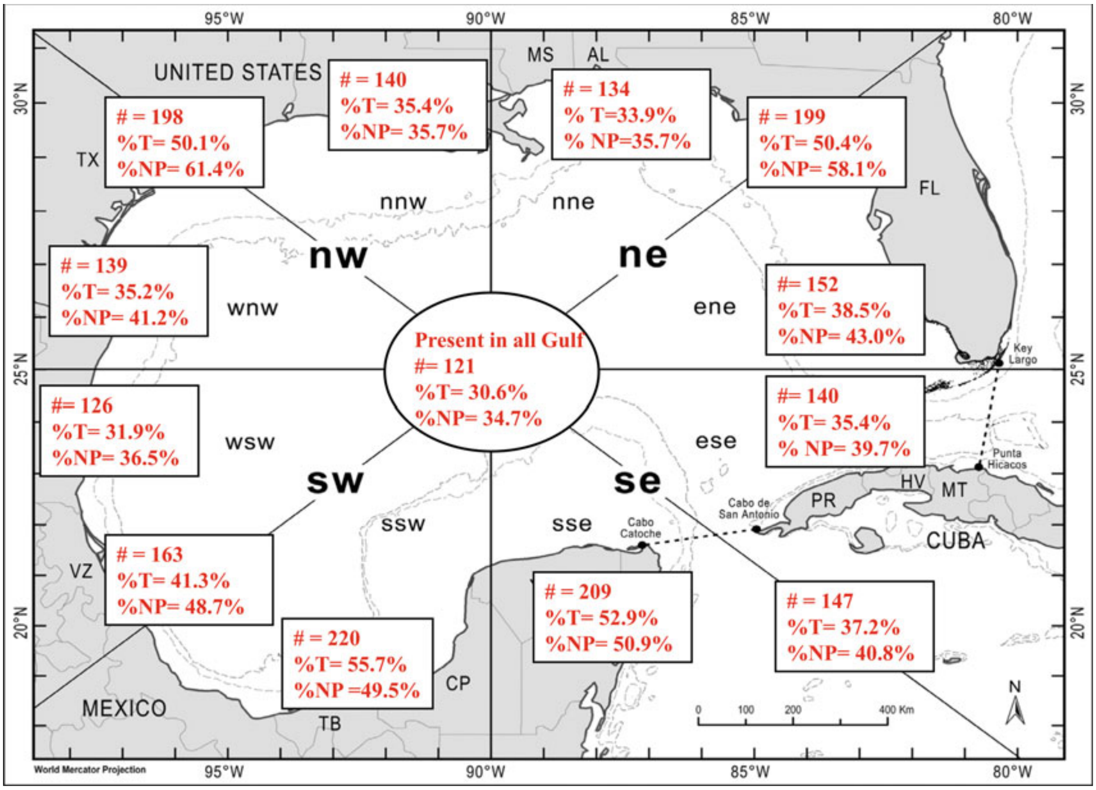

Figure 12.3. Relative avian diversity in the Gulf of Mexico. Shown are the number of species that have been recorded for that sector, the percent of total species found in the Gulf that occur in that sector (%T), and the percent of non-Passerines that are found in that sector (%NP). Data are from Gallardo et al. (2009); map made by Fabio Moretzsohn. © J. Burger.

underrepresented in species lists because they are routinely counted only at designated hawk watches (Kerlinger 1985; Woltmann 2001; Woltmann and Cimpreich 2003).

12.3.2 The Southern Gulf of Mexico Avian Community

The southern Gulf of Mexico (to the northern shores of the Yucatán) differs from the northern coast because of differences in temperature and physiognomy, which supports tropical vegetation and avifauna. From a Mexican perspective, the Gulf of Mexico is extremely important because approximately 60 % of Mexico's watersheds drain into the waters of the Gulf (Gallardo et al. 2004). Estuaries, lagoons, and other wetlands represent 30 % of the Mexican Gulf coastline; the Lagoon system at Alvarado, Veracruz has 26 % of the bird species present in all of Mexico (Gallardo et al. 2004). The extensive mangroves along the southern Gulf coast provide important habitats for foraging and nesting birds.

Lagoons and wetlands fringe the southern Gulf in Mexico, as they do in the United States, and one area, the Laguna Madre in Tamaulipas, contains 15 % of Mexico's migratory aquatic birds. About 82 % of the birds present in Laguna Madre originate in the Nearctic as it represents the southern limit of the range for several species, such as the Bald Eagle, *Haliaeetus leucocephalus*. In contrast, the region from southern Tamaulipas to Campeche

Table 12.4. Species with Distributions That Include the Entire[a] Gulf Coast (after Gallardo et al. 2009)

Common Name	Species Name	Common Name	Species Name
Fulvous Whistling-Duck	*Dendrocygna bicolor*	Semipalmated Plover	*Charadrius semipalmatus*
Wood Duck	*Aix sponsa*	Piping Plover	*Charadrius melodus*
American Wigeon	*Anas americana*	Killdeer	*Charadrius vociferus*
Mallard	*Anas platyrhynchos*	American Oystercatcher	*Haematopus palliatus*
Blue-winged Teal	*Anas discors*	Black-necked Stilt	*Himantopus mexicanus*
Pintail	*Anas acuta*	America Avocet	*Recurvirostra americana*
Green-winged Teal	*Anas crecca*	Greater Yellowlegs	*Tringa melanoleuca*
Ring-necked Duck	*Aythya collaris*	Lesser Yellowlegs	*Tringa flavipes*
Lesser Scaup	*Aythya affinis*	Solitary Sandpiper	*Tringa solitaria*
Masked Duck	[b]*Nomonyx dominicus*	Willet	*Catoptrophorus semipalmatus*
Common Loon	*Gavia immer*	Spotted Sandpiper	*Actitis macularius*
Pied-billed Grebe	*Podilymbus podiceps*	Upland Sandpiper	[b]*Bartramia longicauda*
Wilson's Petrel	[b]*Oceanites oceanicus*	Whimbrel	*Numenius phaeopus*
Masked Booby	*Sula dactylatra*	Long-billed Curlew	*Numenius americanus*
Brown Booby	*Sula leucogaster*	Marbled Godwit	*Limosa fedoa*
American White Pelican	*Pelecanus erythrorhynchos*	Ruddy turnstone	*Arenaria interpres*
Brown Pelican	*Pelecanus occidentalis*	Red Knot	*Calidris canutus*
Double-crested Cormorant	*Phalacrocorax auritus*	Sanderling	*Calidris alba*
American Anhinga	*Anhinga anhinga*	Semipalmated Sandpiper	*Calidris pusilla*
Magnificent Frigatebird	*Fregata magnificens*	Western Sandpiper	*Calidris mauri*
Great Blue Heron	*Ardea herodias*	White-rumped Sandpiper	*Calidris fuscicolis*
Great Egret	*Ardea alba*	Least Sandpiper	*Calidris minutilla*
Snowy Egret	*Egretta thula*	Pectoral Sandpiper	*Calidris melanotos*
Little Blue Heron	*Egretta caerulea*	Dunlin	*Calidris alpina*
Tricolored Heron	*Egretta tricolor*	Stilt Sandpiper	*Calidris himantopus*
Reddish Egret	*Egretta rufescens*	Buff-breasted Sandpiper	[b]*Tryngites subruficollis*
Cattle Egret	*Bubulcus ibis*	Short-billed Dowitcher	*Limnodromus griseus*
Green Heron	*Butorides virescens*	Wilson's Snipe	*Gallinago delicata*
Black-crowned Night Heron	*Nycticorax nycticorax*	Wilson's Phalarope	*Phalaropus tricolor*
Yellow-crowned Night Heron	*Nyctanassa violacea*	Pomarine Jaeger	*Stercorarius pomarinus*
White Ibis	*Eudocimus albus*	Parasitic Jaeger	*Stercorarius parasiticus*
Glossy Ibis	[b]*Plegadis falcinellus*	Laughing Gull	*Larus atricilla*
Roseate Spoonbill	*Platalea ajaja*	Franklin's Gull	[b]*Larus pipixcan*

(continued)

Table 12.4. (continued)

Common Name	Species Name	Common Name	Species Name
Wood Stork	*Mycteria americana*	Ring-billed Gull	*Larus delawarensis*
Osprey	*Pandion haliaetus*	Herring Gull	*Larus argentatus*
Black Rail	*Laterallus jamaicensis*	Lesser Black-backed Gull	*Larus fuscus*
Clapper Rail	*Rallus longirostris*	Gull-billed Tern	*Gelochelidon nilotica*
King Rail	*Rallus elegans*	Caspian Tern	*Hydroprogne caspia*
Sora	*Porzana carolina*	Royal Tern	*Thalasseus maxima*
Purple Gallinule	*Porphyrio martinica*	Sandwich Tern	*Thalasseus sandvicensis*
Common Gallinule	*Gallinula chloropus*	Common Tern	*Sterna hirundo*
American Coot	*Fulica americana*	Forster's Tern	*Sterna forsteri*
Sandhill Crane	*Grus canadensis*	Least Tern	*Sterna antillarum*
American Golden Plover	*Pluvialis squatarola*	Black Tern	*Chlidonias niger*
Black-bellied Plover	*Pluvialis dominica*	Black Skimmer	*Rynchops niger*
Snowy Plover	*Charadrius nivosus*	Belted Kingfisher	*Ceryle alcyon*
Thick-billed Plover	*Charadrius wilsonia*		

The scientific names are those used by Gallardo et al. (2009), not necessarily the most current
[a]The author does not agree with the designation of "entire" for these rare and/or local species
[b]Species may be very rare in Gulf of Mexico

contains mainly aquatic species with neotropical affinities (Correa et al. 2000a, c; Gallardo et al. 2004).

The continental platform off the coasts of Campeche and Yucatán contains reefs and keys (cays or small islands) used by nesting seabirds, including Red-footed Booby (*Sula sula*) and Least Tern, which are both on the Mexican endangered species list (Gallardo et al. 2004). While this region contains neotropical affinities, it is also influenced by the Caribbean (Gallardo et al. 2004). Thus, the Mexican coast has high species diversity because it contains both nearctic resident species (at the end of their southern range) and neotropical species (at the end of their northern range). This parallel pattern has not been given the credit it deserves (Jahn et al. 2004). Both migrants from the north (that pass through the Gulf of Mexico on their way south) and austral migrants from the south (that may migrate as far north as the Gulf in winter) share a common neotropical avifauna (Jahn et al. 2004).

Many Nearctic-Neotropical migrants pass through on their way farther south. Coastal Veracruz is a major migratory pathway for raptors (Ruelas et al. 2000), and the corridor from Texas, through Mexico to the Yucatán, is a major Nearctic-Neotropical migrant route (Rappole 1995). There is also a healthy population of breeding Mottled Ducks along the coast (Perez-Arteaga and Gaston 2004).

As is clear from Figure 12.3, there are more species on the southern Gulf of Mexico coast to Campeche Bank and the Yucatán, than on the northern U.S. Gulf coast. The Campeche Bank is an extensive, submarine continuation of the plateau that forms the Yucatán Peninsula, extending for about 650 km (404 mi) along the western and northern coasts of the Yucatán in the southeastern Gulf of Mexico. The islands used for nesting are located more than 120 km (75 mi) from the mainland and are rarely disturbed by fishermen or recreationists (Tunnell and Chapman 2000). Several species with more tropical ranges nest there, such as Masked Booby, Brown Booby, Red-footed Booby, Magnificent Frigatebird, and Brown Noddy, as well as several other species (Laughing Gull and terns, Tunnell and Chapman 2000). Tunnell and Chapman (2000) suggested that these colonies have remained fairly stable, but they require monitoring and protection. The Campeche Banks is also a stopover site for migrants, and more than a half century ago scientists were concentrating on the number of North American migrants using Veracruz (Loetscher 1955). A fuller description of the ornithology of the Yucatán can be found in Paynter (1955).

12.4 AVIAN USES OF MARINE-LAND INTERFACES

12.4.1 Functional Avian Uses

Birds use marine and coastal habitats in a variety of ways, resulting in overlapping activities, both within and among seasons. Definitions used in this chapter are shown in Table 12.5. A given species can have multiple listings. For example, Laughing Gulls breed on islands along the Gulf coast, and some may remain all year (i.e., residents). However, Laughing Gulls also breed along the Atlantic coast up to New York (Burger 1996a), and in the fall, some migrate through the Gulf of Mexico to Mexico (migrants), while others migrate to the Gulf and remain there as winter residents. They are residents, migrants, and winter visitors. In some cases, status is less clear. Red Knots breed in the Arctic and migrate through the Gulf of Mexico on their way to the Caribbean or South America (Niles et al. 2008): they were spring and fall migrants in Texas (Eubanks et al. 2006). However, recent information indicates that some knots remain the entire winter in Texas and in Florida (Burger et al. 2012a).

12.4.2 Temporal and Spatial Constraints

Birds are constrained by seasonality; most breed in the spring when food supplies are optimal (Weimerskirch 2001) and remain as residents, or migrate when conditions (food, temperature) deteriorate. Seasonal patterns have evolved over time, and there are variations even within a species. More northern members of a species that breed north of the Gulf of Mexico may be migrants that move south through the Gulf, while conspecifics that are resident in the Gulf may remain as year-round residents.

Spatial constraints often have to do with habitat suitability, whether for foraging, courting, breeding, migrating, or overwintering. With few exceptions (such as grebes and others that build floating nests), birds need dry land to breed because they lay eggs and are constrained to their nests during incubation, and often during the chick-rearing phase. Habitat suitability depends on the type and qualities required for each activity, and the stability of the habitats involved.

The most important habitat gradient in the Gulf of Mexico for birds is from open water to upland terrestrial habitats. Because birds are highly mobile, many species can be found anywhere along the gradient. "Normal" distributions change during the year, and can be altered during hurricanes or other inclement weather events. Nevertheless, species show preferences for particular habitats that meet their needs for foraging, roosting, nesting, migrating, and

Table 12.5. Definitions of Terms Used in this Chapter

	Definition of Terms
Breeding	Includes courtship, nest site selection, mate selection, egg laying, incubation, and chick rearing
Migrant	A bird that regularly moves from one region to another and back
Resident	A species that is present throughout the year and thus breeds (when it reaches adult status) and winters in the GoM
Visitor	A bird that may be present in spring, summer, fall, or winter

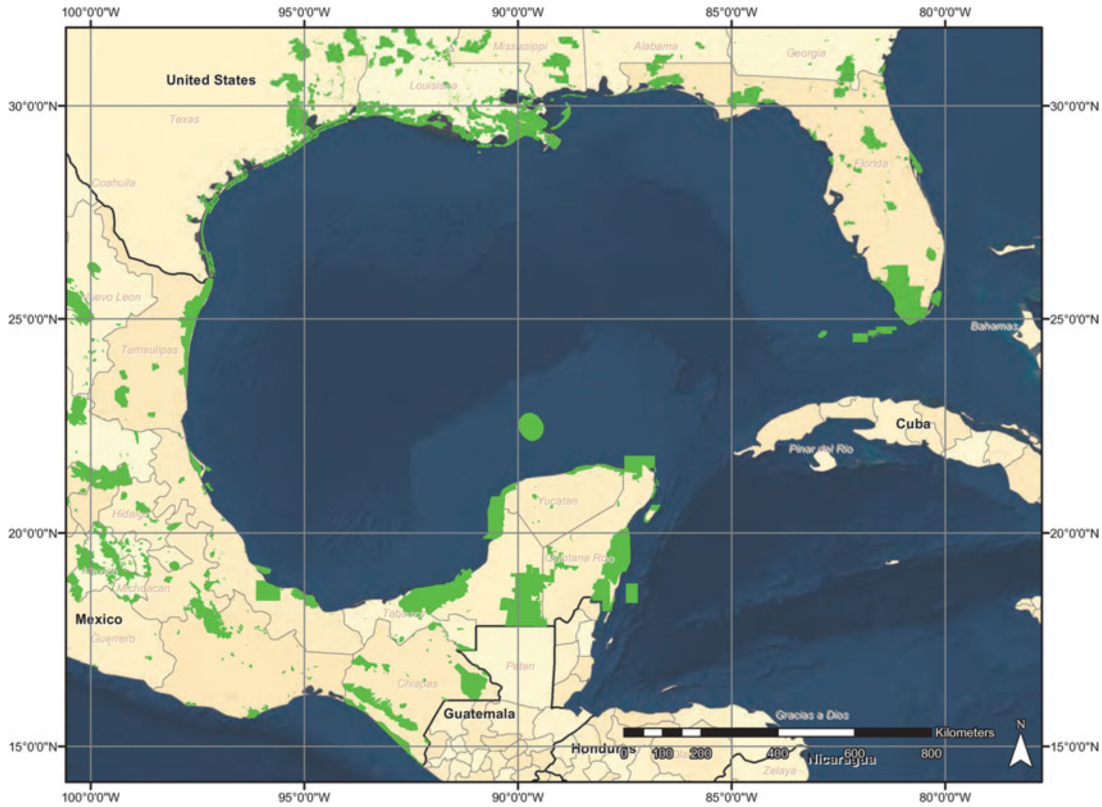

Figure 12.4. Protected coastal areas of the Gulf of Mexico, shown in green. Map courtesy of Wells (2013).

overwintering. Species composition varies along the gradient, and certain species are most likely found in specific habitats. There are also gradients in prey abundance and availability along transects from open water to shallow water, from the water surface to depths, and from the surface into the soil/sediment, depending upon moisture content and salinity. Both spatial and seasonal changes in infauna density determine prey availability for foraging birds. The available habitats, however, are also a function of how much land is protected (Figure 12.4).

12.4.2.1 Habitat Availability

The habitat types available on barrier islands and mainlands include sandy beaches, salt marshes, brackish marshes, freshwater marshes, shrub/scrub, and forests. The National Land Cover Database (2006) has several categories of interest for birds. Maps showing the habitats in each state are presented in Appendix A. In this chapter, they were combined into 11 categories. Most are self-explanatory, but barren land includes rock, sand, and clay, some of which are used by many beach-nesting birds. The three forest types (deciduous, evergreen, mixed forest) were combined (Appendix A). The relative amount of habitat available in each state is shown in Figure 12.5 (10 mile area from the coastline). Texas has a high percentage of woody wetlands, forests, and developed land. Louisiana has the greatest percentage of its coastal area as water and wetlands. Mississippi has mainly open water and wetlands, while Alabama (with the smallest coastal band) has primarily forest and woody wetlands. Florida, with the

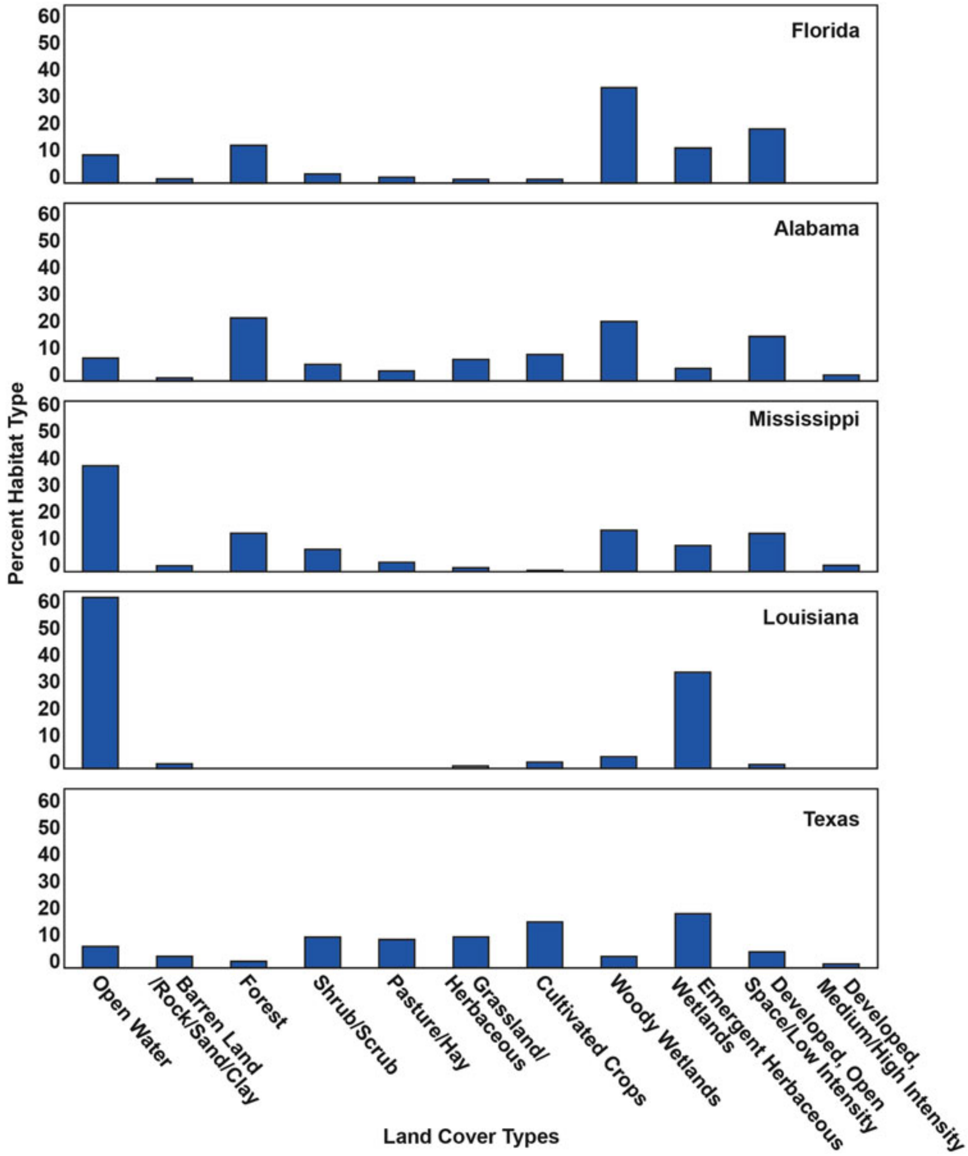

Figure 12.5. Percent of different land cover/land use in the five coastal states, including 10 mile from the Coastline (National Land Cover Database, 2006; computed from data provided by Wells 2013). © by J. Burger.

greatest coastal area, has mainly woody wetlands, developed land, and forests along its coast (Figure 12.5).

Birds have generalized niche requirements that relate to habitat availability. The open waters of the Gulf of Mexico are pelagic, and species living there are normally seabirds and some diving ducks. While winds, currents, and temperatures control the pelagic environment, the landward environments are ruled by tides. Tidal marshes are found in small, narrow pockets

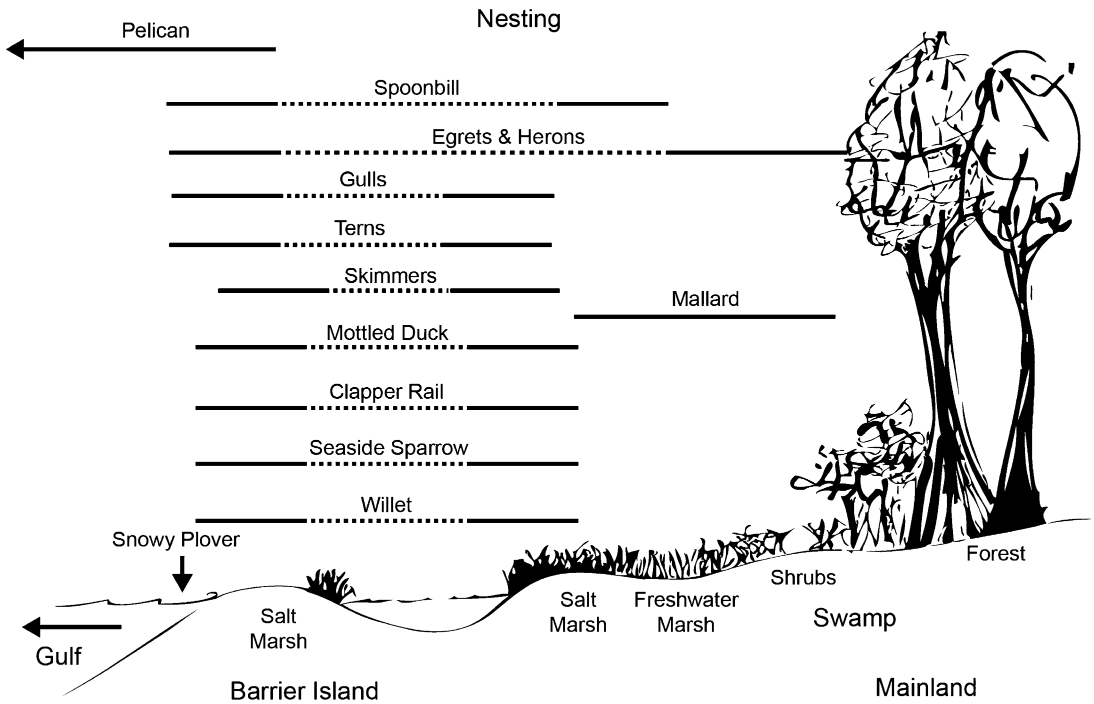

Figure 12.6. Schematic of nesting patterns of birds in the northern Gulf of Mexico. *Solid line* equals where they normally nest, and *dotted lines* connect these habitats. © **J. Burger.**

along coastlines, with the main vegetation being *Spartina* and *Juncus* spp. (Greenberg et al. 2006). The combination of salinity, low floristic and structural complexity, regular tidal fluctuations, catastrophic flooding, and high winds in tidal marshes creates a vulnerable, unpredictable environment, requiring flexibility and adaptability on the part of the birds living there (Greenberg et al. 2006). While tidal marshes support relatively few unique or endemic species of terrestrial vertebrates, some subspecies have differentiated (Greenberg et al. 2006), such as the Louisiana Seaside Sparrow (*Ammodramus maritimus fisheri*) (Gabrey and Afton 2000). Although birds exhibit flexibility in their choice of nesting sites, they prefer particular types of habitats (Wilson and Vermillion 2006). Gulls, terns, skimmers, and shorebirds nest on the ground, usually on bare sand or in places with sparse vegetation, or they build nests in marshes. Pelicans nest on bare ground or in vegetation that is sparse, but tall enough to allow them to maneuver their large bodies underneath it. Herons, egrets, and ibises prefer to nest on low vegetation, particularly in the Gulf, but will sometimes build nests on the ground or in shrubs and trees. Ducks, Willet, and Clapper Rail build nests low in the vegetation or on the ground, usually in marshes. Snowy Plovers and Oystercatchers build nests on open, unvegetated sand, relying on being cryptic to camouflage their eggs. Sparrows and some other songbirds nest in marshes, scrubs, or forests (Moore et al. 1990; Buler and Moore 2011).

A schematic of nesting preferences is shown in Figure 12.6. Wintering birds also have preferred habitats. Figure 12.7 indicates the likely zonation of birds in the winter, which mainly reflects foraging and roosting sites. Habitat use is generally wider during this period as they are not restricted to nest sites.

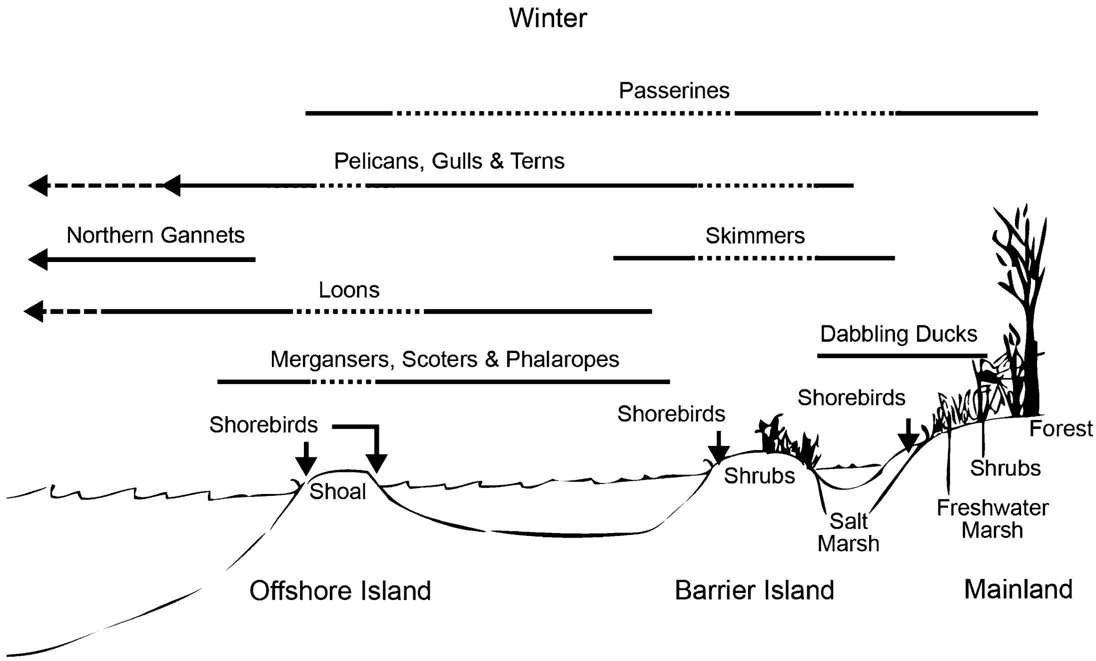

Figure 12.7. Schematic of spatial gradient for birds wintering in the Gulf of Mexico, from open water (pelagic zone) to upland habitats. *Solid line* indicates normal habitat use, *dotted line* indicates area not usually used, and *dashed line* means frequency is less. © J. Burger.

12.4.2.2 Habitat Suitability

Habitat suitability refers to whether a given habitat is usable (or suitable), considering physical, vegetative, and social features, within a context of anthropogenic factors. It is essential to distinguish both interspecific differences and those due to activities (breeding vs. migrating or overwintering; nesting vs. foraging). In the nesting season, birds are tied to their nest site during the incubation period, and non-precocial species are limited to the nest site during much of the chick-rearing phase. The chicks of precocial species (ducks and rails) are able to locomote and search for food shortly after hatching. Chicks that are not precocial (altricial) must be brooded early on because they have no feathers and cannot regulate their body temperature. They are guarded and fed until they are able to forage on their own. This imposes constraints on birds to select nest sites that are removed from the threat of tides, floods, inclement weather, and predators.

A data set for Louisiana-Alabama provides an overview of habitat use by colonial-nesting species (Portnoy 1981). Habitat preferences for common birds normally considered coastal are shown in Figure 12.8 (none with populations below 500). Most of the *Plegadis* species were White-faced Ibis (*Plegadis chihi*). This data set, because it encompassed colonies in three states, can be used to infer habitat preferences (layered upon habitat availability). The patterns reflect choices before the rapid coastal and offshore development of the last 35 years. The Brown Pelican is the only species for which the data are not typical. Because of its sharp decline in the 1950s and 1960s due to pesticides, it had not yet recovered (Wilkinson et al. 1994; Shields 2002). A similar survey in 2001 indicated that 40 % of the active pelican colonies were in saline marshes, 24 % were in freshwater marshes, 22 % were in forested wetlands, and the remainder in scrub, shrub, upland forest, or brackish marshes (Michot et al. 2003).

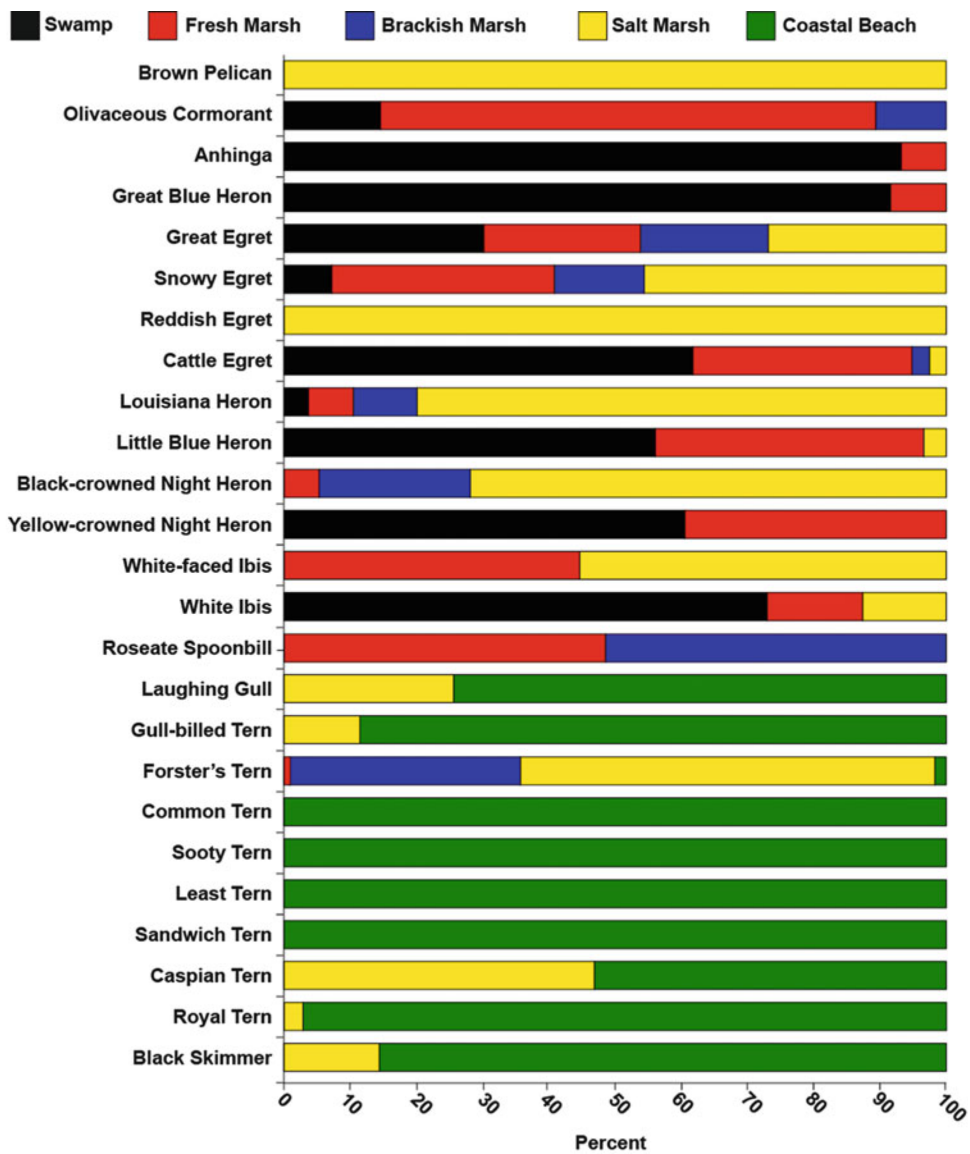

Figure 12.8. Relative habitat use by colonial nesting birds in the Louisiana, Alabama, and Mississippi Coasts of the Gulf of Mexico (after Portnoy 1981). © J. Burger.

Figure 12.8 provides a picture of horizontal nesting stratification from the Gulf landward. Most terns and Laughing Gulls nested on bare sand, and most skimmers nested on sand; although, a few nested in salt marshes. Skimmers and Laughing Gulls sometimes are forced to nest in salt marshes because of competition with other species, lack of available beaches, or human disturbance (Burger and Gochfeld 1990). Forster's Terns always nest in marshes (McNicholl et al. 2001).

Habitat use for nonbreeding birds is a function not only of habitat structure and vegetation types but also of prey types and foraging methods. Seabirds capture prey by a variety of methods, including plunge-diving for fish or invertebrates, surface-plunging, hop-plunging, hover-dipping, and picking food items off the surface of water, although gulls and some other

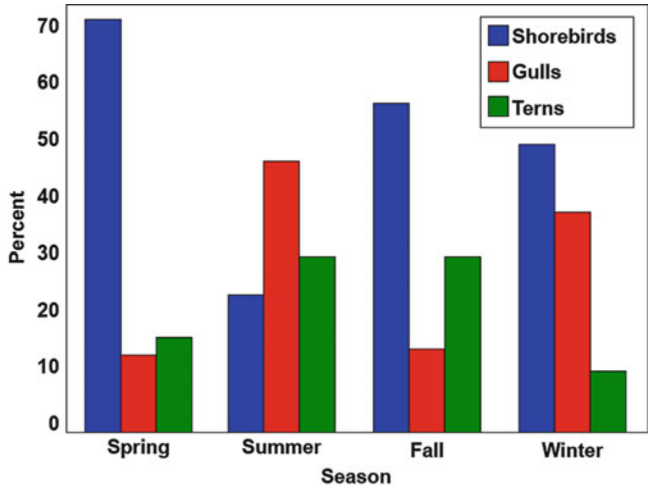

Figure 12.9. Seasonal use of beaches by shorebirds, gulls, and terns in Padre and Mustang Islands, Texas in 1979–1981 (after Chapman 1984). © J. Burger.

seabirds pick up fruit or insects from the ground, follow boats, scavenge on offal along the shore, pirate food from other seabirds, and forage at landfills (Ashmole 1971; Sealy 1973; Burger and Gochfeld 1981; Shealer 2001). In the Gulf, gulls, terns, and skimmers forage in pelagic waters, shallow tidal creeks, and behind boats or near other human activities, as well as at landfills (garbage dumps), inland lakes, and impoundments (Burger 1987a, 1988a; Burger and Gochfeld 1983a; Patton 1988). Ducks breed mainly in marshes or in distant uplands, but spend the winter in coastal areas or in nearshore environments. Some ducks form large flocks on the water and forage on the open sea (diving ducks), while others feed at the marine-land interface in bays, estuaries, marshes, fields, and other terrestrial habitats (dabbling ducks). Herons, egrets, and ibises breed on islands and along coastal areas, and feed in intercoastal habitats; they do not feed in open water as most forage while standing. Shorebirds feed along the shoreline on the mainland, along barrier islands, or around offshore islands. Their feeding method of picking up items from the sand, from shallow water, or along wrack lines, ties them to the narrow band along the shoreline.

Species diversity varies within close habitats, partly as a function of time of day, tide stage, and tide height (Withers 2002). Habitat use can be examined by season, particularly for beach habitats where birds forage and roost throughout the year, as well as during migratory stop-overs. Chapman (1984) examined seasonal use of beaches on Padre and Mustang Island barrier beaches (Figure 12.9).

This figure shows the relationship among species groups by season. Shorebirds made up the largest component in the spring, fall and winter, while gulls made up the largest component in the summer.

12.4.2.3 Mobility and Habitat Suitability

The flight abilities and inclinations to migrate or disperse are variable in birds. Seabirds are the most mobile, and are likely to fly the greatest distances from their nest sites to forage, and some circumnavigate the globe in the nonbreeding season. Many seabirds nest on offshore islands far removed from predators, such as Campeche Bank off the Yucatán (Tunnell and Chapman 2000), or on the Dry Tortugas (Dinsmore 1972), and show very high nest and colony site fidelity. Seabirds that nest on less stable coastal islands shift colony sites as conditions dictate, but have high site fidelity if colony sites remain unchanged (Buckley and Buckley 1980; Coulson 2001).

Pelicans, herons, egrets, and ibises that nest in coastal colonies use the same sites as long as they remain safe from predators and are suitable. For many species, nest site requirements drive their choice of colony site, and they will continue to nest there if the sites remain stable. In some cases, long-term stability is enhanced by habitat modification, as happened on Queen Bess Island for pelicans (Visser et al. 2005). In other cases, stability is reduced by erosion and loss of space.

For some species, choice of colony site is dependent upon foraging opportunities. Roseate Spoonbills depend upon periodic drawdown and flooding to produce pools with high prey availability (Kushlan 1979). While other herons and egrets also depend on such resources, the dependence is not as strong. White Ibis are more nomadic, both in foraging behavior and in nesting behavior (Frederick et al. 2009). They also require dry down and the concentration of suitable prey (Frederick et al. 1996). The combination of nesting and foraging habitat requirements leads to shifting colony locations for these species, and they may move hundreds of kilometers between different years. Other species are quite sedentary and are not likely to fly long distances. This has the effect of isolating populations, which can lead to subspecies. For example, Seaside Sparrows living along the Gulf are resident and do not fly long distances. Separate populations can become isolated, and if they disappear recolonization is unlikely unless there is a population nearby to provide founders (individuals to colonize).

12.5 FACTORS AFFECTING AVIAN POPULATIONS

Several factors affect populations, and provide a basis for understanding the status and trends of birds in the Gulf of Mexico. These include natural environmental factors and anthropogenic events, biological events, and interactions among them. Natural environmental events include storms, hurricanes, tidal regimes and extreme tides, extreme cold, heat or drought, and other normal or extraordinary events, such as global warming. Anthropogenic factors include contamination by oil, heavy metals, DDT, polychlorinated biphenyls (PCBs), and other pollutants (e.g., endocrine disruptors), as well as human disturbance (Coste and Skoruppa 1989). Biological stressors include social interactions (competition, cooperation, social facilitation), predation, infestations (ticks, mites), disease, and invasive species. Global change (warming, sea level rise, subsidence) is a physical change that has anthropogenic causes (Solomon et al. 2007; Edenhofer et al. 2011). Finally, intrinsic factors can affect survival and other aspects of population dynamics, including age, sex, and molt stage. For example, Common Loons are particularly vulnerable during molt while overwintering in the Gulf of Mexico (NW Florida, Alexander 1991). Coastal birds of the Gulf affected by storm events include large colonial nesting species such as Brown Pelican, beach-nesting terns and gulls (Caspian Tern, Royal Tern, Sandwich Tern, Least Tern, Laughing Gull, Black Skimmer), beach-nesting shorebirds (American Oystercatcher, Willet, Wilson's Plover, Snowy Plover), large wading birds (Reddish Egret, Roseate Spoonbill, ibises, herons, egrets), marsh birds (Mottled Duck, Clapper Rail, Black Rail, Willet, Seaside Sparrow), migratory shorebirds (Red Knot, plovers, sandpipers), and migratory songbirds on small barrier islands or coastal shrubs (warblers, orioles, buntings, flycatchers). Offshore seabirds can be affected if nesting islands are impacted (e.g., Magnificent Frigatebird) or if foraging space is reduced or rendered unusable (Northern Gannet).

The following sections are not meant to be exhaustive, but rather to illustrate the range of factors affecting birds using the Gulf of Mexico that must be considered for conservation, management, monitoring, or other purposes. More in-depth discussions can be found in chapters in Burger et al. (1980) and Schreiber and Burger (2001a) for seabirds, Kushlan and Hafner (2000a) for herons, and Moore (2000b) for Passerine migrants.

12.5.1 Habitat Loss

The availability of habitat is a prime characteristic determining nesting and foraging distribution and abundance of birds. Vegetation dispersion and land elevation determine where most birds can nest around the Gulf, while water depth and emergent vegetation influence where water birds, such as shorebirds, herons, and egrets, can forage (Lantz et al. 2010, 2011). Coastal wetlands are increasingly threatened because of development, increased use of beaches, and the continual movement of people to coasts (NOAA 2004). This has led to population declines for birds living there (Delany and Scott 2006). Many factors discussed later in this section affect habitat availability and habitat suitability. All the other threats discussed in the following sections act in concert with habitat loss, amplifying the effects of each. Overall, the U.S. coastline along the Gulf of Mexico has lost 1.2 % of intertidal wetlands (44,810 acres) in only 6 years (1998–2004, Stedman and Dahl 2008).

Louisiana provides the premier example of wetland loss. Louisiana's coasts encompass more than 9.3 million acres of barrier shorelines, swamps, and marshes (Lindstedt 2005). It contains 30 % of the remaining coastal wetlands in the continental United States, yet these wetlands are disappearing rapidly (Field et al. 1991; O'Connell and Nyman 2011). Louisiana coastal wetlands once hosted 77 % of the U.S. breeding population of Sandwich Tern, 52 % of Forster's Tern, 44 % for Black Skimmer, 16 % for Royal Tern, and 11 % for the Laughing Gull (Visser and Peterson 1994). Thus, loss of wetlands that decrease nesting habitat for species will have a significant effect on their overall populations in the United States.

The Coastal Prairie Ecosystem of east Texas and Louisiana has especially suffered losses. Many obligate grassland species breed there or stop over during migration. Losses due to degradation from fire suppression, agricultural practices, and invasive species have resulted in this habitat being globally imperiled (Barrow et al. 2005, 2007). Narrow, elongated patches embedded within these grassy marshes (oak forest patches called cheniere) provide critical stopover areas for migrant songbirds going in both directions over the Gulf of Mexico (Barrow et al. 2007). Anthropogenic and natural disturbances (hurricanes, invasive plants, industrial and residential development, and conversion to cropland) have shrunk cheniere habitat to less than 1 % of the historic presettlement area.

12.5.2 Invasive Species

Invasive species are a great concern because plant invasive species affect habitat quantity and quality, which affects avian distribution. For example, *Phragmites*, spreading into areas once dominated by salt marsh species such as *Spartina* (Greenberg et al. 2006), favors generalists over avian salt marsh specialists (Benoit and Askins 1999). In the Gulf, shifts between *Juncus* and *Spartina* stands can greatly influence the marsh-nesting birds that persist and breed successfully (Rush et al. 2009b). Increases in the nonnative Eurasian Watermilfoil (*Myriophyllum spicatus*) coincided with a 96 % decline in waterfowl populations in the Mobile-Tensaw Delta, Alabama (Goecker et al. 2006). It has largely replaced the native submerged aquatic vegetation (SAV), Wild Celery (*Vallisneria americana*), as the dominant species. Wild Celery was the preferred food of waterfowl in the region (Goecker et al. 2006). However, comparison of six surveys with historic data for waterfowl did not indicate a strong association of the invasive SAV with waterfowl declines. Another important invasive species is the Chinese Tallow tree (*Sapium sebiferum*), particularly in East Texas, Louisiana, and Mississippi (Oswalt 2010), where it forms monospecific stands (Bruce et al. 1995). Tallow seeds are spread by birds such as Red-bellied Woodpeckers (*Melanerpes carolinus*), robins (*Turdus migratorius*), and bluebirds (*Sialia sialis*) in Louisiana and elsewhere along the Gulf (Renne et al. 2002).

The Cattle Egret is one of the most invasive species in the Gulf and along the Atlantic Coast. Native to Africa, the first Cattle Egrets bred in North America in the mid-1940s. Since then, they have expanded dramatically, displacing many native egrets and herons from their traditional breeding colonies. While their spread has caused local declines in native species in traditional colony sites, it is unclear whether Cattle Egrets have generally impacted the populations of native species in the Gulf.

12.5.3 Food Resources

Food resources affect every aspect of avian life, including survival, reproduction, migration, habitat use, and even their response to inclement weather and predators. While availability of food resources is often tied to habitat availability, food will not be available if suitable habitat for the prey is not available, and food resources can be limited even when foraging habitat is not. That is, when vegetation fails to provide adequate food resources, prey can be depleted, or both vegetation types and prey types cannot be optimal or can be difficult to access or capture. For example, fish may be present for birds, but if they are unavailable because they are too deep in the water column, difficult to see or capture, or are in low densities, they may not provide an adequate food base.

Wading birds forage at different water depths, related to leg length (Powell 1987). As expected, long-legged waders forage in a greater diversity of water depths than can shorter-legged birds. The smallest species, such as the Little Blue Heron, Snowy Egret, and White Ibis, have a maximum foraging depth of 16–18 centimeters (cm), medium-sized species (Reddish Egret, Great Egret, Roseate Spoonbill) have a maximum foraging depth of 20–28 cm, and the large Great Blue Heron has a foraging depth of 39 cm (Powell 1987). Species foraging in the Gulf of Mexico exhibit both horizontal and vertical spatial patterns.

Part of foraging habitat stratification is a result of the distance birds will fly to forage away from their nest sites. Gulls and terns, for example, will fly farther than herons or egrets, and both will fly farther than Clapper Rails or Seaside Sparrows. Food resources and foraging methods differ among species as a function of species size and foraging methods, as well as age within species (Brown 1980; Burger and Gochfeld 1983b; Burger 1987a; Shealer 2001).

Songbirds depend upon microhabitats that harbor the invertebrates and fruits they consume, both during the breeding season and during migration (Barrow et al. 2007). These habitats can be destroyed not only by direct habitat destruction, but also by natural and anthropogenic forces, such as fire and hurricanes (Barrow et al. 2007).

12.5.4 Tides, Hurricanes, and Other Weather Events

Weather and unusual weather events are one of the driving forces that affect reproductive success, foraging behavior, migrating, over-wintering, and timing of life-cycle events, as well as seasonal and long-term behavior, physiology, and population trends (reviewed in Schreiber 2001). The Gulf of Mexico has relatively shallow tidal swings (generally less than 1 meter [m]; Conner et al. 1989), which makes very high tides less predictable. In most cases, birds select the highest places to nest. This is especially true for marsh nesting birds, such as solitary-nesting species (e.g., Willets; Burger and Shisler 1978; Lowther et al. 2001) and colonial species (e.g., Laughing Gulls; Burger and Shisler 1980; Burger 1996a). Very high tides, usually associated with hurricanes, other storms, or winds, reduce reproductive success by flooding out nests, eggs, and chicks in ground-nesting species. Tidal effects decrease hatching and fledging rates, and synchronize breeding behavior with lunar cycles (Shriver et al. 2007).

Hurricanes are episodic, high-energy events that accelerate routine processes (erosion, accretion) and activate others (formation of washover fans, Conner et al. 1989). Over the long term, hurricanes can create and destroy suitable habitat for nesting, foraging, and roosting. The immediate impacts of hurricanes include direct mortality from exposure to winds, rain, and storm surge (Butler 2000), as well as decreased nesting habitat for species nesting in low-lying areas, and decreased food availability for migrants, particularly songbirds in the Gulf (Dobbs et al. 2009). Some habitats are particularly vulnerable, such as low-lying barrier islands and cheniere forests. These forests suffer both short- and long-term effects, which in turn decrease foraging habitat for breeding and migrant songbirds (Barrow et al. 2007). Effects of hurricanes on habitat and substrate (leaves vs. bark) can be felt during, immediately after, and up to a year after the event (Dobbs et al. 2009).

While immediate impacts change vegetation, destroy low-lying habitats, and decrease animal populations, species can sometimes recover (Conner et al. 1989). Avian recovery from hurricanes can occur only if suitable areas are available for nesting or foraging. Immediate effects of hurricanes and other severe storms include being blown off course or forced to land (migrants; DeBenedictis 1986), and injury or death to nests, eggs, chicks, and even adults (Marsh and Wilkinson 1991).

Flying birds can flee an oncoming storm, but nests, eggs, and nonflying young are vulnerable to immediate wash-outs, cold stress, and drownings. There are often lasting effects on growing chicks that survive hurricanes. Although young Sooty Terns nesting on the Dry Tortugas (70 mile west of Key West in the Gulf) suffered abnormal growth, Brown Noddies were comparatively unaffected (White et al. 1976). Even adult Passerines can show effects following hurricanes, perhaps due to differences in prey availability (Waur and Wunderle 1992). Shorebirds can also decline following hurricanes due to habitat degradation (Marsh and Wilkinson 1991). Understanding relative vulnerability of different species to hurricanes and other severe storms may provide insights into relative population numbers, population declines, and shifts in habitat use, and can inform management and conservation.

Storms are often associated with mass mortality incidences of enroute migratory birds, including grebes (Jehl et al. 1999), eagles (Newton 2007), shorebirds (Roberts 1907), ducks (Schorger 1952), and various Passerines (Webster 1974; King 1976). One storm killed an estimated 40,000 migrant birds of 45 species on one day—the largest kill recorded for the Gulf at that time (Wiedenfeld and Wiedenfeld 1995). Weather, in conjunction with food supply, adversely affects body weight at migration time, which then affects resighting probability (indicative of survival differences), and subsequent breeding success (Newton 2006). Birds for which these effects have been found include shorebirds (Pfister et al. 1998; Baker et al. 2004), ducks (Pattenden and Boag 1989; Dufour et al. 1993), and Passerines (Smith and Moore 2003). Birds stressed by weather and a shortage of food, particularly small Nearctic-Neotropical Passerines, are often vulnerable to predators (Moore et al. 1990). Weather events, however, usually function on the large spatial scale of migration as well as affect food availability (Moore 2000b). Weather events have the potential to increase or decrease the effect of other stressors; strong winds and currents can increase the movement of pollutants and can also force oil or other contaminants further onto islands or into marshes or mangroves. Weather events, alone, however, have not caused long-term avian population declines in the Gulf because such adverse events are usually limited in space and time.

12.5.5 Climate Change, Sea Level Rise, and Land Subsidence

Climate change affects temperature, precipitation patterns, oceanic and atmospheric circulation patterns, sea level rise, and frequency, distribution, and intensity of storms, hurricanes and other weather events (Michener et al. 1997; Root et al. 2003). The Intergovernmental Panel on Climate Change (Edenhofer et al. 2011) predicts that global temperatures will rise 1.4–5.8°Celsius (°C) by 2100, an increase that is probably without precedent in the last 10,000 years. Changes can occur in the means and the extremes of temperatures and precipitation, in the length of seasons, the timing of spring, and the frequency of catastrophic events. Warmer temperatures would result in melting of glaciers and acceleration of sea level rise, which in turn would flood low-lying islands used for nesting. For example, assuming a conservative global warming scenario of only 2°C over the next century, Galbraith et al. (2005) predicted that major intertidal habitat losses for shorebirds in bays in Washington, California, Texas, and New Jersey/Delaware would range from 20 to 70 %. Such habitat losses may be large both spatially and temporally and could negatively affect avian populations in the Gulf and elsewhere if they continue. Climate change has already affected the timing of migration and breeding in some Nearctic-Neotropical migrants (Marra et al. 2005).

Changes in the timing, frequency, and intensity of storms and hurricanes can alter coastal hydrology, geomorphology, and nutrient structure, leading to changes in vegetative structure (Michener et al. 1997), which in turn will markedly affect bird use of coastal areas. Birds can adapt to slow changes more easily than to extreme events (van de Pol et al. 2010). Rush et al. (2009a) conducted censuses of birds nesting in coastal marshes of Alabama and Mississippi and found that Seaside Sparrows and Clapper Rails nested in habitats with higher salinity than did Least Bitterns (*Ixobrychus exilis*). Their models indicated that coastal alterations, sea level rise, and landward changes in habitat and salinity will lead to population increases in the former two species and declines in Least Bittern.

12.5.6 Predation, Competition, and Other Social Interactions

Social effects on survival, including competition, cooperation, and predation, are reviewed in Burger (1988b, c), Nettleship et al. (1994), and Coulson (2001). Predation pressures are often cited as the primary reason for colonial, ground-nesting species to select islands far removed from predators (Burger 1981a, 1982; Wittenberger and Hunt 1985; Coulson 2001). Predation pressures are lowest for species nesting on distant offshore islands that do not have mammalian predators, and highest for ground-nesting species on barrier islands or the mainland that are exposed to a full range of predators. Predation pressure is one of the main factors influencing colony site selection for island nesting seabirds in coastal Louisiana (Greer et al. 1988). While mammalian predators influence nesting patterns for ground- and low-nesting species, avian predators (e.g., Great Horned Owl, *Bubo virginianus*, hawks, grackles) can affect many species of birds in different habitats (Skoruppa et al. 2009).

Although birds have evolved with predators, the predator landscape has shifted with increased human occupation of the coasts. Human commensals (dogs, cats, rats) live with people in coastal communities, and people bring dogs and cats when they visit the shore: worldwide, cats are the most important predators on bird eggs and young (Nettleship et al. 1994), even on relatively remote islands such as Campeche Banks, Mexico (Howell 1989). People also inadvertently increase native predator numbers by leaving garbage out, which results in increased numbers of raccoons (*Procyon lotor*) (Burger and Gochfeld 1990), and presumably coyotes (*Canis latrans*) as well. Both are predators on some Gulf Coast barrier islands (W. Tunnell, Texas A&M University—Corpus Christi, personal communication), and if their populations increase all along the Gulf Coast, including on small, barrier islands used by nesting birds, they could seriously impact avian populations.

Competition for nest sites is often mediated by differences in arrival times, age, or size (Burger 1979a, b, 1983). Some of these factors also affect competition for foraging space or prey types (Burger 1987a; Burger and Gochfeld 1981, 1983c). Whenever prey stocks are depressed, often due to human overfishing, seabirds relying on them will also decline (Overholtz and Link 2007). Age-related differences in foraging behavior occur in many different species. For example, in the Gulf of Mexico, there were age-related differences in the success of frigatebirds pirating from Laughing Gulls in Seybaplaya, Campeche (Mexico, Gochfeld and Burger 1981), in Laughing Gulls foraging in Texas and Mexico (Burger and Gochfeld 1981, 1983c), and in Black-necked Stilts feeding in Texas (Burger 1980). Many fishery operations enable piracy because the concentrated food draws a range of species, and food items are too large to handle quickly (Furness et al. 1988).

Nesting in colonies has both negative and positive advantages (Gochfeld 1980; Burger 1981a, b; Coulson 2001). Advantages include social facilitation of breeding activities, early detection of predators, antipredator behavior, and information transfer about food sources (Ward and Zahavi 1973; Flemming and Greene 1990). Disadvantages include increased competition for food, competition for nest sites, and conspicuousness of colony members to predators (Furness and Birkhead 1984). Nesting in mixed species colonies increases the advantages (increased predator protection), while decreasing the disadvantages (competition for food resources or space; Burger 1981a, 1984a, b). Social facilitation, whereby one species derives a benefit from nesting with another, is one advantage of nesting in mixed species colonies (Gochfeld 1980; Coulson 2001). For example, Black Skimmers derive advantages from nesting with terns and gulls that mob predators to drive them from colonies, thereby protecting the nests, eggs, and chicks of skimmers from predation (Burger and Gochfeld 1990).

12.5.7 Parasites and Disease

Birds are exposed to numerous parasites and diseases, but only a few Gulf examples will be given here to illustrate possible incidences and effects. Garvin et al. (2006), examining blood parasites of Nearctic-Neotropical Passerines during spring migration in the Gulf coast, found that 21 % of 1,705 migrant Passerines were infected with one or more blood parasites. Helminth (parasitic worms) infections are quite common in Brown Pelicans along the Gulf coast, and although the effects of infections are unclear at times (Dyer et al. 2002), stressed pelicans can show the effects of parasitism (Grimes et al. 1989; Dronen et al. 2003). Similarly, 22 species of endohelminths were found in Willets collected from Texas (Dronen et al. 2002), and several platyhelminthes species (*Clinostomum* sp., *Mesotephanus* sp., *Galactosomum* sp.) were reported from shorebirds (Cormorant, Great Egret, Laughing Gull, and Pelican) in Tampa Bay and Boca Grande in Florida (Hutton and Sogandares-Bernal 1960). Nematodes (*Contracaecum* spp.) cause lesions in the proventriculus of Brown Pelicans and Double-crested Cormorants (*Phalacrocorax auritus*), and occasionally other water birds in Louisiana. The impact of harmful algal blooms (red tides) on marine bird populations has been demonstrated. Brevetoxin, a potent neurotoxin produced by the red tide dinoflagellate (*Karenia brevis*, formerly *Gymnodinium*), was found in tissues of dead Double-crested Cormorants (Kreuder et al. 2002) and in Royal Terns and Laughing Gulls (Vargo et al. 2006) in the Gulf coast region.

12.5.8 Pollutants

The land-margin interface is particularly vulnerable to pollutants, fertilizers, and wastes that flow from associated watersheds (Greenberg et al. 2006), such as from the Mississippi River (NOAA 2011). While a "dead zone" (area of hypoxia) occurs off the Louisiana and Texas Coast (NOAA 2011), its effects on overall avian populations in the Gulf have not been demonstrated.

Birds are indicators of contaminants (Sheehan et al. 1984; Fox et al. 1991; Peakall 1992; Burger 1993; Custer 2000; Burger and Gochfeld 2001, 2004a, b), because of the potential for contaminants to cause chronic effects and population declines, as well as acute mortality and other impairments (reviewed in Monteiro and Furness 1995; Rattner 2000; Burger et al. 2002). Effects have been demonstrated in both laboratory (Burger and Gochfeld 2000, 2005; Spalding et al. 2000a; Hoffman et al. 2011) and field studies (Burger and Gochfeld 1994; Frederick et al. 1999; Jackson et al. 2011). While most pollutants are anthropogenic in nature, oil and mercury also can come from natural sources. Oil seeps were known from the Gulf of Mexico long before Western colonization (Geyer 1981).

Mercury occurs naturally in seawater and also comes from anthropogenic sources (Wolfe et al. 1998; O'Driscoll et al. 2005). Comparisons of museum specimens of feathers from wading birds nesting in the Everglades from 1920 to the 1970s indicated that samples taken during the 1990s had mercury levels that were 4–5 times higher than feathers from specimens collected before 1970 (Frederick et al. 2004), indicating an anthropogenic source. Fish-eating birds are particularly vulnerable to the effects of methylmercury because it accumulates in fish. Birds that eat large fish with the highest mercury levels are most at risk (Pinho et al. 2002; Storelli et al. 2002; Burger 2009; Burger et al. 1994, 2011; Frederick et al. 1999, 2004). Common Loons (Burger et al. 1994; Burgess et al. 2005; Burgess and Meyer 2008; Evers et al. 2008), raptors (Albers et al. 2007), and songbirds (Jackson et al. 2011) are species with high mercury levels that have impaired reproduction, with possible population declines.

Ducks, such as Mallards, were once affected by seed treated with mercury (Krapu et al. 1973; Heinz 1976a, b). The toxic effects of methylmercury, particularly reproductive and neuro-behavioral deficits, have been demonstrated in the laboratory (Heinz 1979; Spalding et al. 2000b) and in the field (Frederick et al. 1999). Mercury levels in eggs from some Great Egrets in the Everglades exceeded effects levels found in the laboratory (Rumbold et al. 2001). Sensitivity to methylmercury varies greatly among species (Heinz et al. 2009). Several reviews discuss contaminants in birds in general, or of the species groups discussed in this chapter (e.g., Burger 1993; Hoffman et al. 1995; Beyer et al. 1996; Burger and Gochfeld 2001; Frederick et al. 2002; Custer 2000), but there have been no clear demonstrations that mercury levels in birds in the Gulf have affected avian population levels.

Other metals, or metalloids, including lead (Burger and Gochfeld 1994) and selenium (Ohlendorf et al. 1986, 1989) also affect bird behavior, development, and survival. Natural experimentation with Little Blue Herons in southern Louisiana wetlands (West Baton Rouge) indicated that chicks exposed to cadmium in their foods had significantly slower growth rates than nonexposed chicks, and exposure to lead was correlated with increased nestling mortality (Spahn and Sherry 1999). However, population effects from these experiments are not shown.

Brown Pelicans are the poster bird for the effects of DDT on population levels. Pelicans declined from about 5,000 individuals in Texas in the early 1960s, to fewer than 20 individuals by 1974 (King et al. 1977). Eggshell thinning, caused by the endocrine disruption effects of DDT, led to total reproductive failures (Blus et al. 1974). After DDT use was banned in the United States, pelican populations increased (King et al. 1985), and they are no longer federally listed as threatened or endangered. Similarly, high residues of organochlorine pesticides and

PCBs were found in Black Skimmers (Custer and Mitchell 1987), cormorants, and gulls (King and Krynitsky 1986), and other waterbirds from Texas (Mora 1995, 1996), and in Great Egrets from other locations (McCrimmon et al. 2011). However, population declines of gulls, skimmers, egrets, and other waterbirds from the Gulf have not been demonstrated from organochlorine pesticides. Pelican populations have increased dramatically in the Gulf since the banning of DDT (see Pelican in Indicator Species, Section 12.6.1).

Oil contributes to foraging difficulties, lowered reproductive success, and mortality, especially in seabirds (Piatt et al. 1990). The effects of oil discharges could be acute (mortality) (Dunnet 1982; Hunt 1987; Burger 1994a, 1997a, b; Lance et al. 2001; Payne et al. 2008; Wiens et al. 1996), or chronic, including the effects from operational oil discharges that affect marsh structure (McCauley and Harrel 1981; Mendelssohn et al. 1990; Fraser et al. 2006). Effects of oil include cessation of growth in chicks, osmoregulatory impairments, hypertrophy of hepatic, adrenal, and nasal gland tissue (Miller et al. 1978), reduced thermoregulation (O'Hara and Morandin 2010), reduced survival of chicks (Trivelpiece et al. 1984), and changes in hematology and blood chemistry (Newman et al. 2000). Macko and King (1980) found that oil from the Libyan crude oil spill in Redfish Bay, Texas (1976) caused significant embryo mortality in Louisiana Heron eggs, but did not affect hatchability of Laughing Gull embryos. Oil also can affect population levels of invertebrate prey, which secondarily affects birds, mammals, and even humans (Lees and Driskell 2007). However, the effects demonstrated for birds nesting along the Gulf coast are on individual birds, and not on populations or species. There is no evidence that oil in the Gulf of Mexico up to 2010 has resulted in declines in avian populations.

Because of oil development and transportation in the Gulf, birds have been exposed to both chronic and episodic spills since the 1970s. One of the first large spills was the Ixtoc I spill of June 3, 1979 in the Bay of Campeche. It released about 30,000 barrels per day, which eventually formed a thick mousse-like emulsion that floated on the surface (Energy Resources 1982). When the oil reached the southern Texas coast in August, it had broken into smaller pieces. As it reached the shore, birds moved to less suitable but unoiled places on the backshore; fewer than 20 % of shorebirds remained on the foreshore (Chapman 1981, 1984). Oiled Sanderlings and Willets spent less time foraging, and more time resting and engaged in preening than unoiled birds (Chapman 1981), which agrees with findings in shorebirds from elsewhere (Burger 1997b; Burger and Tsipoura 1998). There is no evidence, however, that such movements had long-term effects on these migrant shorebird populations in southern Texas.

Plastics and other ocean debris can cause direct mortality and injury, as well as obstruction of the gastrointestinal tract (Day et al. 1985; Azzarello and Van Vleet 1987). Vulnerability of particular birds depends upon their anatomy, methods of digestion, methods of foraging and prey identification, and their distribution geographically relative to shipping lanes, coasts, and oceanographic conditions that control the distribution of marine debris. Some birds, such as gulls, herons, and egrets, can regurgitate plastic that they ingest, although strings, plastic with jagged edges, and hooks can be caught in their esophagus or lodge in the stomach. Seabirds in the order Procellariiformes are most vulnerable to the effects of plastics because they have a small gizzard and cannot regurgitate ingested plastic (Azzarello and Van Vleet 1987). Accumulation of plastic in the stomach impedes absorption, and nonfood items may reduce food intake if the bird's stomach is full (Sturkie 1965). Plastic debris is also a problem near shore, where birds become entangled in fishing line, nets, and strings attached to kites and balloons. One bird can drag back fishing line attached to its feet, and several additional birds in the colony can then get caught in it. Although the presence of plastic debris may impact individual birds, there is no evidence that such debris has impacted avian population levels of birds nesting or migrating through the Gulf of Mexico.

Finally, birds have evolved mechanisms to deal with natural stressors (hurricanes, severe storms, native predators). These mechanisms function unless there are several years with no reproduction (e.g., Pelicans and DDT). In birds, some mortality or decreased reproduction can be compensated for by several mechanisms: (1) higher survival of remaining young or adults, (2) recruitment from elsewhere, (3) higher reproductive success of remaining birds, (4) breeding at an earlier age, and (5) breeding of birds that had not bred in previous years. For example, some young adults are unable to compete for nest sites and these do not normally breed. However, if breeding sites open (due to a mortality event), sub-adult birds, or others previously unable to breed, move in, and overall productivity remains the same.

12.5.9 Management and Physical Anthropogenic Disruptions

Many management practices are employed in coastal areas that impact birds, and many of them are designed to improve conditions for people, including dredging, shoal removal, beach nourishment, beach raking to remove debris or shells, water control, and groins or barriers (seawalls, jetties). In the nearshore and along the shore, wind energy development can impact avian use and distribution. In the Gulf itself, oil and gas development has resulted in the building of thousands of platforms in the northern Gulf of Mexico (Russell 2005). These platforms provide habitat for foraging birds that use them as roosting sites or as hunting perches (raptors). However, they also have the potential to disrupt songbird migration, especially for birds leaving the Yucatán Peninsula (Morrison 2006).

Dredging is performed to deepen channels and harbors, and the disposition of dredge spoil can have positive and negative effects on birds (Shabica et al. 1983; Guilfoyle et al. 2006). Some dredging can remove habitat, but soil deposition can create nesting habitat for Piping Plovers (Webster 2006), Least Terns (Golder et al. 2006), and Black Skimmers (Burger and Gochfeld 1990). Species of high concern with respect to dredging (both foraging and nesting) include Snowy Plover, Wilson's Plover, American Oystercatcher, Willet, Royal Tern, Least Tern, and Black Skimmer, among others (Hunter 2006).

Marshes are burned in southwestern Louisiana and Texas during the winter to favor waterfowl (Lynch 1941; Gabrey and Afton 2000). The timing of burning and the spatial extent are critical factors influencing how a given species responds to burning. For example, Louisiana Seaside Sparrows decreased in burned areas during the first breeding season, but increased during the second (Gabrey et al. 1999; Gabrey and Afton 2000).

Marsh terracing is intended to slow marsh erosion, increase marsh edge, and possibly increase bird numbers. Louisiana has 75 % more wading and dabbling birds in terraced marshes than in non-terraced marshes, but terracing did not increase bird diversity (O'Connell and Nyman 2011). Terracing slightly increased the number of herons, egrets, ibises, gulls, and terns, but it dramatically increased the number of waterfowl and Moorhens (*Gallinula chloropus*) (O'Connell and Nyman 2011).

Other managed coastal habitats in the Gulf, such as rice fields, are used by wintering waterfowl (Day and Colwell 1998; Link et al. 2011) and wading birds (Acosta et al. 1996, 2010). In Cuba, White Ibis, as well as other wading birds, concentrated in rice fields because they provided an abundance of fish, crabs, and aquatic insects (Acosta et al. 1996). Nesting on gravel rooftops, as Least Terns do in northwestern Florida and elsewhere (Gore 1991; Zambrano et al. 1997), is a prime example of using man-made habitats. Fisheries operations, such as processing, canning, and fishing itself, provide offal and other food for seabirds and coastal waterbirds (Shealer 2001; Montevecchi 2001).

12.5.10 Direct Human Activities

Habitat loss is often accompanied by increases in human activities that can affect nesting assemblages, habitat choice, foraging behavior, and reproductive success (Buckley and Buckley 1980; Erwin 1989; Burger 1994b; Carney and Sydeman 1999; Burger et al. 2004, 2007). In many cases, however, birds habituate to the presence of humans, and sometimes become more aggressive (Safina and Burger 1983; Vennesland 2010), as they do at landfills (Pons and Migot 1995). Closing landfills, however, can decrease reproductive success and survival of young birds that have difficulty foraging in other situations (Pons and Migot 1995).

The effects of increased human disturbance can be illustrated by a study of coastal birds over a three-decade period on Mustang Island, Texas (Foster et al. 2009). At the beginning of the study, an average of 19 people per day were observed on the beach, but it increased to 75 people per day by the early 1990s, and then rose to nearly 100 per day (Foster et al. 2009). Foster et al. (2009) found that some species increased significantly (Brown Pelican, Laughing Gull), but many more decreased significantly (Table 12.6). They attributed the changes to human disturbance.

Disturbance includes direct approaches, inadvertent destruction of eggs or chicks, interruption of foraging or roosting, and increased presence of dogs, as well as indirect effects, such as increased mammalian predators because of provisioning of food (Burger 1991b; Maslo and Lockwood 2009). Increased human disturbance can even delay the initiation of egg laying in Black Skimmers (Safina and Burger 1983), which has consequences if food is less available later in the season. Data on the complex interactions between species, species size, species density, and the presence of people and other disturbances bear further examination with shorebirds along the Gulf Coast. Understanding these interactions is critical for protecting the nest sites of Snowy Plover, and less so for Willet and American Oystercatcher that also nest elsewhere. Furthermore, because the Gulf is an important foraging and wintering area for more than 20 species of shorebirds, understanding how human activities affect their foraging and distribution is important for their conservation (Withers 2002). Management includes signs, fencing, wardening, and prevention of beach access by people and vehicles during the nesting season (Burger 1989; Elliott-Smith and Haig 2004), although the last method is often controversial (Mabee and Estelle 2000).

Similar data on human disturbance exist for many groups of birds, such as grebes (Keller 1989), waterfowl (Korschgen and Dahlgren 1992; Mallory and Weatherhead 1993), gulls (Hunt 1972; Burger 1981c; Burger and Gochfeld 1983b), herons (Tremblay and Ellison 1979; Parsons and Burger 1982; Fernandez-Juricic et al. 2007), pelicans (Johnson and Sloan 1975), guillemots (Cairns 1980; Ronconi and St. Clair 2002), cormorants (Kury and Gochfeld 1975; DesGranges and Reed 1981), and other colonial waterbirds (Rodgers and Smith 1995). Habitat loss amplifies the effects of human disturbance (Burger 1981d; Skagen et al. 2001). Reducing the effects of human disturbance can involve reducing the amount and types of human activities, prohibiting the presence of dogs or off-road vehicles, or habituating birds to the presence of people (Vennesland 2010).

Human disturbance, however, can also include organized human activities, such as tourist boats for diving, snorkeling, fishing, or, nature tourism. In the Yucatán, for example, two barrier peninsulas (Ria Lagartos, Celestun) are exposed to tourism boats, despite their designation as Yucatán Biosphere Reserves (Savage 1993). Disturbance comes not only from the boats and people but also from the construction of structures designed to enable tourism (Savage 1993). Presumably the effect would differ depending upon whether people are on foot, in small boats, or in large boats.

Table 12.6. Changes in Abundance of Birds on Mustang Island, Texas, from 1979 to 2007 (after Foster et al. 2009). Mean daily abundance of species ranged from 2.4 to 328.

Species	Status	Trend in Percent
Eared Grebe, Podiceps nigricollis	Winter	280.0
*Brown Pelican	Resident	586.0
Double-crested Cormorant	Winter	-82.2
*Great Blue Heron	Resident	-38.9
Cattle Egret	Resident	45.4
*Black-bellied Plover	Winter	-34.2
Piping Plover	Winter	-25.4
Snowy Plover	Winter	-3.6
*Wilson's Plover	Summer	-62.9
*American Oystercatcher	Resident	137.4
Willet	Winter	-3.4
Ruddy Turnstone	Winter	-5.5
*Red Knot	Winter	-54.0
*Sanderling	Winter	26.2
Western Sandpiper	Winter	-3.1
Least Sandpiper	Winter	-27.3
*Herring Gull, Larus argentatus	Winter	-70.3
Ring-billed Gull	Winter	10.2
*Laughing Gull	Resident	58.7
*Caspian Tern	Resident	-58.8
*Royal Tern	Resident	-68.0
Sandwich Tern	Breeding	-13.2
Common Tern	Migrant	49.0
*Forster's Tern	Resident	-87.5
Least Tern	Breeder (summer)	-35.6
Black Tern	Migrant	214.9
*Gull-billed Tern	Breeder	-53.3
*Black Skimmer	Resident	-71.3

*Before species name indicates a significant change in abundance ($p < 0.05$). Changes were attributed to human disturbance. Declines are shown in *red*.

All of the factors discussed in the sections above have been singly, or in combination, shown to affect bird populations in the Gulf over the short term (a storm event, a breeding season for nesting species, at migratory stopovers for Nearctic-Neotropical migrants). Long-term (decade-long) shifts in population levels of birds in the Gulf of Mexico have not been demonstrated as a result of a specific factor, except for the Brown Pelican whose population declined dramatically due to DDT. Habitat loss resulting from coastal development (and associated direct human disturbance), and sea level rise, have the potential to negatively impact avian populations along the Gulf of Mexico because they are directional and likely to continue.

12.6 STATUS OF BIRDS IN THE GULF OF MEXICO

12.6.1 Overview of Indicator Species and Groups

Because nearly 400 species reside, winter, or migrate to or over the Gulf of Mexico, it is impossible to give an account of each species. In this chapter, selected indicators are used to form a pattern to illustrate: (1) bird use in the Gulf, (2) status and trends of key species, and (3) changes of conservation concern. The Gulf of Mexico contains some of the most important habitats in North America for migrant raptors (Gallardo et al. 2009), migrant songbirds (Rappole 1995), and wintering/migrating shorebirds (Withers 2002), as well as breeding pelicans, gulls, terns, shorebirds, ibises, egrets, and herons. Indicators are used to understand the distribution and abundance of birds in the Gulf, although they are also useful as indicators of contaminants, disease, and restoration efforts (Burger 1993; Custer 2000; Erwin and Custer 2000; Frederick et al. 2009). Two kinds of indicators are considered: individual species and species groups. These indicators can serve as a baseline for future studies and for evaluating future anthropogenic effects, including restorations.

The species considered below were chosen because they were endangered or threatened (such as the Whooping Crane), species of concern, species whose major populations occur in the northern Gulf of Mexico, species that are typical of the Gulf (e.g., Reddish Egret), or were unusual in other ways (e.g., Piping Plovers winter there extensively). The rationale for the use of each species is given in Table 12.7. They were also chosen to balance migrant and resident, colonial and solitary, and different habitats. While many others could have been selected, this represents a balance for the characteristics shown in Table 12.7. Species groups were selected because the Gulf of Mexico plays an important role in their life cycle, including pelagic seabirds, waterfowl, raptors, colonial nesting birds (gulls, terns, herons, egrets, and ibises), and migrant Passerines and shorebirds, although trends data for the latter are not available. The species indicator accounts are not meant to be exhaustive or complete life history information (see *Birds of North American* [BNA], Hamer et al. 2001). Rather, the accounts give a brief description of the bird's niche and available information about their status and populations within the northern Gulf of Mexico. Information on the southern Gulf is added where available.

12.6.2 Indicator Species

12.6.2.1 Common Loon

Common Loons are large, long-lived birds with delayed maturity and low fecundity. They nest on small isolated islands in lakes in the northeastern United States and Canada. They are awkward on land, have webbed feet, are superb swimmers, and dive for fish. Their breeding range is restricted to mainland North America (Evers et al. 2010). They nest from Washington to Montana, to northwest Wyoming, north-central North Dakota, and the upper Great Lakes, and from New York to New England (Evers et al. 2010). They winter on the Pacific and Atlantic coasts, including the Gulf of Mexico and the Gulf of California. Common Loons in Mexico winter off the Texas coast (Howell and Webb 1995). They rarely winter farther south of central Mexico; some remain as far north as Newfoundland and the Aleutian Islands of Alaska (Evers et al. 2010). They also breed in Greenland, Iceland, and Northern Eurasia, and winter from the southern coast of Norway and Sweden south to the Caspian and Black Sea, China, and Formosa (Stevenson and Anderson 1994). In winter they are white below with dark gray upperparts (Figure 12.10).

Common Loons are used as indicators of environmental health in the northeast because of documented effects from acid rain and mercury (Burger et al. 1994; Nocera and Taylor 1998; Burgess et al. 2005; Burgess and Meyer 2008; Evers et al. 2008). They also are useful indicators

Table 12.7. Summary of Rationale for Selection of Indicator Species[a]

Species	Endangered & Threatened	Largely a Gulf Species	Resident	Migrant	Colonial	Solitary	Open Ocean	Mud Flat	Beach or Sand	Sand, Light Veg.	Marsh
Common Loon				X		X	X				
Brown Pelican		X	X		X		X				
Great Egret			X		X			X			
Reddish Egret		X	X		X			X			X
Roseate Spoonbill		X	X		X			X			X
Mottled Duck		X	X			X					X
Osprey			X			X					
Whooping Crane	X	X		X	X		X				X
Clapper Rail			X			X					X
Snowy Plover		X	X			X			X		
Piping Plover	X			X		X			X		
Laughing Gull			X		X		X	X	X	X	X
Royal Tern			X				X		X	X	
Black Skimmer			X				X		X	X	
Seaside Sparrow			X			X					X

[a]The last five columns are habitat categories

Figure 12.10. Common Loons (here in winter plumage) normally forage near the shore off the Gulf Coast, although they will forage farther out. © J. Burger.

in the Gulf of Mexico because they swim on the surface and dive for relatively large fish that are 10–15 cm long or more (Imhof 1962). Acid rain increases biomethylation of mercury in cold water, and methylmercury accumulates in fish. On the breeding grounds, mercury continues to build up in tissues as the Loons age, and increasing body burdens reduce the number of young fledged per pair (Evers et al. 2008). While they usually occur inshore, they can also range up to 100 km out into open Gulf waters (Evers et al. 2010), making them vulnerable to oceanic and Gulf coast pollutants.

Common Loons breed on small to large lakes, nesting near the edge of isolated small islets devoid of predators (Vermeer 1973a; McIntyre 1988; Barr 1996). Loons usually lay two eggs, but only fledge one chick (McIntyre 1988). Loons arrive on the northern coasts of the Gulf of Mexico by the third week of October, mainly from Minnesota and Wisconsin (Evers 2004), and numbers build up until mid- November (Alexander 1991). Mortality in Loons is due to mercury contamination, commercial fishing (Vermeer 1973b), botulism (Brand et al. 1983), and nutritional stress from high costs of plumage replacement in winter (Alexander 1991), among other factors.

Common Loon populations are probably stable to increasing in the United States (Evers et al. 2010), and the United States and Canadian population is estimated at 607,000–634,000 birds (Delany and Scott 2006). Using Christmas Bird Counts for the entire U.S. Gulf coast, Niven and Butcher (2011) computed a significant 1.6 % per year increase over the period from 1965 to 2011. Imbedded in this increase was a decrease in numbers and reproductive success in the 1980s and 1990s, partly from acid rain and mercury (Evers et al. 2010). Using the same Christmas Bird Count data, running 3-year averages were computed for Common Loon numbers from 1940 to the present (Figure 12.11). There is variation along the Gulf, with few birds recorded from Mississippi, Louisiana, and Texas, and the majority recorded off the coast of Alabama and Florida. The data show a peak in the 1980s, with a recent increase in Alabama and a decline in Florida.

Resiliency in Common Loons is low because of low clutch size (two eggs), low reproductive rate (usually raise one or fewer young per year), high mortality while at sea the first 2–3 years of life, and delayed breeding age (average age of 6 years; Evers et al. 2010). Although the loon has a long life span of around 30 years (Evers et al. 2010), it is susceptible to mercury poisoning because it eats large fish on the breeding grounds of lakes where prey fish accumulate high mercury levels (Evers et al. 2008).

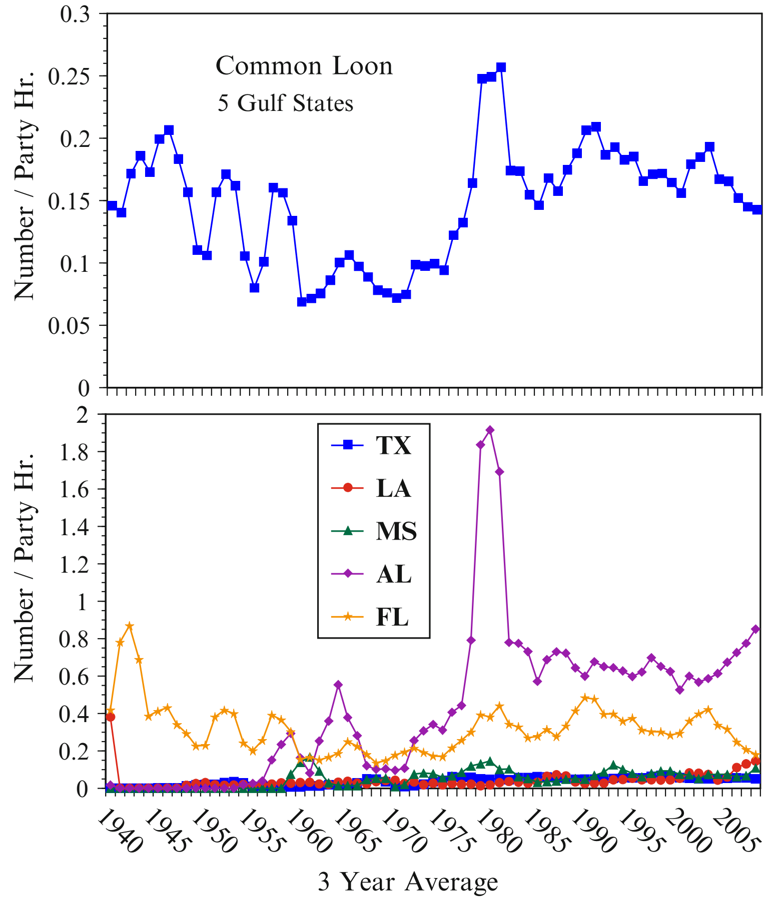

Figure 12.11. Number of Common Loons observed (number/party per hour) from 1940 to 2005, derived from Christmas Counts in the winter. Running 3-year averages were plotted to smooth out the patterns. The bottom graph shows the numbers for each state, and the top is a composite graph for all five Gulf States. © J. Burger.

12.6.2.2 Brown Pelican

Pelicans are very large, plunge-diving birds with recognizable gular pouches. They nest colonially along the Pacific, Atlantic, and the entire Gulf coasts (Figure 12.12). These iconic birds only breed along coasts, and their image is put on placemats, postcards, billboards, and signs throughout the Gulf (Eubanks et al. 2006). Their breeding range is along the Pacific coast from southern California to southern Ecuador (including the Galapagos), and along the Atlantic coast from Maryland south, around the Gulf of Mexico and Caribbean coast, to northern Venezuela and Colombia (Shields 2002).

Brown Pelicans feed on small fish (10–28 cm long), such as Menhaden (*Brevoortia patronus*) (Imhof 1962; Hingtgen et al. 1985), a major commercial fish in the Gulf. Fishermen have persecuted them because they were believed to eat commercial fish (Sprunt 1954). Pelicans dive with the bill ajar, and the force of water on impact causes the pouch to expand, trapping the fish inside. The Pelican then raises the bill above the water, pointed downward, and the water runs out, leaving prey in the pouch (Stevenson and Anderson 1994). Pelicans usually feed within 20 km of the nest site (Briggs et al. 1981), indicating the importance of having suitable nesting colonies near foraging opportunities.

Figure 12.12. Brown Pelicans nest either on the ground or in low bushes, which have to support their weight. This colony was on a small sand spit in Louisiana. © J. Burger.

Current population estimates for Brown Pelicans (*P.o carolinensis*) are 44,000–45,000 pairs; about 60 % of the 40,000 that nest in the United States do so along the Gulf Coast (Shields 2002). Pelicans are resident in most of their breeding range (Shields 2002). Pelicans breed in monospecific and mixed-species colonies, often with other ground-nesting species. They use the same colony site in successive years unless it becomes unsuitable because of habitat loss, human disturbance, or predators (Schreiber and Schreiber 1982). Colony site selection in pelicans depends upon the availability of nest sites that are free from predators and human disturbance, and are reasonably close to food. Colonies in Louisiana averaged 13 km from the mainland (Visser et al. 2005). Brown Pelicans are monogamous, mate for life, lay up to five eggs, and the young are fed predigested fish that parents deposit on the nest.

Brown Pelicans exhibited one of the most dramatic population declines ever observed in birds, which occurred between the late 1950s and the early 1970s, due to the organochlorine pesticide DDT (Shields 2002). Before the decline, populations in Louisiana and Texas were estimated at greater than 50,000 birds (Shields 2002). Lowery (1974) claimed that before the decline, most Brown Pelicans seen along the entire northern Gulf coast were produced in Louisiana. Pelicans declined from about 5,000 individuals in Texas in the early 1960s, to fewer than 20 individuals by 1974 (King et al. 1977). Populations disappeared in other places, and reintroductions were necessary. The mechanism of decline was through eggshell thinning caused by DDT; pelicans that incubated broke their eggs (Blus et al. 1974).

Brown Pelicans were reintroduced into Louisiana at Queen Bess Island in 1971 and the Chandeleur Chain in 1979 (Wilkinson et al. 1994). Before 1983, no Brown Pelicans nested in Alabama; the first ones were relocated there in 1983, and by 1990 there were 1,374 nests (Wilkinson et al. 1994). The Florida Gulf coast population of breeding Brown Pelicans declined, but remained stable in Tampa Bay after the 1990s (Hodgson and Paul 2010), while the Atlantic coast population increased (Wilkinson et al. 1994).

Trends in breeding populations have been examined in many places. Two examples are given: Queen Bess Island in Louisiana, and Galveston Bay in Texas. Breeding populations at three sites in Louisiana were followed from 1971 (when numbers had declined drastically from

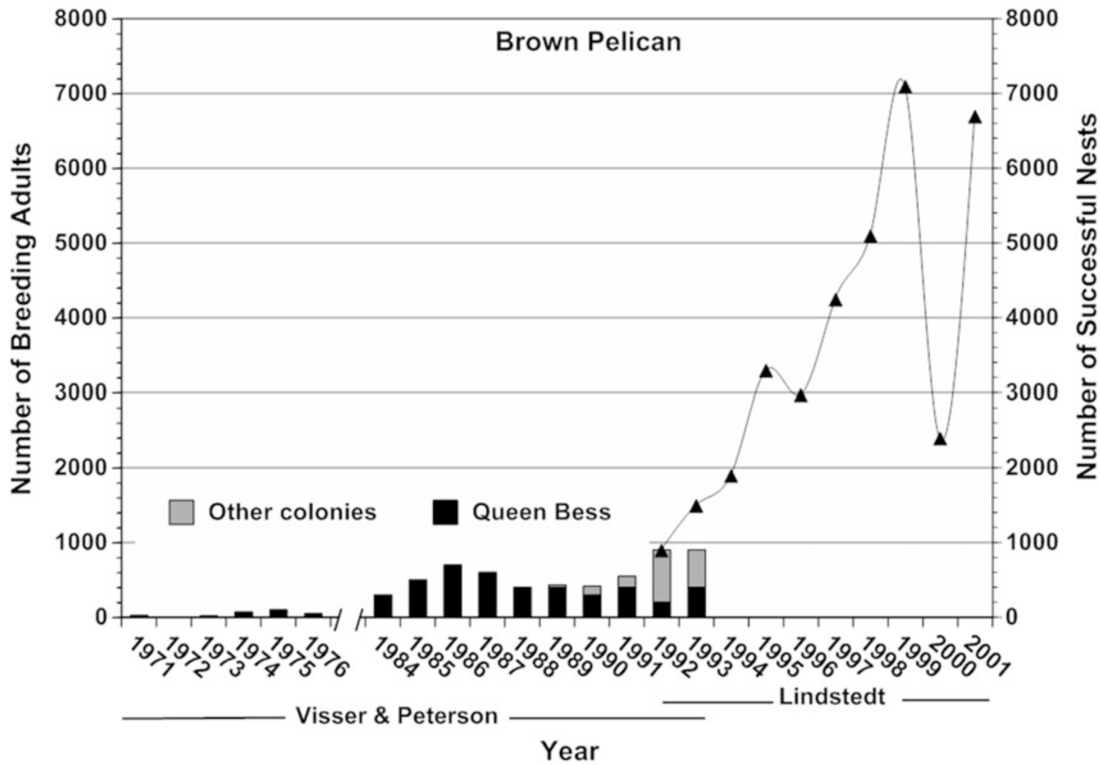

Figure 12.13. Nesting population of Brown Pelicans at Queen Bess and other colonies in Louisiana. Data from Visser and Peterson (1994) and Lindstedt (2005). © J. Burger.

DDT) to 1993 (Figure 12.13, after Visser and Peterson 1994). Pelicans were locally extirpated in Louisiana and were reintroduced at Queen Bess Island in the early 1970s (Holm et al. 2003). Subsequently, when numbers declined at Queen Bess, they increased at a nearby colony. Lindstedt (2005) reported the number of successful nests at Queen Bess and Last Islands after 1993 (Visser and Peterson 1994), and showed a small decline in the mid-1990s (Figure 12.13). Pelicans in Louisiana increased in these colonies from about 2,000 nests in 1990 to stabilize around 15,000 nests in 2003 (Holm et al. 2003; Visser et al. 2005). Pelican colonies in Louisiana are located far from the mainland and human activity, and colonies such as Queen Bess Island have required the addition of land to provide sufficient habitat (Visser et al. 2005).

Surveys of Brown Pelicans nesting in Galveston Bay, Texas, have also been made for a number of years. The number of nesting pairs has been increasing there although there were large shifts in the number of nesting pairs (Figure 12.14). The Galveston Bay Status and Trends report rated the species, used as an indicator by the program, as good—significantly increasing (GBEP 2006).

Brown Pelicans are reaching population levels on the Gulf Coast of North America that were present before the widespread use of DDT (Robinson and Dindo 2011). Pelicans are faced with severe habitat loss that might threaten their populations once again, particularly in Louisiana due to loss of available nesting sites (Visser et al. 2005). Robinson and Dindo (2011) comment that the future of Brown Pelican populations in the Gulf is unclear because of the ephemeral nature of spoil islands and natural coastal areas, as well as natural disasters, and manmade ones. Periodic reproductive failures have little effect on population levels, but recurrent breeding failures result in population declines (Schreiber 1980a). Another cause of

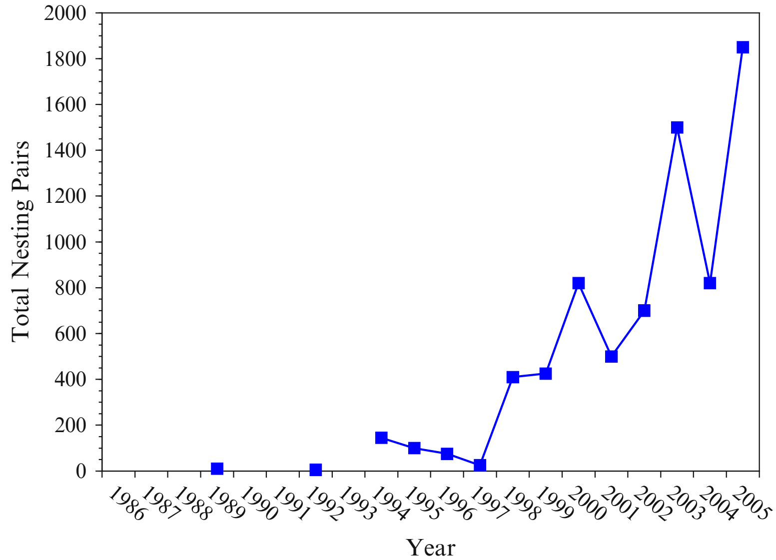

Figure 12.14. Number of nesting pairs of Brown Pelicans in Galveston Bay (after GBEP 2006). © J. Burger.

mortality is exposure to cold and storms, hypothermia, frostbite damage to gular pouches and foot webs, starvation, and longer-term cold weather effects on breeding phenology (Schreiber 1980b; Shields 2002). Therefore, changes in temperature because of global warming could increase populations of Brown Pelicans in the northern coast of the Gulf of Mexico.

Another cause of mortality in Brown Pelicans, unlike most other indicators, is from people. A study of 3,106 recoveries of Brown Pelicans banded in the Carolinas and Florida, from 1925 to 1983, indicated that more than half died from human activity, with entanglement in fishing lines as a major cause (Schreiber and Mock 1988). Pelicans are sometimes killed or maimed maliciously.

Shields (2002) plotted recovery of Brown Pelicans along the Gulf Coast as a whole, showing a steady rise in nests from the 1970s through the 1980s, with greater increases thereafter (Figure 12.15). The number of nesting Pelicans did not increase as sharply along the Atlantic coast, or along the California coast; populations in California fluctuated around 5,000 pairs since the mid-1980s (Shields 2002).

Resiliency is relatively high as evidenced by their population recovery following devastation by pesticides in the 1950s and 1960s. Pelicans reach sexual maturity at 3–5 years of age, lay up to five eggs (modal clutch is three), usually fledge one or fewer chicks, only 30 % survive the first year, and fewer than 2 % survive beyond 10 years (Schreiber and Mock 1988; Shields 2002). They probably have only an effective reproductive life span of 4–7 years although they can live for 25–30 years (Schreiber and Mock 1988). Since human disturbance and breeding habitat availability seem to be major problems, recovery from any declines will partly depend on these factors.

12.6.2.3 Great Egret

The dazzling white plumage of Great Egrets, with their long lethal yellow bill, and their motionless stance as they wait to capture prey, makes them easy to recognize (Figure 12.16). Great Egrets are cosmopolitan, inhabiting freshwater, estuarine, and marine wetlands, and are intermediate in size between the larger Great Blue Heron and the smaller egrets. Great Egrets

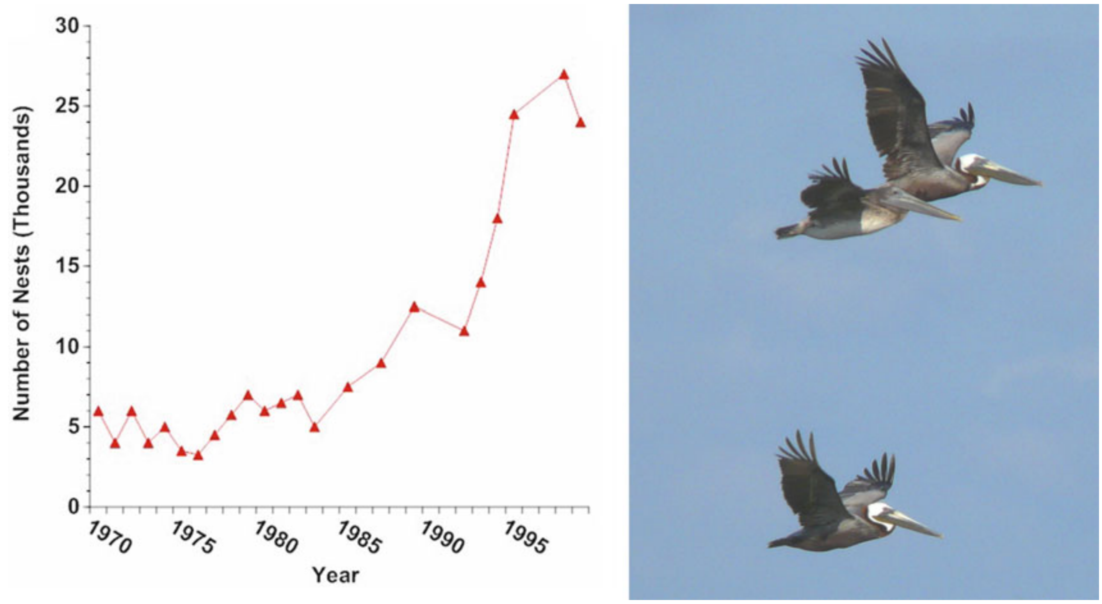

Figure 12.15. Populations of Brown Pelicans nesting along the northern Gulf Coast (after Shields 2002).

breed in North and South America, in southeast Europe, northern Asia to Siberia, north China, and northern Japan, as well as in Australia (McCrimmon et al. 2011). In North America, they breed primarily along the Atlantic Coast from Maine south to all regions along the Gulf coast, to the east coast of Mexico, and down to South America, including the Caribbean Islands. On the west coast they breed in California, and on the west coast of Mexico and Central America. They also breed in scattered inland areas in the Central United States (McCrimmon et al. 2011). They winter throughout their breeding range, except for interior North America and the northeast coast (McCrimmon et al. 2011).

Egrets are useful indicators for the Gulf Coast because they are colonial, conspicuous (large and white), usually nest higher in vegetation when it will support their nests, and are key members of wading bird nesting assemblages in the coastal regions all along the Gulf of Mexico, including Mexico (Burger 1978a; Mock 1978, 1980). They feed on intermediate-size fish, as well as reptiles, amphibians (especially frogs), small mammals, birds, crustaceans, mollusks, and insects (Stevenson and Anderson 1994). They also visit inland rice fields, crawfish ponds, and wet fields to find frogs, as well as dry fields to stalk small reptiles (Eubanks et al. 2006).

Great Egrets nest in mixed-species colonies with other egrets, herons, ibises, and often Brown Pelicans. These colonies are stable as long as conditions remain viable and the habitat suitable; otherwise they switch sites (Kelly 2006a). They are monogamous, and both parents incubate and care for the young, including provisioning (McCrimmon et al. 2011). Incubation (28–29 days) begins with the first or second egg so that young hatch asynchronously; when food is in short supply, competition between siblings results in older chicks kicking eggs or younger chicks out of the nest (Mock and Lamey 1991; Stevenson and Anderson 1994).

Great Egret populations, along with other herons and egrets, declined dramatically in much of the United States during the late 1800s and early 1900s due to hunting their plumes for the millinery trade (Ogden 1978). Their plumes (called aegrettes), used in courtship displays, have a delicate, lacey appearance (Figure 12.16). The North American population of Great Egret

Figure 12.16. Great Egrets sometimes stand and wait for prey, either on logs or in shallow water. © J. Burger.

declined by more than 95 % with market hunting (McCrimmon et al. 2011). Populations quickly recovered with the passage of the Migratory Bird Treaty Act in 1913, and they once again moved into breeding areas in the Northeast where they had largely disappeared (Burger 1996b; McCrimmon et al. 2011). The North American population is currently estimated at about 270,000 birds (Delany and Scott 2006). The nesting population of Great Egrets along the western Gulf coast increased from the 1930s to the 1990s. For example, numbers in Louisiana were 2,900 pairs in 1959, 11,000 pairs in 1974, and 29,000 pairs in 1990; Texas, had 5,000 pairs in 1939, 1,450 pairs in 1959, and 6,500 pairs in 1969 (McCrimmon et al. 2011).

Trends data from Shamrock Island in Texas indicate that the number of Great Egret pairs varied markedly from almost zero in 1973 to more than 160 pairs in 1999 (Gorman and Smith 2001), and thereafter numbers increased (TCWS 2012). However, there is now evidence from south Florida that numbers have declined (Figure 12.17).

Using Christmas Bird Counts (1965–2011) as a database, Niven and Butcher (2011) reported that wintering Great Egret showed a significant increase of 2.1 % per year in coastal U.S. Gulf counts. Furthermore, when Fleury and Sherry (1995) used Christmas Bird Count data to examine the effects of crayfish aquaculture on Louisiana birds, they found that Great Egrets also increased significantly from 1949 to 1989. Using Christmas Count data for all states combined also shows an increase (Figure 12.18). Using Breeding Bird Survey data, Sauer et al. (2005, 2008) shows a steady but small increase in the Great Egret population nationwide.

Great Egrets have fairly high resiliency because they were able to recover from the devastation of plume hunting. They breed when they are 1–3 years old; clutch size varies from 1 to 6; average hatching rate is about 60 %, most commonly fledge between 0.5 and 1.5 chicks per nest; and between 40 and 75 % of nests in a colony are successful (McCrimmon et al. 2011). Success can vary; Parsons and Burger (1982) reported a hatching rate of 97 %, but a fledging success of only 50 % in a Louisiana colony. These parameters do not apply if the colony is harassed, food is scarce, or they suffer hunting or other external stressors.

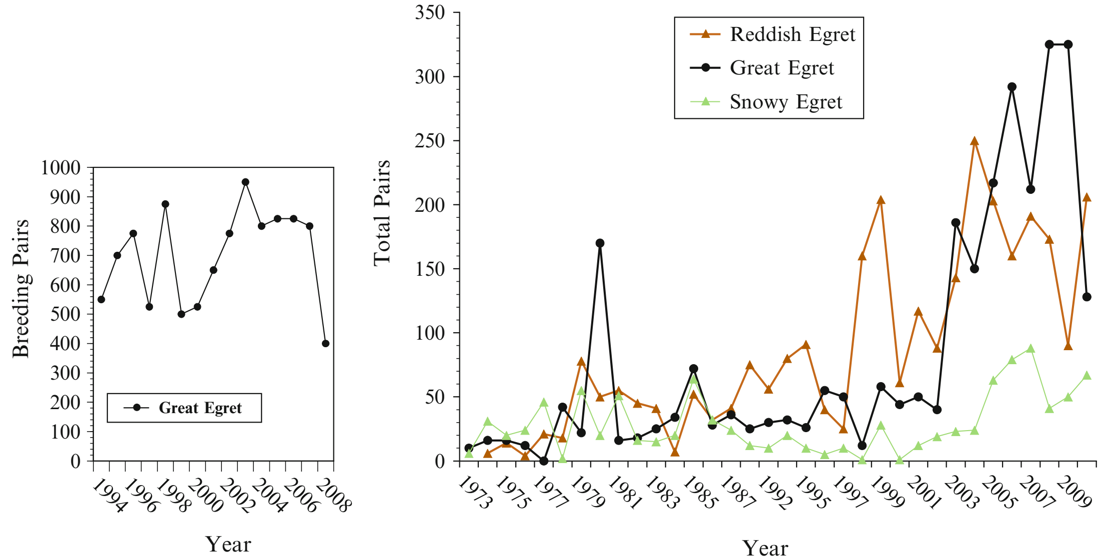

Figure 12.17. Trends in nesting pairs of Great Egret, Reddish Egret, and Snowy Egret for the Shamrock Island Colony in Texas (after Gorman and Smith 2001 and TCWS 2012, right). Left shows trends for Tampa Bay (after Hodgson and Paul 2010). © J. Burger.

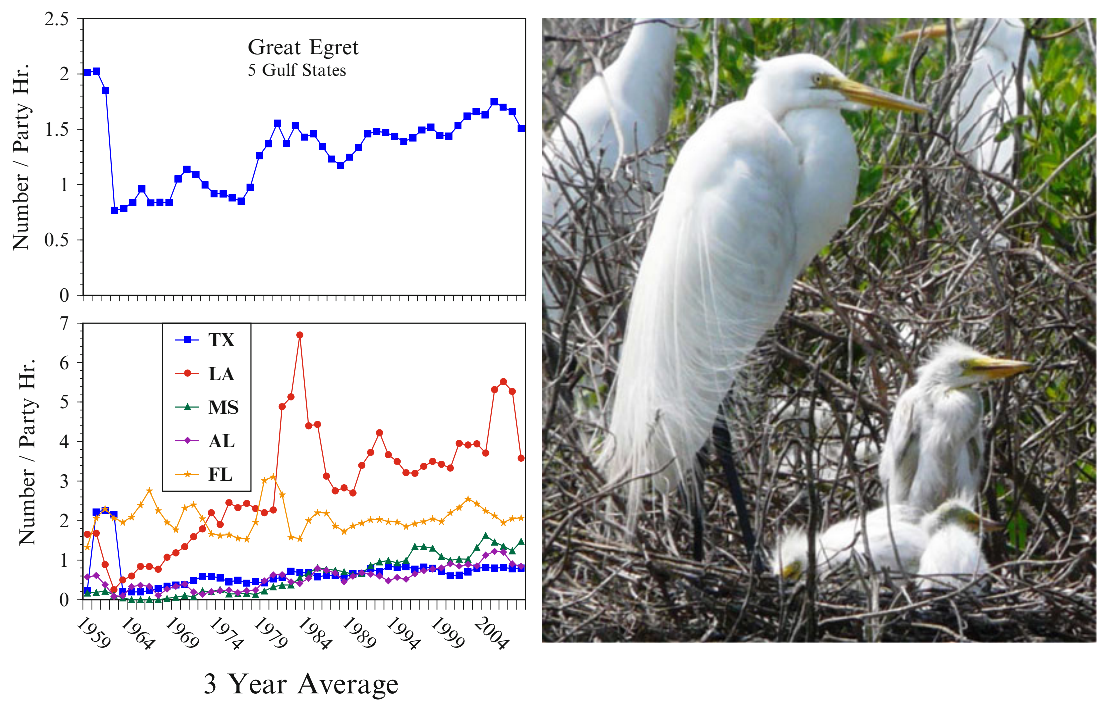

Figure 12.18. Population trends in Great Egrets determined from Christmas Bird Counts from the 1950s to the present. There was a slight increase in the late 1970s. © J. Burger.

12.6.2.4 Reddish Egret

Reddish Egrets are the rarest species of heron in North America. They have a rather shaggy appearance because of the feathery plumes on both the head and back (Figure 12.19). They breed in coastal wetlands on both coasts of Florida (except in the Panhandle), Gulf of Mexico from Louisiana to south Texas and into Tamaulipas, along the Yucatán peninsula, in the Caribbean and Bahamas, and sporadically along Baja California and the Pacific coast of Mexico (Lowther and Paul 2002). The first Reddish Egret bred in Louisiana on North Island in the Chandeleur Sound in 1958 (Lowery 1974). They are resident in their breeding range, but following breeding, some birds spread out on the east coast of Mexico, down to Costa Rica and Belize, and all along the Pacific coast of Baja California and of Mexico into Central America (Lowther and Paul 2002). Significant wintering flocks can be found in the Laguna Madre in Texas and Mexico (Eubanks et al. 2006).

Reddish Egrets are of particular interest because (1) the Gulf of Mexico plays a key role in their breeding and resident distribution; (2) they are a species of special concern by the U.S. Fish and Wildlife Service (USFWS) (Bates et al. 2009); (3) they are a species of moderate concern as evaluated by the U.S. Shorebird Conservation Plan (Elliott and McKnight 2000), as well as the Southeast U.S. Regional Waterbird Conservation Plan (Hunter et al. 2006); (4) they are a priority species for habitat planning by the Gulf Coast Joint Venture (Vermillion and Wilson 2009); (5) their populations were greatly impacted by plume hunting and their populations never recovered (Paul et al. 1975; Lowther and Paul 2002; Hunter et al. 2006); and (6) they are extremely coastal. They are mainly residents, although some withdraw farther south in the Gulf of Mexico in winter (Turcotte and Watts 1999; Lowther and Paul 2002).

Reddish Egrets forage only in coastal habitats where they can appear both comical and elegant when foraging. They hunt by running, hopping, flying, and employing open-wing antics as they pursue small fish, although they sometimes stand and wait for prey. Reddish Egrets mainly forage in shallow pools where fish and invertebrates are concentrated by cyclic flooding and drying (Powell et al. 1989).

Reddish Egrets typically nest in bushes or trees in mixed species colonies along the coast and on coastal islands, and they forage in shallow, salt-water habitat (Lowther and Paul 2002), making them vulnerable to any coastal threats (Toland 1999). They also nest on dredge spoil islands (Toland 1999). They sometimes breed in small groups, and very rarely, as isolated pairs (FFWCC 2003).

Figure 12.19. Reddish Egrets often forage by waving their wings around and running about. © J. Burger.

In the 1950s, Reddish Egrets in Florida were limited mainly to the Keys, and wildlife managers experimented with transferring eggs from Texas to place them in heron nests (Sprunt 1954). Only in the last 30 years have Reddish Egret populations begun to increase in Florida Bay enough to spread up the Gulf Coast on their own (Paul et al. 1975; Powell et al. 1989). Currently, about 2,000 breeding pairs are in the United States, and 75 % of the U.S. population resides in Texas (Lowther and Paul 2002; Bates et al. 2009). The Bahamas are an important site for Reddish Egrets (Moore and Gape 2008), although surveys there indicate more than a 50 % decline in numbers since the 1980s (Green et al. 2011), which is a cause for concern. Because of their limited range, nonmigratory pattern, and colonial nesting, populations can be estimated. The breeding populations for the Gulf states are as follows: Texas 900–950 pairs, Louisiana 60–70 pairs, Alabama 5–10 pairs, and Florida 350–400 pairs, for a total of 965–1,030 pairs (>39 % of global population) (Lowther and Paul 2002; Green 2006). No Reddish Egrets breed in Mississippi. Lowther and Paul (2002) previously estimated the U.S. population to be about 2,000 pairs, but current estimates are 3,000–5,000 breeding pairs (Delany and Scott 2006). Populations are subject to considerable yearly variation. If their Gulf habitats are rendered unusable, Reddish Egrets have nowhere else to go since they are strictly a coastal species (Vermillion and Wilson 2009). Conservation concern led the Gulf Coast Joint Venture Conservation waterbird working group to designate several sites as high priority for Reddish Egret (Vermillion and Wilson 2009). These sites are centered on the south Texas coast; the waterbird working group believes they can increase breeding populations at some of these colonies by 25 %.

There are few trends data for Reddish Egrets from the Gulf States. Gorman and Smith (2001), however, tracked populations at Shamrock Island in Texas from 1973 to 1999 (Figure 12.17). While this is only one colony, it provides information on trends and variability in that colony. Reddish Egret numbers generally increased from 1973 to 1999, although the numbers were quite variable. After 1999, the numbers seemed to increase (TCWS 2012). In contrast, in Tampa Bay the numbers remained low and constant at about 100 breeding pairs (Hodgson and Paul 2010).

Fleury and Sherry (1995) used Christmas Bird Counts (1949–1988) to examine long-term population trends in Louisiana and found that populations of Reddish Egret increased 3 % per year over the 40-year period. However, from 1980 to 1988 they declined by 11.4 %. Niven and Butcher (2011) using Christmas Bird Counts for the entire U.S. Gulf coast computed a 1.6 % per year increase over the period from 1965 to 2011. A 3-year running average of Christmas Bird Count data over a longer period was computed (Figure 12.20). Variability was much greater in Texas, particularly in three time periods (early 1950s, early 1990s, and 2004–2006), which bears further examination. While Niven and Butcher (2011) show an overall increasing trend from 1965 to the present, it is not a clear consistent pattern.

Resiliency in Reddish Egrets is low as evidenced by its slow recovery from the devastation of plume hunting, particularly in relation to other egrets that recovered quickly. Most breed in the fourth year, clutch size is usually three eggs, and the maximum longevity from banded bird studies is just over 12 years.

12.6.2.5 Roseate Spoonbill

Roseate Spoonbills are stately, delicately pink birds with a greenish, flattened bill that move slowly through the water, swinging their bill from side to side (Figure 12.21). They are neotropical birds whose range extends northward to the southern United States, especially along the Gulf Coast. The main breeding area of Roseate Spoonbill is south of the United States, perhaps in Brazil (Hancock et al. 1992), and the main breeding areas in North America

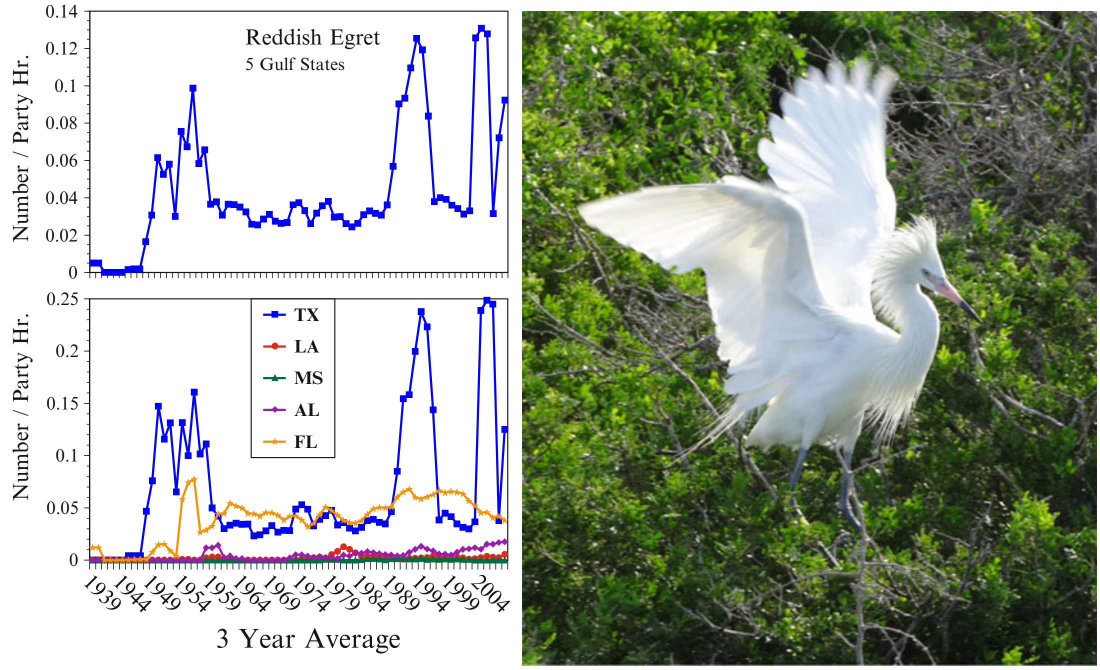

Figure 12.20. Three-year running averages of Reddish Egret, computed from Christmas Counts from the late 1930s to 2008. Reddish Egrets have two color phases (*white* phase shown here). © J. Burger.

Figure 12.21. Roseate Spoonbills are the only pink species of Spoonbill (the others are all white). © J. Burger.

are along the coasts of Texas, Louisiana, and south Florida (from Tampa Bay south), with a few records from Louisiana (Dumas 2000). They rarely nest in Alabama and Mississippi. They breed sporadically along both coasts of Mexico, south to Argentina and Chile (Lewis 1983; Dumas 2000). They winter along both southern coasts of Florida, in the Gulf of Mexico, along both coasts of Mexico to Belize and Central America, and on the Pacific coast to South America (Dumas 2000). They disperse in the nonbreeding season, but mainly remain along the coasts of Louisiana and Texas, and rarely are sighted in Alabama and Mississippi (Turcotte and Watts 1999). The U.S. breeding population of this largely Gulf coast species is about 5,500 pairs, with another 3,230 pairs along the Mexican Gulf coast (Dumas 2000).

Spoonbills feed by tacto-location during day or night, at low tide (Hancock et al. 1992). While walking, they swing their slightly open bill from side to side; when it contacts prey, it snaps shut, mainly on fish, crayfish, shrimp, insects, and other aquatic invertebrates (Lewis 1983; Dumas 2000). Decline of the species in a specific area of the Gulf could be caused by loss of foraging habitat, although Spoonbills can move to other areas with suitable shallow pools for foraging.

Roseate Spoonbills nest in mixed-species colonies with other herons and egrets, although in some places they nest mainly with White Ibis (Imhof 1962). They prefer islands and keys without predator access. In a colony in Nueces Bay, Texas, they nested with Great Blue Herons, Great Egrets, Snowy Egrets, Cattle Egrets, Louisiana Herons, Black-crowned Night Herons, and Laughing Gulls (White et al. 1982), which is typical in other parts of their range. They nest low in trees or shrubs, including mangroves (Sprunt 1954; Portnoy 1977; Lewis 1983). Incubation requires 22–24 days (Lewis 1983), and the nesting season can be prolonged because nesting is not synchronous within a colony (Sprunt 1954). Postbreeding movements require more study, although some birds from Texas move a little south into Mexico (Dumas 2000), and birds from Florida move northward (Hancock et al. 1992).

Roseate Spoonbills, like many other wading birds, suffered virtual extirpation in the late 1800s to the mid-1930s because of harvesting for plumes and food. From 1865 to the late 1880s they were limited to small areas in Texas, Louisiana, and Florida (Imhof 1962). They were nearly extirpated by the late 1800s from the U.S. Gulf coast; their numbers declined to only 15 pairs during the end of the plume trade era (Rodgers et al. 1996). Spoonbill numbers gradually increased after protection from the Migratory Bird Treaty Act. They first began breeding in Texas in 1923, and Friedmann (1925) saw flocks of 75–100 feeding in shallow water and reported another flock of 1,000 feeding in southern Texas. They increased to 830 pairs by 1941 to 3,000 pairs in the 1970s, and then declined to 1,124 pairs in the 1980s (Dumas 2000). By 1996, they were up to 2,901 pairs (Dumas 2000). In Louisiana, numbers ranged up to 150 pairs in the 1940s, and then increased thereafter (while they decreased in Texas), with a 36 % increase from 1966 to 1989 (Breeding Bird Survey) (Dumas 2000). Data from Florida Bay indicated a steady increase in the number of Roseate Spoonbill colonies, and nests, but great variability among years (Figure 12.22) (Powell et al. 1989). There were fewer than 500 pairs in the 2000s (Lorenz et al. 2008). Thus their numbers appear to have declined. A recent review by the Florida Fish and Wildlife Conservation Commission (FFWCC 2011a) recommended that Roseate Spoonbills be given the status of threatened because populations are very small and restricted. Nesting colonies are affected by hydrological changes caused by management. For example, construction of canals in the Everglades reduced the flow of freshwater to the Florida Bay and decreased Roseate Spoonbills in the 1980s (Davis et al. 2005). Small fish are the primary food of Roseate Spoonbills in Florida Bay (Bjork and Powell 1994), and without a water depth threshold of 12 cm, fish are not sufficiently concentrated to provide adequate food reserves (Lorenz 2000). Thus, hydrology (salinity gradients, water depth, and dry-down) influences whether birds nest and also their reproductive success (Davis et al. 2005). Delany and Scott (2006) estimated that the number of Roseate Spoonbills in Florida and the West Indies was 3,400 individuals. Data from Shamrock Island in Texas indicated a variable, but generally stable trend from 1973 to 1999 (Gorman and Smith 2001). The number of breeding pairs varied from about 25–200 (Figure 12.23). Thereafter, numbers seemed to increase (TCWS 2012).

Using Christmas Bird Counts from 1965 to 2011, Niven and Butcher (2011) reported that wintering Roseate Spoonbills showed a significant increase of 5.9 % per year. Figure 12.24 shows populations from 1951 to 2001.

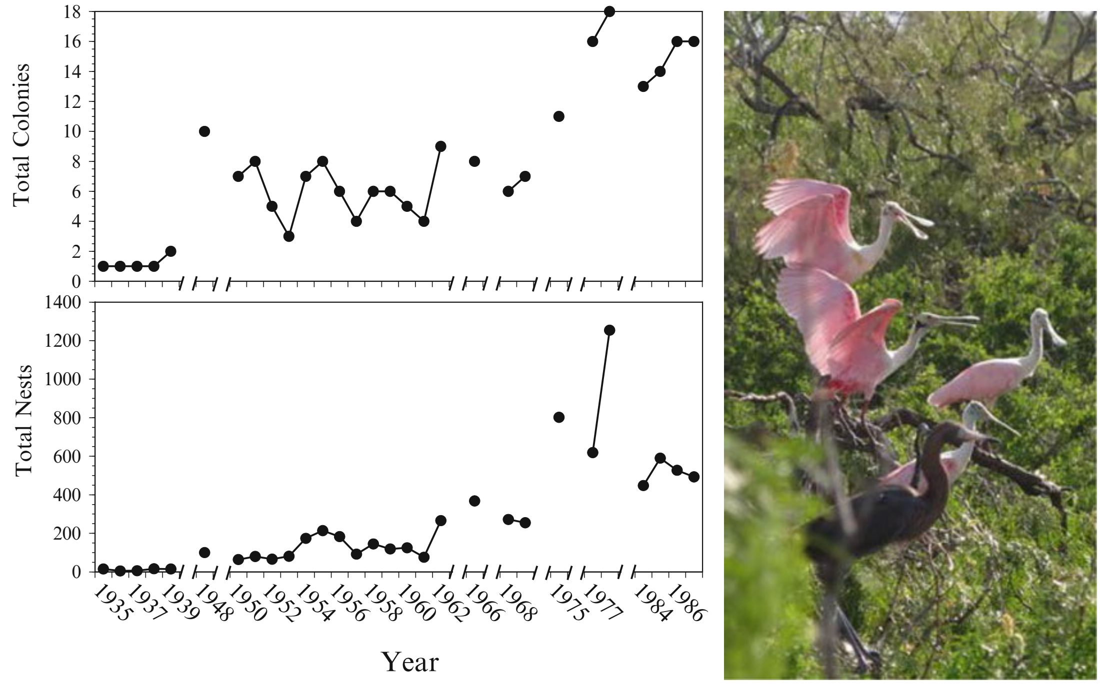

Figure 12.22. Number of colony sites and total nests of Roseate Spoonbills in Florida Bay (from Powell et al. 1989). © J. Burger.

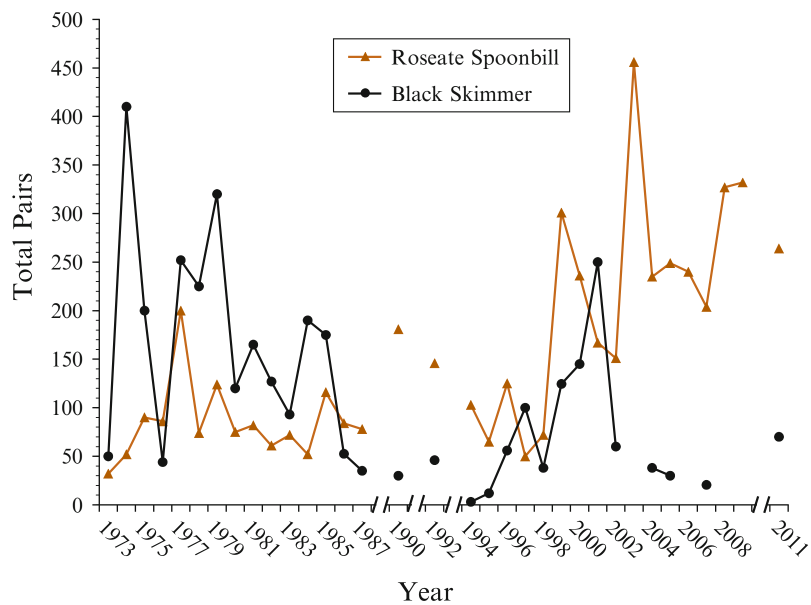

Figure 12.23. Number of breeding pairs of Roseate Spoonbills and Black Skimmers on Shamrock Island, Texas (after Gorman and Smith 2001); computed from Texas Colonial Waterbid Survey (TCWS 2012). © J. Burger.

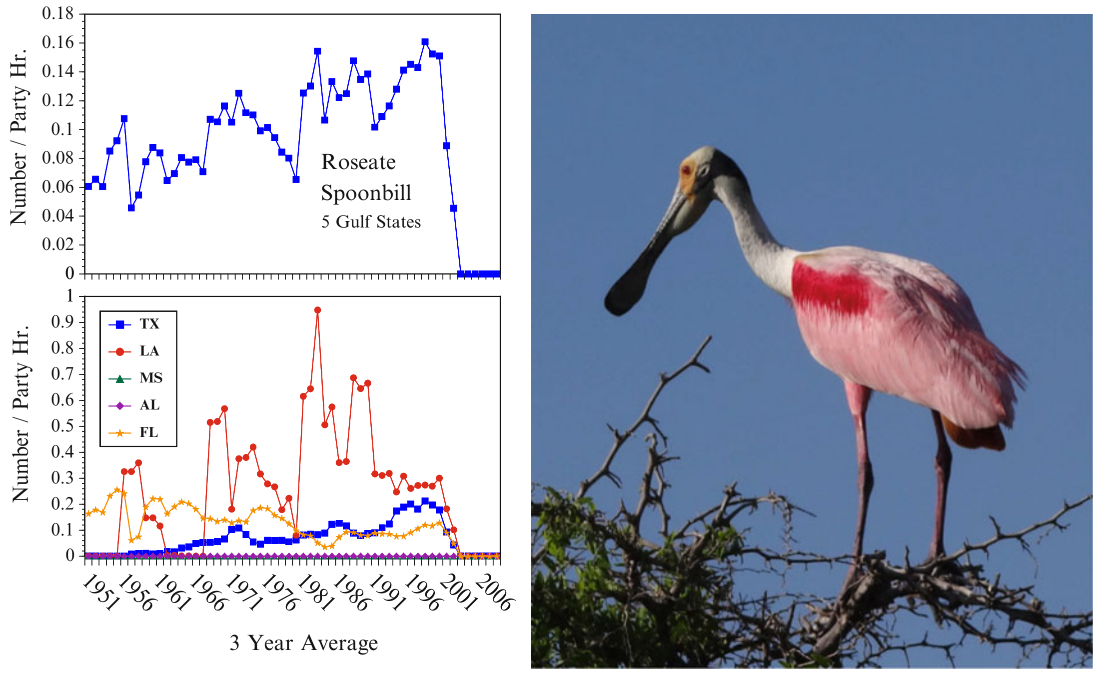

Figure 12.24. Data from Christmas Bird Counts to illustrate changes in numbers of Roseate Spoonbills over time. © **J. Burger.**

Resiliency may be low in the Gulf region because historical populations were believed to be higher prior to plume hunting, and Spoonbill populations have not recovered to those levels (Dumas 2000). They usually breed at 4 years, but may breed at 3 years of age, usually lay 3–4 eggs (up to 5) and average 1–2 young fledged per nest (but this varies considerably and often colonies fail completely). Little information is available on longevity (Lewis 1983; Dumas 2000). Reproductive success partly depends upon the availability of prey that is concentrated by drying down periods (Powell et al. 1989) and varies greatly from year to year (White et al. 1982).

12.6.2.6 Mottled Duck

Mottled Ducks, a southern relative of the American Black Duck (*Anas rubripes*) and the Mallard, breed in marshes and wetlands along the Gulf of Mexico (Bielefeld et al. 2010). They resemble female Mallards, except Mallard females have a blotched bill, a whitish tail, and a white border on the front and rear of the blue speculum (Figure 12.25). They are a non-migratory resident in the Gulf Coast of the United States and into northeastern Mexico (Tamaulipas) (Howell and Webb 1995). The two disjunct populations are from western Alabama to northeast Mexico (south to Tampico), and one isolated in Florida (Johnson 2009; Bielefeld et al. 2010). The Mottled Ducks in Florida migrate north in Florida in the winter (Stevenson and Anderson 1994).

Mottled Ducks occur in near-subtropical climates of the Texas and Louisiana Gulf coast where wetlands are not subjected to near freezing temperatures (Figure 12.25) (Grand 1992). Wetland drainage, degradation of coastal marshes by saltwater intrusion and urban development pose a risk, along with hybridization with Mallards. In the nonbreeding season they concentrate in fallow-flooded fields in Florida and in harvested rice fields in the western Gulf Coast (Figure 12.26) (Bielefeld et al. 2010).

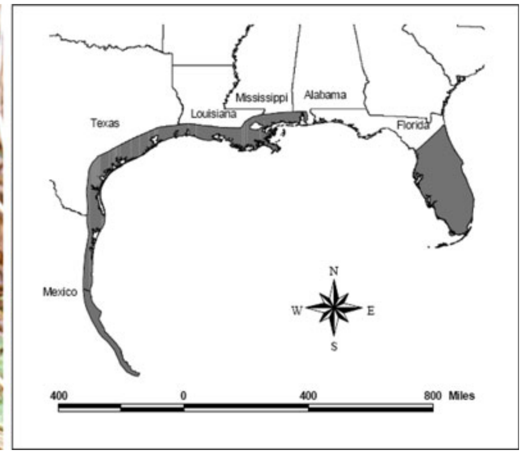

Figure 12.25. Mottled Ducks resemble female Mallards, except they lack the *white* border on the front and rear of the *blue* speculum (wing bar) © J. Burger. Shown also is the range (after Johnson 2009).

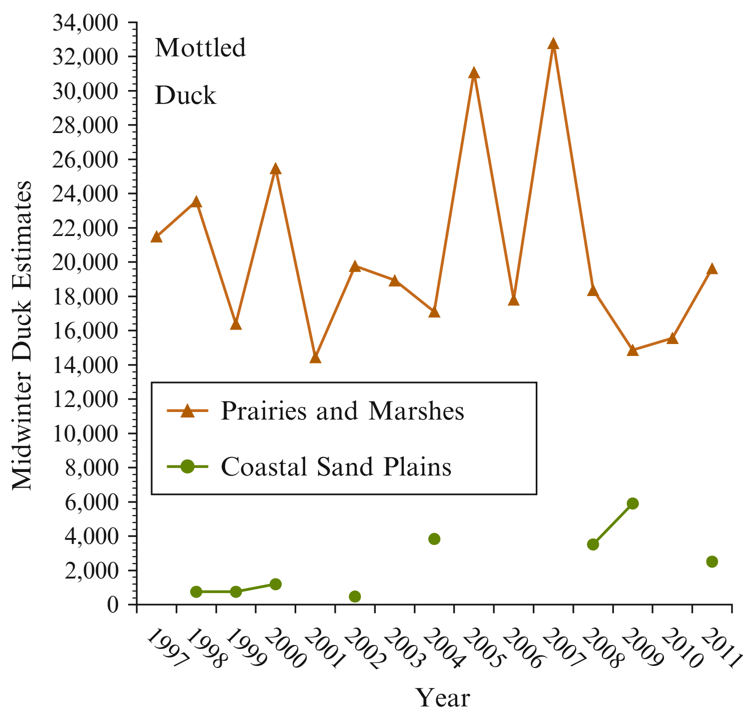

Figure 12.26. Midwinter counts of Mottled Duck from the Texas coast for two different regions (1997–2011, after Texas Parks and Wildlife Department [TPWD] 2011). © J. Burger.

The Mottled Duck prefers to feed in shallow, ephemeral wetlands (Swanson and Meyer 1977), which means they have a narrow range of habitat requirements for nesting. They feed on submerged vegetation in delta and saltwater marshes, on invasive species such as Eurasian Watermilfoil (Goecker et al. 2006), and snails and insects (Imhof 1962). They also feed on vegetation and animal matter (mollusks and crustaceans, insects) in Florida (Stevenson and

Anderson 1994). In Mississippi, more than half of their diet is animal matter (insects, snail, fish, crustaceans), as well as rice, bulrushes, pondweeds, and other aquatic vegetation (Turcotte and Watts 1999). Their dependence on estuarine habitats requires further study, as Moorman et al. (1991) found that Mottled Duck ducklings died if salinity was much greater than 12 parts per thousand (ppt), and that the tolerance may be closer to 9 ppt. This suggests that management to enhance Mottled Duck populations should take salinity into consideration when creating impoundments. Mottled Ducks breed and winter at very low densities in the fringe of the Gulf of Mexico in coastal Alabama and Mississippi, and reach their highest densities in coastal Louisiana and southeast Texas, with smaller numbers south to Veracruz (Bielefeld et al. 2010). They nest in estuarine marshes, although they have been reported nesting in farm fields (Eubanks et al. 2006). Nests and eggs are vulnerable to a wide range of predators, including raccoons, skunks, opossums, dogs, and snake; turtles and alligators (*Alligator mississippiensis*) prey on ducklings (Stevenson and Anderson 1994), and in Texas, predators also include River Otters (*Lutra canadensis*), Striped Skunks (*Mephitis mephitis*), mink (*Mustela visor*), coyotes (*Canis latrans*), Red Fox (*Vulpes vulpes*), Gray Fox (*Urocyon cinereoargenteus*), and feral dogs (*Canis familiaris*), cats (*Felis domesticus*), and Snapping Turtles (*Chelydra serpentina*) (Bielefeld et al. 2010).

Half of the Mottled Duck populations in the United States reside in Louisiana (Lindstedt 2005). Estimated Mottled Duck populations in southeastern Louisiana increased until 1994 (peak of more than 100,000), and then declined to about 18,000 by 2001. Although these populations are currently stable, estimates project further declines with loss of habitat (Lindstedt 2005). Most Gulf Coast states have designated this species of “conservation concern” (Bielefeld et al. 2010), largely because of marsh degradation and drainage. Large-scale efforts to restore hydrology of coastal marshes, as well as construction of smaller impoundments, would benefit the species (Moorman et al. 1991; Wilson 2007). Currently, the breeding population in Florida is estimated to be about 40,000 individuals, and the western Gulf Coast population is estimated at 600,000 birds (Johnson 2009), although estimates differ. For example, Delany and Scott (2006) estimated 35,000 individuals in Florida, and only 135,000 individuals in the western Gulf (Alabama to Mexico). The Florida population is stable, while the status of the western Gulf population is unclear. Breeding surveys from National Wildlife Refuges in Texas suggest a precipitous decline since 1985, when the surveys began (Johnson 2009), although breeding bird surveys show a moderate decline, and Christmas Bird counts show a decline in the same period. They increased before the 1990s (see Figure 12.27 below).

The Texas Parks and Wildlife Department (TPWD 2011) conducts annual waterfowl surveys of the central Gulf Coast Prairies and Marshes, and of the southern Coastal Sand Plains. These data indicate trends for one of the important Mottled Duck breeding areas (Figure 12.28). Mottled Ducks were much less abundant in the southern marshes of Texas, compared to the central areas.

Breeding Bird Survey data are useful for Mottled Duck because they only occur along the coasts, and although the number of routes is small, it still provides an index of numbers. Mottled Ducks showed a sharp decline in Texas, and a decline in Louisiana, although they remained stable in Florida (Figure 12.27). Trends in waterfowl populations for Mexico indicated significant long-term declines for some species, but no significant long-term trends for Mottled Duck (Figure 12.27) (Perez-Arteaga and Gaston 2004). They surveyed only two places along the Gulf Coast of Mexico, but this represented 91 % of the Mexican population. The average count last year was 49 % below the mean, and declines since the mid-1980s bear watching (Figure 12.27).

Using Christmas Bird Counts from 1965 to 2011 as a database, Niven and Butcher (2011) reported that Mottled Duck winter populations increased significantly by 1.2 % per year along

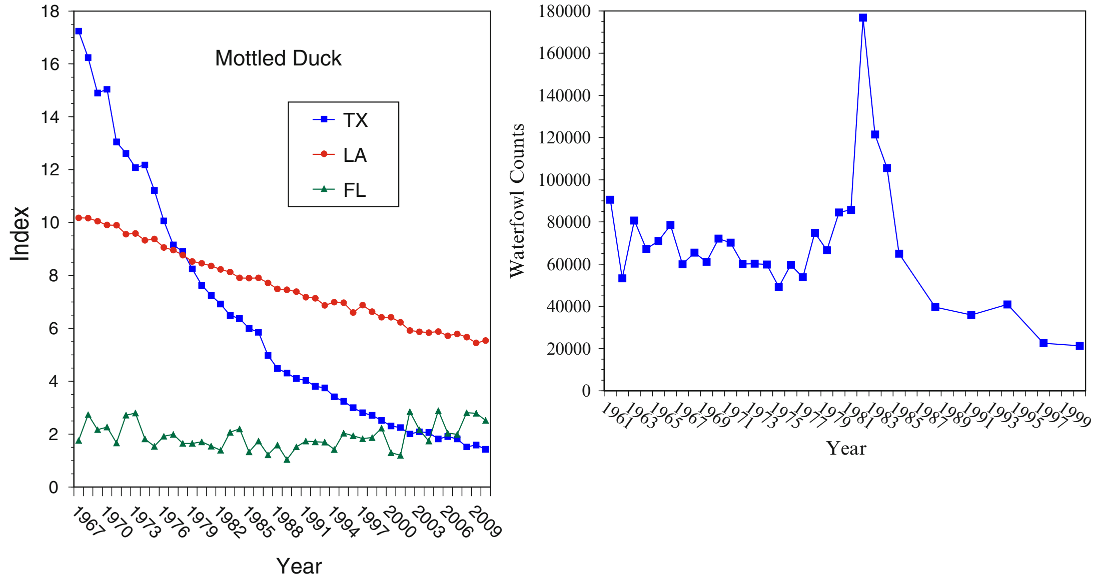

Figure 12.27. Index of Mottled Duck surveyed during the Annual Breeding Bird Surveys (shown on *left*), conducted by the U.S. Fish & Wildlife Service (Bird Banding Laboratory), with trends along the southern Gulf of Mexico coast (on *right*). Mexico counts after Perez-Arteaga and Gaston (2004). © J. Burger.

the U.S. Gulf Coast (Figure 12.28). The conflicting data (Breeding Bird Surveys vs. Christmas Counts) is troubling and bears further examination, especially given the declines at National Wildlife Refuges.

Resiliency is unclear, since the age of first breeding is unknown (perhaps at 1 year); they lay clutches of 8–12 eggs, and breeding success is unknown (Bielefeld et al. 2010). While intrinsic resiliency may be intermediate to high (based on age of breeding and clutch size), massive loss of habitat gives them few options for movement because they are an obligate estuarine species.

12.6.2.7 Osprey

These dramatic white-headed, eagle-sized hawks are familiar to coastal people throughout the United States (Figure 12.29). They are the only North American raptor to feed entirely on fish; they have strong, sharp claws and are also called "fish hawks." Ospreys are one of the most widespread species in the world; they breed or winter on all continents except Antarctica (Farmer et al. 2008). Their main breeding range in North America extends north to central Alaska, northwest Yukon, Northwest Territories, Saskatchewan, Manitoba, and Ontario, to the tree line of Newfoundland (Poole et al. 2002). They dip down into the western, central, and eastern United States, and breed along the Atlantic coast down to almost the tip of Florida, as well as sporadically along the northern Gulf Coast (Eubanks et al. 2006). A nonmigratory race breeds in Cuba (Raffaele et al. 1998). On the west coast they breed down the coast from Alaska to northern California, on Baja California coasts, and on the western Mexican mainland (Poole et al. 2002). The bulk of the North American population winters south of the United States in Central and South America (Poole et al. 2002).

They dive feet first to capture their prey from the top meter of water; this restricts them to surface-schooling fish and to shallow water. Where there is shallow water and abundant prey, they nest more densely and are considered semicolonial (Poole et al. 2002). They frequent large

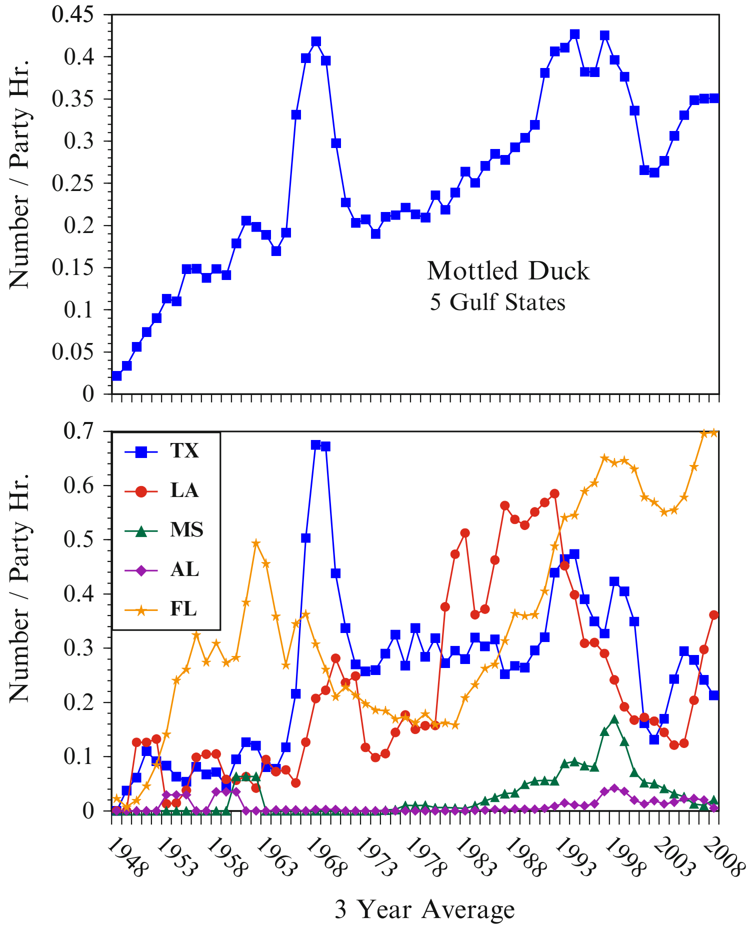

Figure 12.28. Trends data from Christmas Bird Counts to show variation in Mottled Duck counts for different states. © J. Burger.

Figure 12.29. Osprey populations declined dramatically because of exposure to DDT, and in many places, artificial nest structures and egg replacement were used to restore populations. *Right* photo shows three osprey chicks in their nest. © J. Burger.

lakes, rivers, and coastal areas where manmade structures provide perches and nesting sites. Most breed at 4 years of age. They are monogamous, lay a clutch of 1–4 eggs in April, only the female incubates (35 days), and they fledge their young in July and August. Fledging success varies greatly from region to region, perhaps as a result of prey availability. Ospreys make long migrations to Central and South America, although some remain in Florida and Mexico, and more recently, in the other northern Gulf States.

Osprey, like many other fish-eating birds, suffered population declines from the 1950s through the 1970s due to pesticides (DDT) and other contaminants (Poole et al. 2002). The chemicals resulted in eggshell thinning, depressed reproduction, and population declines. The percent of eggshell thinning was directly related to levels of dichlorodiphenyldichloroethylene (DDE), a metabolic breakdown product of DDT. Since the ban on DDT, populations have rebounded.

In 1983, there were about 8,000 breeding pairs in the United States (Henny 1983) and 16,000 to 19,000 pairs in 2001 (Poole et al. 2002). The population in the United States and Canada is about half of the world population of approximately 100,000 birds (Farmer et al. 2008). Migration counts and Breeding Bird Surveys indicate that populations have increased or remained stable; east and midwestern North America had greater increases than in the Great Lakes or western North America, based on counts in the Gulf of Mexico (Farmer et al. 2008). Surveys of Osprey at four locations around the Gulf of Mexico from 1995 to 2005 indicated that they increased significantly in the Florida Keys, in South Point and Corpus Christi, Texas, but with no significant trend in Veracruz, Mexico (Smith et al. 2008).

Christmas Bird Count data shows a clear increase in Osprey in the Gulf States, although the greatest increase was in Florida (Figure 12.30). The increase in Florida was rather steady, but increases in the other states began in the early 1980s.

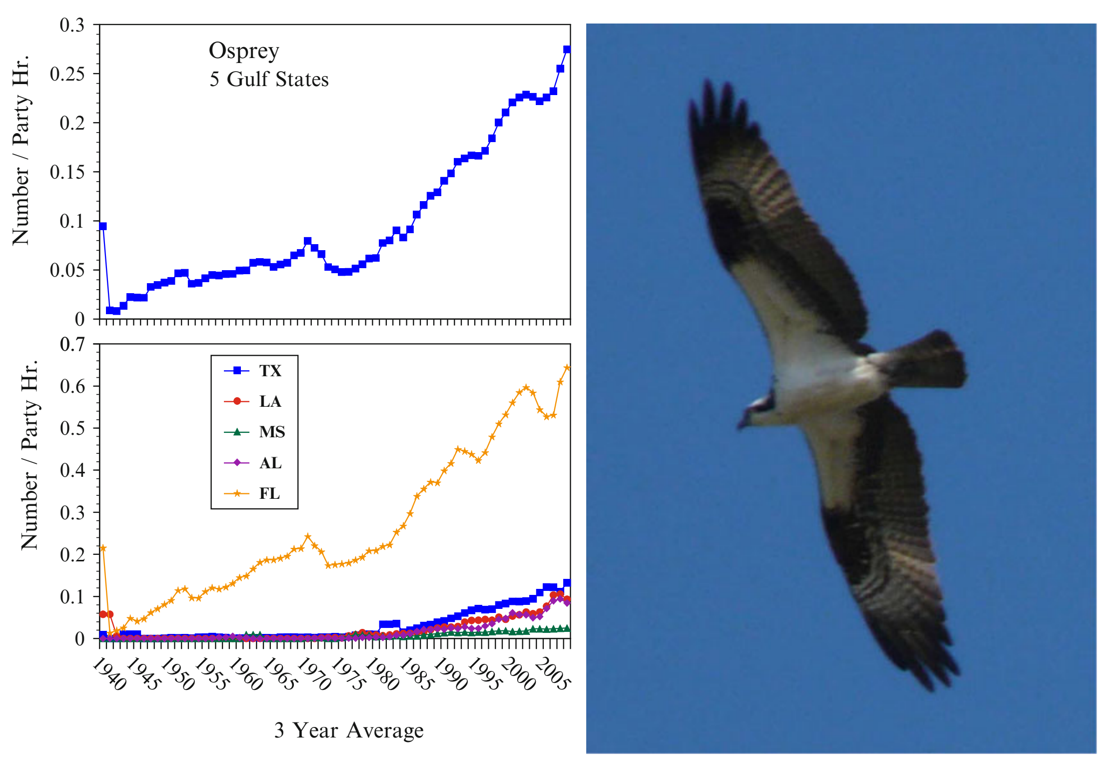

Figure 12.30. Christmas bird count data for Osprey, showing steady increases. © J. Burger.

Resiliency in Osprey is low to intermediate; they breed at 4 years of age, and lay an average of three eggs, but most Osprey do not live beyond 12 years. Since they eat fairly large fish, they are vulnerable to effects from mercury, as well as to pesticides and other contaminants. They forage in shallow water and are more affected by fish abundance and behavior than other species that can fish at a greater water depth. While they adapt to the presence of people, they can suffer disturbances from approaching boats.

12.6.2.8 Whooping Crane

Whooping Cranes, the tallest North American birds (1.5 m), are snowy white with black primaries, and a brilliant carmine crown (Figure 12.31). They are a symbol of international efforts to save an endangered species, and were brought back from the brink of extinction with collaboration among Canadian and U.S. provincial and state agencies (USFWS 1986; Lewis 1995). In 1941, only 15–16 individuals wintered in Texas. They were placed on the Endangered Species List in 1967 and are one of the rarest birds in North America. Whooping Cranes are omnivorous, feeding on insects, frogs, rodents, small birds, minnows, and berries in the summer, and estuarine animal foods (blue crabs and clams) in the winter (USFWS 2010b). On their wintering grounds, in the area between the Rio Grande and Galveston Bay, Whooping Cranes feed in three habitats: (1) estuarine intertidal unconsolidated shore mud, (2) palustrine emergent persistent wetlands, and (3) estuarine intertidal emergent persistent wetlands (Anderson et al. 1996).

Whooping Cranes were once widespread, although not common in the prairie marshes of north-central United States and southern Canada, and they were a common winter resident along the coast, even in Louisiana (Lowery 1974). They are monogamous, mate for life, and nest in bulrushes (USFWS 2010b). The incubation period is 29–31 days, and chicks fledge in 80–90 days (Lewis 1995). They remain in family groups following fledging, and the young learn the

Figure 12.31. Whooping Cranes are pure *white* with a *red* crown (USFWS 2012c).

Table 12.8. World Population of Whooping Cranes in the Wild and in Captivity (after WCCA 2012)

Location	Adult	Young	Total	Adult Pairs
Aransas/Wood Buffalo	235	44	279	78
Florida non-migratory	20		20	8
Louisiana non-migratory	0	10	10	0
Wisconsin/Florida (migratory)	88	17	105	17
TOTAL BIRDS IN THE WILD	343	71	414	103
Patuxent WRC, Maryland	68	5	73	15
Crane Foundation, Wisconsin	34	1	35	11
Other Zoos	48	1	50	8
TOTAL BIRDS IN CAPTIVITY	150	7	157	34

migration route from their parents. On migration they face weather-related problems, shooting, and collisions with wires and fences, and on the wintering grounds they face shooting, disease, and predation (CWS/USFWS 2007; Gil-Weir et al. 2012). They fly some 2,600 mile (over 4,000 km) between their breeding grounds and Texas.

The Whooping Crane population from 1860 to 1870 was estimated at 1,300–1,400 (Allen 1952), although others estimated it at only 500–700 birds (Lewis 1995). In 1937, only two breeding populations remained: a sedentary population in southwestern Louisiana and the Wood Buffalo population that migrated to Aransas National Wildlife Refuge (Lewis 1995). A hurricane in 1940 reduced the Louisiana population from 12 to 6, and the last individual was taken into captivity in 1950.

There is currently only one truly wild population of Whooping Cranes; they breed in Wood Buffalo National Park in Northwest Territories and adjacent Alberta, and winter at Aransas National Wildlife Refuge (Lewis 1995; USFWS 2010b; WCCA 2012). There are, however, other Whooping Cranes at four places: (1) Grays Lake National Wildlife Refuge in Idaho, (2) Kissimmee Prairie in Florida, (3) an eastern migratory population, and (4) captive populations (USFWS 2010b, 2012c; WCCA 2012). In 2012, the total world population of Whooping Cranes was 571, of which 73 % were in the wild; the remainder were in research facilities or zoos (Table 12.8) (WCCA 2012).

The Aransas/Wood Buffalo National Park Whooping Crane population has continued to grow steadily (Figure 12.32). Resiliency in Whooping Crane is low as they start breeding when they are 4 years old, lay only two eggs, and have an estimated life span of 22–24 years (USFWS 2012c, d), although some scientists believe it is as high as 30 (Lewis 1995).

12.6.2.9 Clapper Rail

Clapper Rails are large (the size of a half-grown chicken) with gray-cinnamon buff tails and a long decurved bill. They are emblematic of salt marshes and mangrove swamps, although they are more often heard rather than seen as they skulk through the marsh (Figure 12.33). Their breeding range is from the northern United States to Brazil on the coastal fringes. They range from Massachusetts south to the Florida Keys, on the Gulf Coast from Cape Sable (Florida) west to Tamaulipas, Mexico, and from San Francisco to Baja California, as well as in some inland areas (such as the Salton Sea). Their ranges in Mexico, Central America, and South America are poorly known, but they are reported from many areas (Eddleman

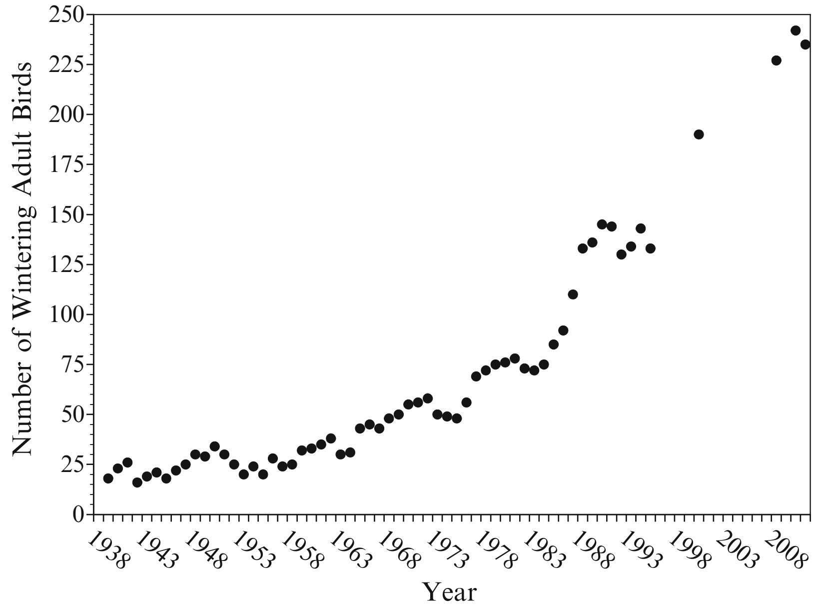

Figure 12.32. Population growth of the Arkansas National Wildlife Refuge adult population of Whooping Cranes that breed in Buffalo Wood National Park in northern Canada (after Lewis 1995; WCCA 2012). Birds are surveyed in the winter in Texas. © J. Burger.

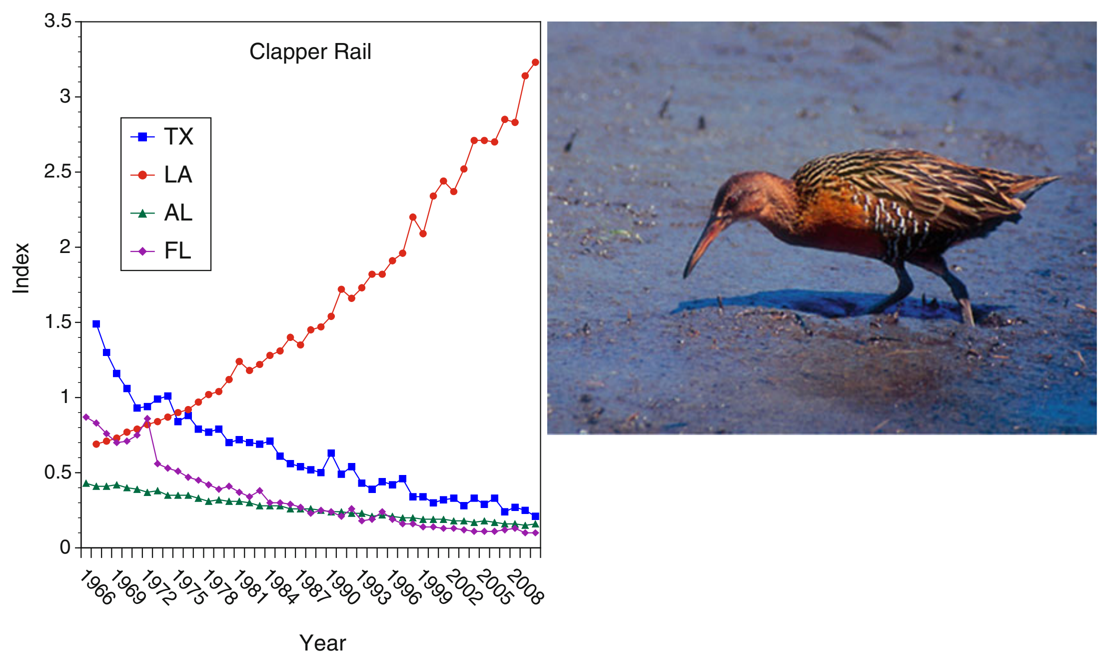

Figure 12.33. Data on Clapper Rail from the Breeding Bird Survey, showing relative increase in Louisiana. © J. Burger. (Photo by USFWS 2012e).

et al. 1998). Most populations are resident, but the more northerly rails move south in the winter.

Clapper Rails are strictly estuarine—they very infrequently nest in freshwater marshes (Olson 1997), and are thus good indicators of marsh conditions, especially contaminants, oil, and habitat loss (Novak et al. 2011). They are a solitary species, and space out within marshes or mangroves. Clapper Rails mainly feed on crustaceans (Eddleman et al. 1998). They build nests in thick vegetation on the higher places, usually where vegetation is taller, providing some protection from aerial predators. They lay 7–9 eggs; most nest failures are due to predation on eggs, and flooding, which is likely to increase with sea level rise. Although young rails feed on their own, they remain with parents until they fledge.

Future habitat changes that result from environmental stress, sea level rise, and subsidence will result in a landward increase in salinity (McKee et al. 2004), with changes in vegetation types and nesting bird populations (Greenberg et al. 2006). Since Clapper Rails nest and forage in habitats with higher salinity than some salt marsh birds, they may increase in Gulf Coast marshes with increased salt water intrusions (Rush et al. 2009a). While habitat loss is the most critical factor, tidal flooding and hunting pressures also decrease their populations (Stevenson and Anderson 1994). Because Clapper Rails breed and forage in coastal marshes and remain hidden most of the time, it is difficult to track their population numbers, although high tides (Rush et al. 2009b) and recent advances in acoustical monitoring make it easier to count them. There are no estimates for the number of Clapper Rails in Gulf Coast marshes, although they are counted on Breeding Bird Surveys and on Christmas Bird Counts. Breeding Bird Surveys indicate that they are declining in all states, except Louisiana, with lower declines in Florida than elsewhere (Figure 12.33).

Using Christmas Bird Counts from 1965 to 2011 as a database, Niven and Butcher (2011) reported no significant trend in Clapper Rail wintering populations along the U.S. Gulf Coast. However, when these data are examined in detail, there appears to be a decline in the northern Gulf from the mid-1970s to the present (Figure 12.34).

Resiliency may be intermediate to high, depending upon the availability of a source population. If a population is extirpated from a region because of habitat loss or degradation, excess available breeders from nearby areas would be necessary to reestablish the population. They likely breed at 1 year, have average clutch sizes of more than nine eggs in the Gulf Coast, and have variable hatching success, depending upon flood losses, that can average 85 % (Eddleman et al. 1998).

12.6.2.10 Snowy Plover

Snowy Plovers are small, snowy shorebirds that blend in with their sandy habitat until they move (Figure 12.35). They were formerly considered conspecific with Kentish Plover (*Charadrius alexandrines*) in Eurasia, but are now separated as a distinct species (*C. nivosus*) (Page et al. 2009). Two subspecies of Snowy Plover breed in North America, one that nests west of the Rocky Mountains, and one that breeds east of the Rockies, primarily on the Gulf Coast (Paton 1994; Elliott-Smith et al. 2004). The west coast subspecies is already listed as threatened on the U.S. Endangered Species List, and the southeastern birds are currently being considered for listing (Brown et al. 2001). Both populations of Snowy Plover are listed as declining by the U.S. Shorebird Conservation plan (USSCP 2004). Snowy Plover has been given the highest conservation priority by the Gulf Coast Prairie Working Group (GCPWG 2000). Recently, Thomas et al. (2012) estimated the total breeding population of Snowy Plovers in North America as 23,555 (95 % confidence limits = 17,999–29,859), and noted that they may be one of the rarest of shorebirds in North America.

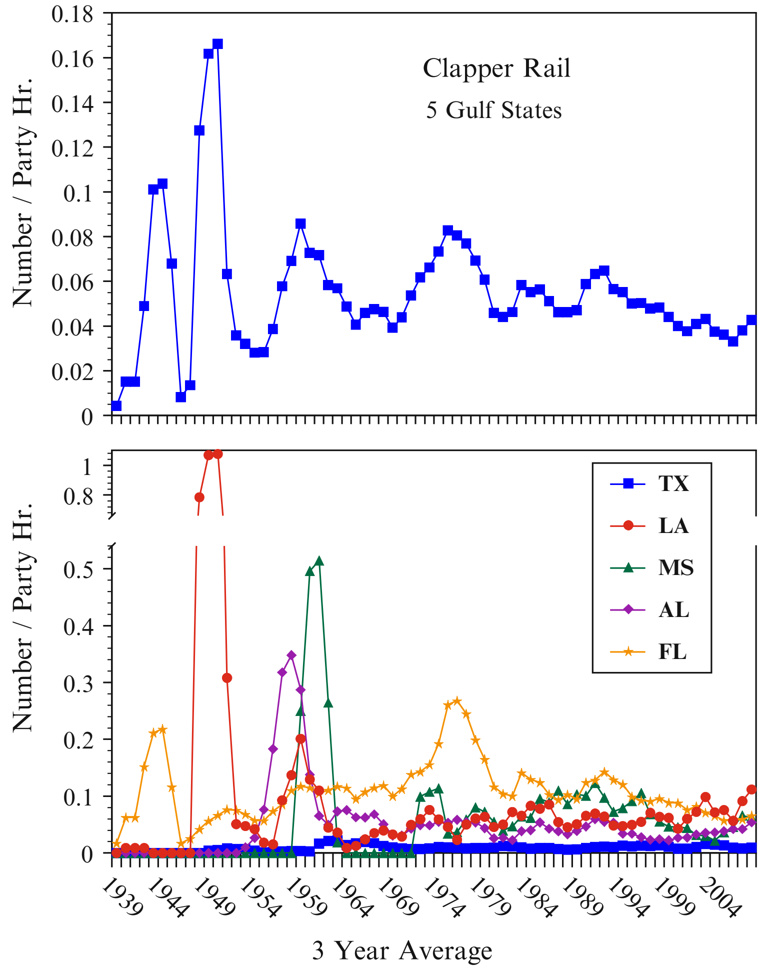

Figure 12.34. Population trends in Clapper Rail as determined by Christmas Bird Counts. Trends seem fairly constant, although the possible downturn since the 1970s bears examination. © J. Burger.

In the Gulf Coast, Snowy Plover are distributed sparsely along the southwest coast of Florida north to Anclote Key and along the Panhandle, in Alabama and Mississippi (mainly on offshore islands), in Louisiana—only two pair in 2001 (Zdravkovic 2005), along the lower Texas coast from Matagorda Island to the Mexican border, and south to Veracruz and the northern coast of the Yucatán Peninsula (Page et al. 2009), where they have been observed in flocks of 100 (Ornat et al. 1989). Results from a recent survey of breeding Snowy Plovers in North America, conducted in 2007 and 2008, indicated that 42 % of all breeding Plovers resided in Great Salt Lake in Utah and Salt Plains National Wildlife Refuge in Oklahoma (Thomas et al. 2012). The total population for the coast of the Gulf of Mexico was 4,515 (19 % of total). Approximately 9 % of the North American breeding population occurs in Mexico (Thomas et al. 2012).

Snowy Plover are attracted to extensive beaches with tidal pools and sand flats that provide foraging areas, although they will also feed in marshes (Withers 2002). They eat small mollusks, crustaceans, marine worms, and insects. In winter, Snowy Plovers often associate with Piping Plovers (Elliott-Smith et al. 2009) and Wilson's Plovers (*Charadrius wilsonia*) (Howell and

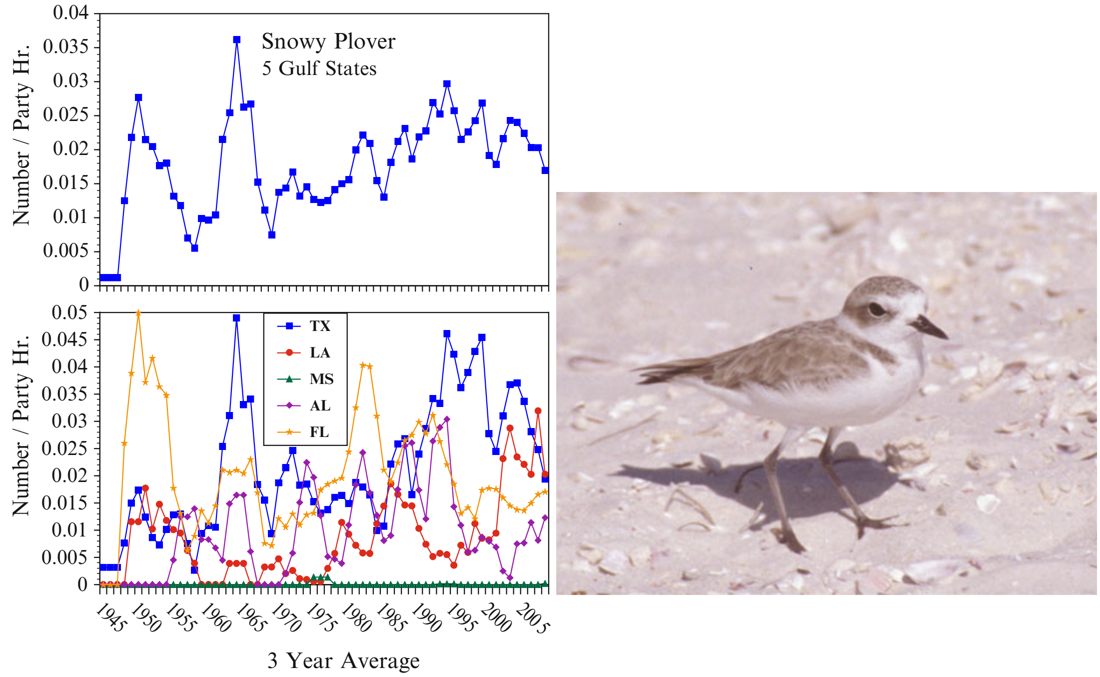

Figure 12.35. Three year running averages of Snowy Plovers counted on Christmas Counts for the five U.S. Gulf states. © **J. Burger.**

Webb 1995). Snowy Plovers nest on sandy beaches on the mainland and on barrier islands, where they make nest cups on the sand, sometimes in colonies with Least Terns (Stevenson and Anderson 1994). Incubation period is 28 days (Warriner et al. 1986); both sexes incubate, and females desert the brood soon after hatching (Page et al. 2009). Counting Snowy Plovers during the breeding season is difficult because studies of marked individuals indicate that at least twice as many birds are present for each one seen, and detection probability is 0.58 (Warriner et al. 1986; Hood and Dinsmore 2007).

Populations of Snowy Plover are likely lower in the Gulf Coast than they were in the late 1880s due to habitat loss and disturbance (Page et al. 2009). Hood and Dinsmore (2007) identified the Laguna Madre (Texas) as an important breeding area, suggesting that it be protected from development since the species is reported to be declining in the Gulf. Coordination with Tamaulipas, Mexico is critical for protection of this species; wintering Snowy Plovers use the algal mudflats there, illustrating the importance of the entire Laguna ecosystems (Mabee et al. 2001). Morrison et al. (2006) reported that the Gulf of Mexico and Caribbean race of Snowy Plover is decreasing, and likely was only 1,500 birds, although more were counted on the next census (Table 12.9) (Elliott-Smith et al. 2009).

Computing 3-year averages using Christmas Bird Count data from 1942 to 2010 indicates variability in the numbers of Snowy Plovers counted (Figure 12.35). Although there appears to be an overall increase, they have declined since 1995 (Niven and Butcher 2011). It is hard to interpret the two peaks in the early 1950s and early 1960s.

Resiliency in Snowy Plover is intermediate as they breed when 1 year old, lay a mean clutch of three eggs, and hatching success varies greatly from 12.5% to 87 % (often depending on the degree of human protection), but they can have multiple broods per season (Page et al. 2009). Paton (1994) estimated a mean adult survival of 2.7 years. Vulnerability of nests and chicks,

Table 12.9. Snowy Plover Surveyed in the Gulf of Mexico During the Winter

States	Number in 2001	Percent in 2001	Number in 2006	Percent in 2006
Texas	690	66	1,340	71
Louisiana	36	3	207	11
Mississippi	13	1	36	2
Alabama	0	0	6	<1
Florida	311	30	312	16
Total	**1,050**		**1,895**	

An additional 119 Snowy Plover were counted in 2006 in Tamaulipas, Mexico in an 89 km (55 mi) habitat survey (Elliott-Smith et al. 2009), © J. Burger

habitat losses, human disturbance, and mammalian predators all contribute to lowered success, particularly in the Gulf.

12.6.2.11 Piping Plover

Piping Plovers are a threatened and endangered shorebird that lives on open beaches, alkali flats, and sand flats. They have a distinctive dark and white pattern of bands on the head, neck, and upper breast (Figure 12.36). The black and white breaks up the outline of birds, allowing them to disappear when motionless. They were listed in 1985, and recovery plans for several regions have been developed (USFWS 1999). They are endemic to North America, with a total population of about 8,000 (Gratto-Trevor and Abbott 2011). The Piping Plover has been given the highest conservation priority by the U.S. Shorebird Conservation Plan, including for the Gulf Coast where they only winter (GCPWG 2000).

They breed on the Atlantic coast of Canada and the U.S. Great Lakes region, Great Plains, the Canadian Prairies, and St. Pierre and Miquelon (French territories off the southwest coast of Newfoundland) (USFWS 1999; Elliott-Smith et al. 2004). They do not breed in the Gulf of Mexico. They winter along the Atlantic and Gulf coasts (into Mexico), and in the Caribbean (Elliott-Smith et al. 2004; Gratto-Trevor and Abbott 2011). Piping Plovers in Texas show wintering site fidelity (Drake et al. 2001).

Piping Plovers forage on beaches, washover areas, and tidal flats on small invertebrates (Withers 2002). They frequently nest on sandy beaches with little vegetation, but with some shell or pebble cover; often near dunes (Wilcox 1959; Burger 1987b; Maslo et al. 2011). They are monogamous for one breeding season, although there are rare reports of sequential polyandry (Amirault et al. 2004). Both members of the pair incubate their four-egg clutch for 26–31 days (USFWS 1999), and both parents brood the young (Gratto-Trevor et al. 2010). The parents draw predators from their nests and chicks with very elaborate distraction displays, which involve a broken wing act (Figure 12.36).

They are dependent on management, such as restrictive access for off-road vehicles (Burger 1991b, 1994b; USFWS 1999; Maslo and Lockwood 2009). There is controversy about the effectiveness of nest protection techniques. Nest protection includes nest enclosures (predator exclosures), electrified wires on enclosures, fencing (mainly for people), wardening, predator control, and captive breeding (Burger 1987b; Murphy et al. 2003; White and McMaster 2005; Cohen et al. 2008, 2009; Maslo and Lockwood 2009). Beach nourishment increases habitat for Piping Plover (Webster 2006). Management has largely focused on reducing mortality during the breeding cycle, and it is unclear whether the sustained efforts required can be maintained (Gratto-Trevor and Abbott 2011).

Figure 12.36. Piping Plover depend upon being cryptic to avoid predators, but when faced with a predator, they begin a distraction display that ends with a full broken wing act (*right*). © J. Burger.

Table 12.10. Trends in Wintering Populations of Piping Plover Surveyed Along the Northern Gulf Coast (after Haig et al. 2005[a]; Elliott-Smith et al. 2009)

State	1991	1996	2001	2006
Florida (Gulf)	481	320	305	321
Alabama	12	31	30	29
Mississippi	59	27	18	78
Louisiana	750	420	511	226
Texas	1,904	1,333	1,042	2,090
Totals for the Gulf States	**3,206**	**2,131**	**1,906**	**2,744**

Given are number of adults recorded. In 2006, 76 Piping Plover were recorded in 89 km (55 mile) of habitat in Tamaulipas, Mexico (censuses did not cover the remainder of the southern Gulf (Elliott-Smith et al. 2009))
[a]Table 2 of Haig et al. (2005) lists 44 for the Gulf states, but this must be a typographical error, since they report only 31 from the Atlantic coast and 44 from the Gulf Coast (with a total count of 375)

As a federally endangered species, Piping Plovers are useful indicators because their populations are closely monitored, and their wintering in the Gulf Coast makes them vulnerable to coastal stressors. Populations declined during shorebird harvesting for the millinery trade in the late 1880s and early 1900s (USFWS 1999). In the latter half of the twentieth century, however, Piping Plover populations declined because of habitat loss and alterations, human disturbance, and increased nest predation (Sidle 1984). The breeding population estimate of 5,945 plovers is probably an underestimate (Elliott-Smith et al. 2009). The U.S. Fish and Wildlife Service identified human disturbance and habitat loss as the two greatest threats to Piping Plovers on the wintering ground (USFWS 2009b). Other threats during the fall and winter include hurricanes, oil spills, and red tides. Gratto-Trevor and Abbott (2011) provide the best and most comprehensive review of conservation efforts for Piping Plover.

A complete winter survey of Piping Plovers was conducted in 1991, 1996, 2001, and 2006 (Haig and Plissner 1993; Haig et al. 2005; Elliott-Smith et al. 2009). In 2001, they reported 2,389 piping plover during the winter, but 5,945 adults were counted during the breeding season (Haig et al. 2005). In 2006, the International Piping Plover Census covered more than 12,400 km of potential habitat in 2 weeks (2,470 sites, 1,300 observers) (Elliott-Smith et al. 2009; Gratto-Trevor and Abbott 2011). More Piping Plovers were recorded in 2006 in the northern Gulf than in either 1996 or 2001, but numbers were lower than in 1991. In all years, Texas had most of the Piping Plovers (Table 12.10).

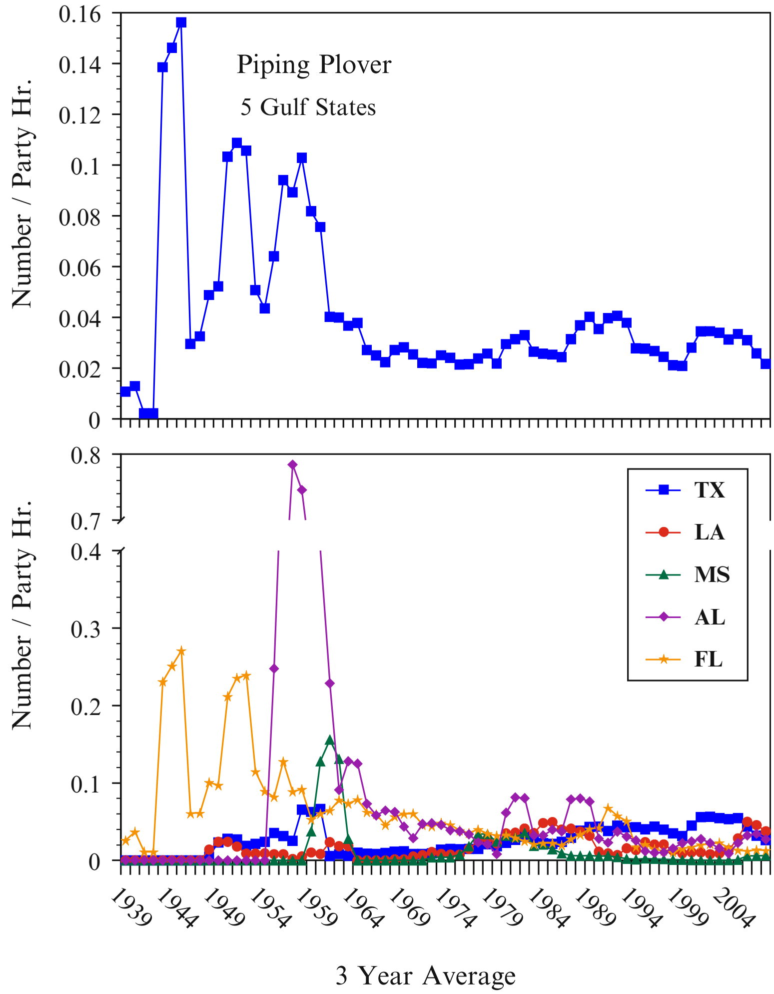

Figure 12.37. Christmas Bird Count data for Piping Plover, showing early variability, followed by much less variability in wintering plover along the Gulf Coast. © J. Burger.

It is also instructive to examine the Christmas Bird Count data for yearly variations (Figure 12.37). Despite recovery efforts, the number of wintering Piping Plovers counted along the Gulf Coast has remained relatively constant, and appears to have declined since the late 1990s.

Resiliency of Piping Plovers is apparently relatively low, as indicated by the great effort by the USFWS Recovery Team and state agencies to protect nesting and foraging habitats, with relatively modest success (USFWS 2003, 2009b). They breed the first spring after hatching, the number of chicks fledged per year varies from 0.3 to 2.5 per nest, and average life span is 5 years (Wilcox 1959; USFWS 1999; Elliott-Smith and Haig 2004; Gratto-Trevor et al. 2010). However, since they nest on sandy beaches exposed to human disturbance, predators, high nest failures, and habitat loss, resiliency of breeding populations is low, explaining the recent decreases in wintering birds along the Gulf of Mexico.

12.6.2.12 Laughing Gull

Laughing Gulls are small, dainty, black-hooded gulls that careen low over beaches and mudflats, or soar high in the air hawking insects (Figure 12.38). They nest in colonies of up to 25,000 pairs on sandy or rocky shores, and in salt marshes along the Atlantic and Gulf coasts of North America, as well as on some Caribbean islands, the Gulf of California, and Pacific coast of Mexico (Burger 1996a). Although they nest on the Chandeleur Islands of Louisiana, they do not nest in Mississippi (Turcotte and Watts 1999). They also nest on the islands in the Campeche Bank of the southern Gulf (Tunnell and Chapman 2000). They winter from North Carolina south through the remainder of the breeding range, along the west coast of Baja California, and along the Pacific coast from Colima, Mexico, south to Peru, the Galapagos, and Chile (Burger 1996a). They are particularly common in winter in the southern Gulf of Mexico (Howell and Webb 1995). Formerly *Larus atricilla*, Laughing Gulls are now listed as *Leucophaeus atricilla* in the latest AOU checklist and supplements (AOU 1998).

Laughing Gull populations were devastated by market hunting for plumes and eggs in the late 1880s and early 1900s (Sprunt 1954). They expanded their numbers thereafter in the northeast, but suffered competition with the larger Herring Gulls that did not breed in the region until the late 1940s (Burger 1983). Laughing Gulls did not face such competition from an expanding exotic species in the Gulf of Mexico, perhaps accounting for their large populations there. They are good indicators because they are common along the Gulf Coast, are nesting and foraging generalists, and are an integral component of nesting colonies and foraging assemblages both along the coast and in the Gulf.

Laughing Gulls are generalist foragers, eating fish, insects, other invertebrates, and garbage. They follow shrimp boats in Texas (Eubanks et al. 2006) and fishing boats off Mississippi (Turcotte and Watts 1999) in search of scraps. They dive for fish, follow boats that stir up prey, “hawk” for flying insects, and catch food thrown by beach-goers or fishermen (Stevenson and Anderson 1994; Burger and Gochfeld 1983c).

Laughing Gulls are one of the most common breeding birds along the Gulf Coast, and they are residents, migrants, and winter visitors. They do not nest in Alabama (Imhof 1962), but they do on the nearby Chandeleur Islands of Louisiana (Imhof 1962), where they are mainly coastal and rarely move inland (Lowery 1974). Along the Gulf they nest on sand and in marshes (Imhof 1962; Schreiber and Schreiber 1979; Burger 1996a, b). Most Laughing Gull colonies in coastal Louisiana are in marshes (80 %), and the remaining 20 % are on sand or in shrubs (Greer et al. 1988). They are monogamous, lay three eggs, and both sexes incubate and

Figure 12.38. Laughing Gulls often nest in marshes (*left*) and are opportunistic foragers on fish or invertebrates along the shore. © J. Burger.

Table 12.11. Changes in Abundance of Breeding Colonial Waterbirds in Galveston Bay, Texas (after Glass and Roach 1997)

Year	All Species	Laughing Gull	Black Skimmer
1973	54,645	35,860 (66 %)	1,873 (3 %)
1979	50,160	32,070 (64 %)	2,472 (5 %)
1985	39,008	22,698 (58 %)	1,101 (3 %)
1990	46,813	17,608 (38 %)	1,900 (4 %)
1996	48,126	19,052 (40 %)	1,582 (3 %)

Given are numbers of nesting pairs (with percent of total birds)

care for the young (Burger 1996a). Yearly differences in reproductive success are due to flooding, predators, and human disturbance (Burger 1996a). Nesting is a compromise between nesting on islands that are high enough to avoid flooding, while being low enough to avoid mammalian predators, and competition with other ground-nesting colonial species (Burger 1983).

A significant proportion of the North American breeding population is located in the Gulf. Many Laughing Gulls that breed along the Gulf Coast remain there, wandering along the coast in the winter, while gulls from farther north also winter along the Gulf Coast. Local surveys provide an indication of trends information. For example, periodic surveys in Galveston Bay indicate that Laughing Gulls make up a significant portion of the colonial nesting birds (Table 12.11) (Glass and Roach 1997). From 1973 to 1996 nesting pairs of Laughing Gulls declined. In 2001, there were 22,000 breeding pairs in the Galveston Bay survey (Eubanks et al. 2006). The downward trend has continued; the Galveston Bay Status and Trends Project rated Laughing Gulls as significantly decreasing (GBEP 2006).

Similarly, information from Louisiana shows declines in the number of breeding Laughing Gulls (Figure 12.39) (Visser and Peterson 1994).

There was an overall increase in Laughing Gulls on Shamrock Island in Texas from 1973 to 1999 (Figure 12.40). The trend continued until about 2007 and then declined (TCWS 2012). Information from Tampa Bay shows that the number of breeding pairs was stable until about 2008, and then they increased (Hodgson and Paul 2010). Data from Breeding Bird Surveys show a different pattern, with Laughing Gulls increasing in Texas and Alabama (Figure 12.41). This bears further examination and suggests that population trends need to be followed for a region, rather than for one colony. Furthermore, the counts are from shore and not from boats near breeding islands, which may suggest that Laughing Gulls are now foraging closer to shore.

Using Christmas Bird Counts from 1965 to 2011 as a database, Niven and Butcher (2011) reported that wintering Laughing Gulls showed a significant increase of 3.0 % per year in the Gulf region. This may reflect an increase in wintering Laughing Gulls, rather than from local residents. Using Christmas Bird Count data from 1940 to 2005, 3-year running averages were computed, showing a decline from the 1990s to the present (Figure 12.41). The 1-year increase (mainly Texas) in the last year may not reflect a real increase. These two conflicting analyses indicate the difficulty of taking different time periods to examine trends. It appears that the 40-year trend may be increasing, but the trends over the last 15 years are decreasing for both breeding populations and wintering populations along the Gulf.

Resiliency in Laughing Gulls is intermediate to high because they can breed when 3 years old, lay three eggs, have high hatching success (74–81 % in Florida) (Schreiber et al. 1979), fledge up to 1.32 chicks per nest, and live up to 19 years (Burger 1996a). Recovery potential is

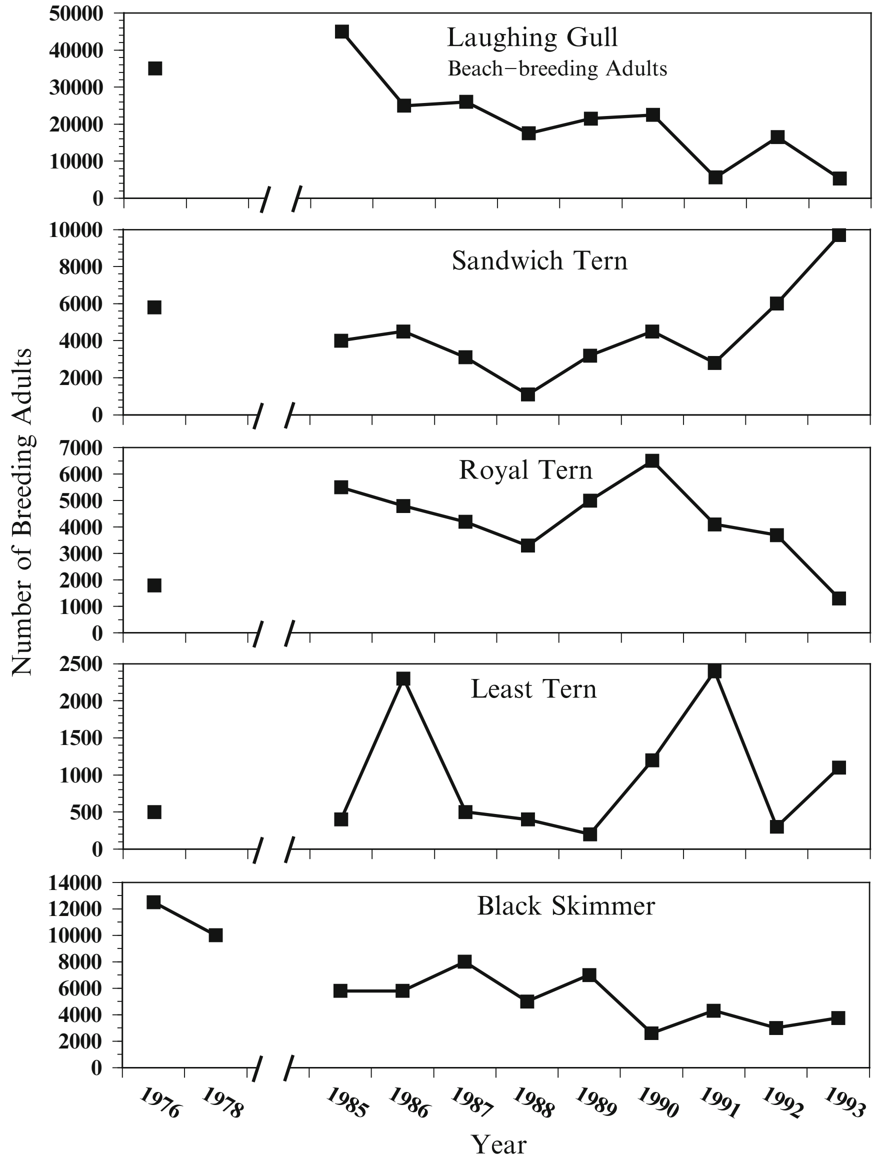

Figure 12.39. Number of breeding adults for several species nesting in Louisiana (after Visser and Peterson 1994). Photo (following page) shows Laughing Gulls at a breeding colony in Texas (photo by J. Burger). © J. Burger.

high, but in the Gulf this must be balanced against losses due to habitat loss, predators, tidal flooding, and hurricanes (Burger 1978b).

12.6.2.13 Royal Tern

Royal Terns are large, stocky terns with bright orange bills and a black crest when they start breeding. They breed primarily along the Atlantic coast from Virginia south to Florida, and along the Gulf Coast to Texas, throughout the Caribbean, along the Pacific coast of Mexico, and on the Atlantic coast of South America (Buckley and Buckley 2002). They are common

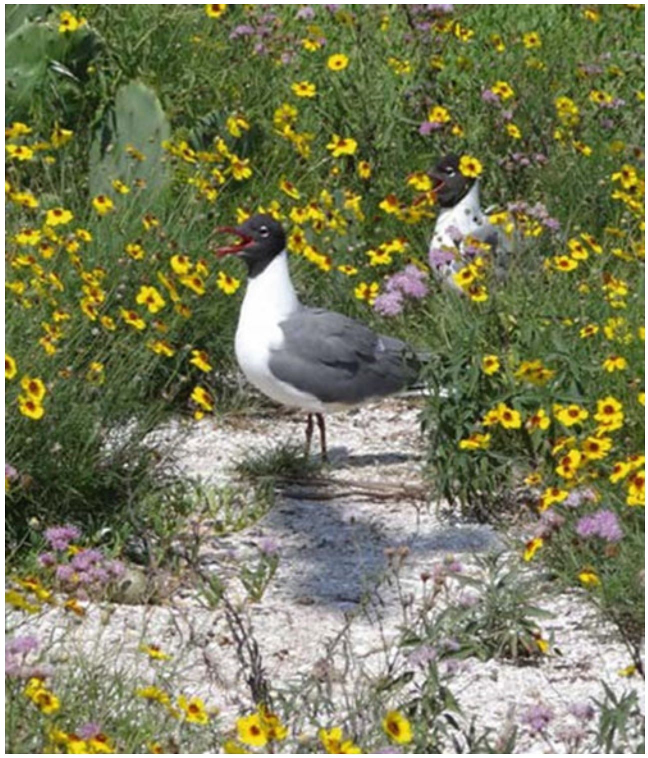

Figure 12.39. (continued)

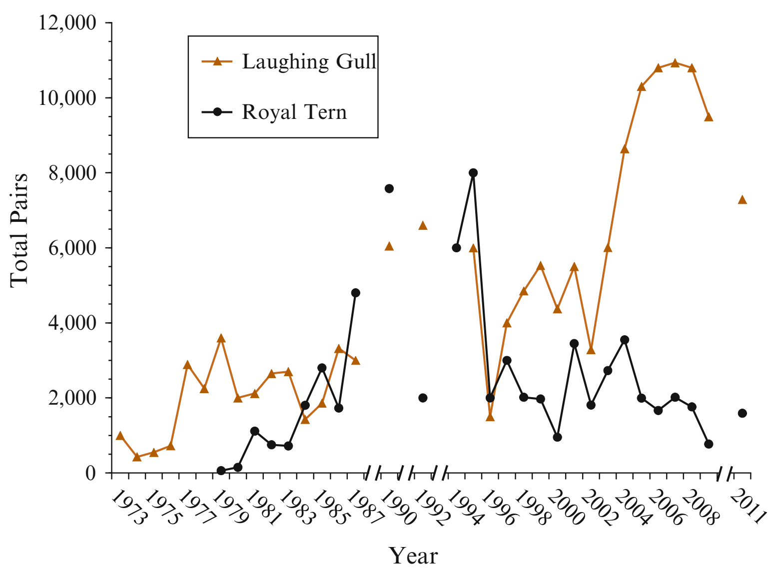

Figure 12.40. Data on pairs of Laughing Gulls and Royal Terns from 1973 to 1999 from Shamrock Island, Texas (after Gorman and Smith 2001; TCWS 2012). © J. Burger.

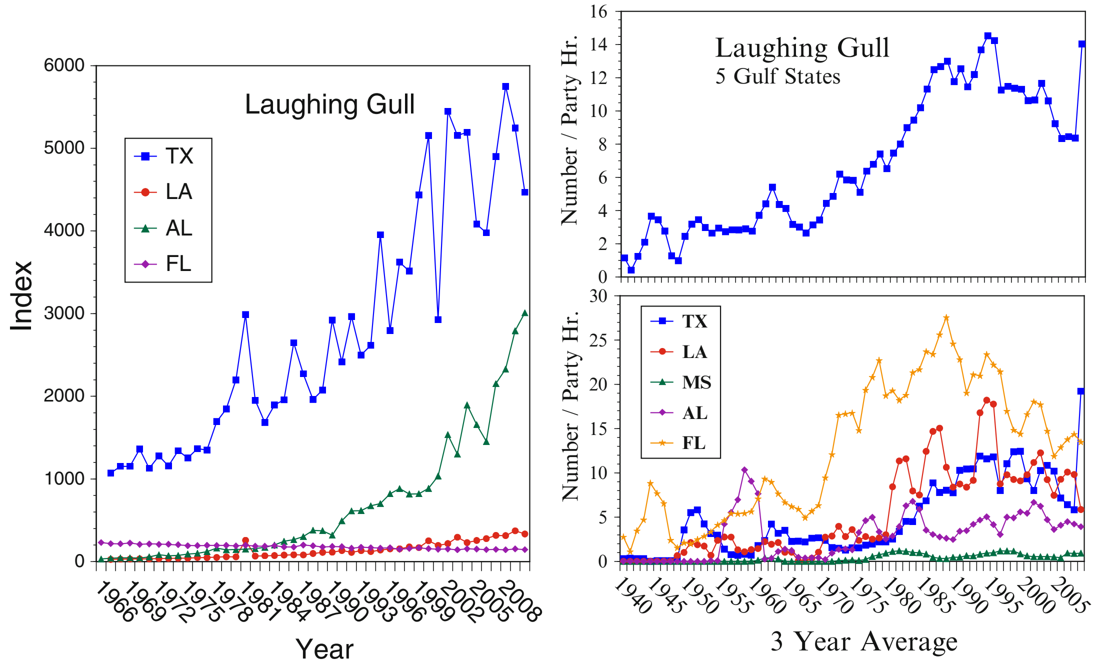

Figure 12.41. Breeding Bird Survey data for Laughing Gull showing increases in Texas and Alabama (*left*), compared to Audubon Christmas Count Data (*right*). © **J. Burger.**

Figure 12.42. Royal Terns have an orange bill; Caspian Terns have a red bill. © **J. Burger.**

breeding birds along the Gulf, nest on islands off Veracruz (Howell and Webb 1995), in the Campeche Banks (Tunnell and Chapman 2000), and in the West Indies, northern South America, and on islands in the Caribbean (Buckley and Buckley 2002). They are rarely found inland (Sprunt 1954). Formerly *Sterna maximus*, they are now listed as *Thalasseus maximus* in the latest AOU supplements (Figure 12.42).

Royal Terns are of interest because they nest on the sand in large colonies, have high colony turnover rates, and the Royal Terns along the Gulf represent about 40 % of the U.S. breeding

Figure 12.43. Royal Terns nest in dense colonies on sand. Photo by M. Gochfeld (with permission).

population (Visser and Peterson 1994; Lindstedt 2005). Abandonment of colonies is indicative of habitat quality problems that need to be addressed in the Gulf States. Royal Terns forage on small prey fish, which they capture by diving, but they also eat squid, shrimp, and crabs in Florida (Stevenson and Anderson 1994).

Royal Terns nest in dense groups, either in monospecific colonies, or with other terns (e.g., Caspian, Sandwich), Laughing Gulls, and Black Skimmers (Figure 12.43). Royal Terns nest a mere body length apart. When they nest with other species, they still nest in dense groups, which may be within or adjacent to more spaced-out gulls and terns. Royal Terns lay one egg, both incubate, and both provision the young. There is usually synchrony in egg-laying within subcolonies, which results in synchronous hatching. Parents brood very young chicks, but chicks quickly join a crèche (young birds that stay in a close-knit group), which protects them when parents are away foraging (Buckley and Buckley 2002). Buckley and Buckley (2002) estimated the number of breeding pairs for the Gulf region as follows: 1,000 in Florida (both coasts), 250 in Mississippi, 10,590 in Louisiana, and 22,463 in Texas. Breeding populations in Louisiana declined in the early 1990s (Figure 12.39) (Visser and Peterson 1994). They attributed the variability in nesting numbers to the vulnerability of their nesting habitat to storms and high tides. Delany and Scott (2006) estimated the number of Royal Terns in the United States to be 139,000. Trends data from Shamrock Island in Texas (Figure 12.40) indicates an overall increase in the number of breeding Royal Terns until the mid-1990s (Gorman and Smith 2001), and then they declined (TCWS 2012). Breeding Bird Survey data indicate a great increase in Royal Terns in Louisiana, but a slight decline in Alabama and Texas (Figure 12.44).

Analysis of Christmas Bird Count data does not indicate a significant trend (Niven and Butcher 2011), although an examination of data from Florida seems to indicate a decline, as well as a decline in the Gulf Coast overall (Figure 12.45).

Resiliency is intermediate because they do not breed until the age of 5–6 years and lay one egg, and Royal Terns can live up to 28 years, but most live fewer years (Buckley and Buckley 2002). There are few data on reproductive success because the young form crèches, making it difficult to follow families. Royal Terns have extended parental care up to the second year (Buckley and Buckley 1974), placing an additional stress on parents.

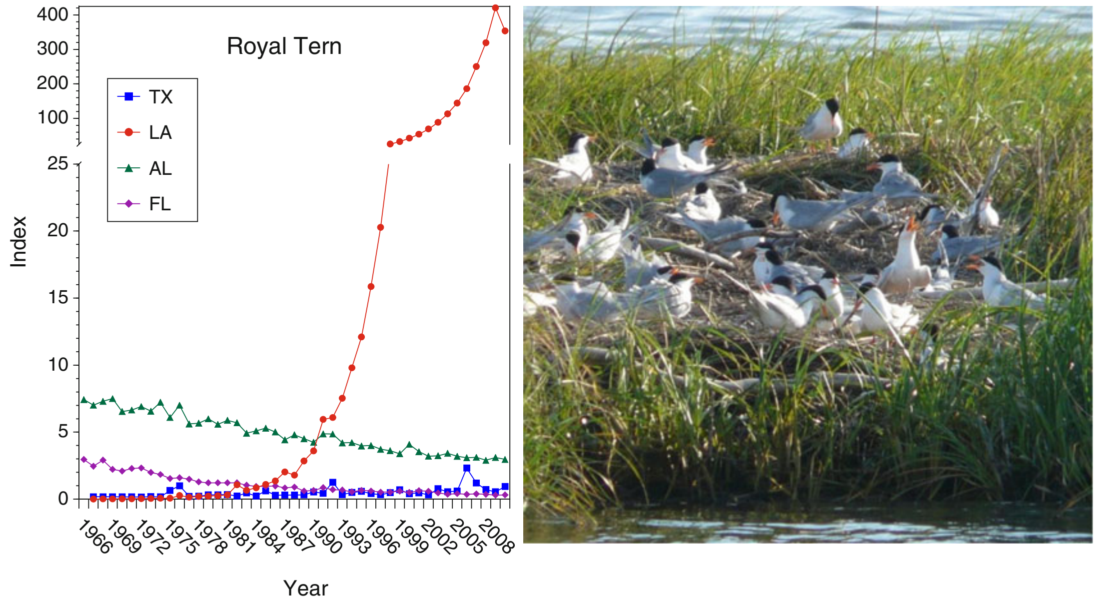

Figure 12.44. Breeding bird survey data for Royal Terns in the Gulf States. © J. Burger.

12.6.2.14 Black Skimmer

Black Skimmers, which are about the size of a Royal Tern, are familiar and striking as they fly silently just above the water with their bill dipped in—skimming (Figure 12.46). They breed from Massachusetts south along the Atlantic and Gulf coasts to southern Mexico, on islands in the Caribbean, and from southern California (and inland Salton Sea) to Nayarit, Mexico (Gochfeld and Burger 1994). A significant proportion of the world population of Black Skimmers breeds along the Gulf Coast. They winter from North Carolina south, along the Gulf Coast, south to Panama, and on the Pacific Coast to Costa Rica (Gochfeld and Burger 1994). Birds breeding in Florida are residents (Stevenson and Anderson 1994), which may also be the case for the rest of the Gulf Coast. One estimate for the number of Black Skimmers nesting along the Atlantic and Gulf coasts is 90,000 to 101,000 individuals; another 4,200 are in California and on the Pacific coast of Mexico (Delany and Scott 2006).

Black Skimmers skim across the water's surface to catch fish and invertebrates, feeding within the top 5–6 cm of water, often at dusk or at night (Erwin 1990; Burger and Gochfeld 1990; Yancey and Forys 2010). At St. Vincent National Wildlife Refuge on the Gulf Coast of Florida, 71 % of Black Skimmer foraging occurred within 2 m of the land (in water depths of 13.4 cm, Black and Harris 1983).

Black Skimmers usually nest on bare sand in colonies with gulls and terns, including Least, Sandwich, Royal and Caspian Terns, and Laughing Gulls, deriving some protection from their aggressive neighbors (Gochfeld 1978; Erwin 1979; Burger and Gochfeld 1990; Turcotte and Watts 1999). They also nest on dredge spoil or on salt marshes (Figure 12.47), and in northwestern Florida, on roofs (Gore 1991). In coastal Louisiana, Skimmers nest mainly in herbaceous vegetation (79 %), or on sand and shell beach (12 %, $N = 27$ colonies) (Greer et al. 1988). Black Skimmers are monogamous; courtship is synchronous; they lay up to six eggs, and both sexes incubate, defend the nest, and care for the chicks (Gochfeld 1980; Burger 1981e; Burger and Gochfeld 1990, 1992). The chicks are cryptically colored and blend in with sand or bleached wrack, and remain motionless until a predator or person is upon them, when they run frantically

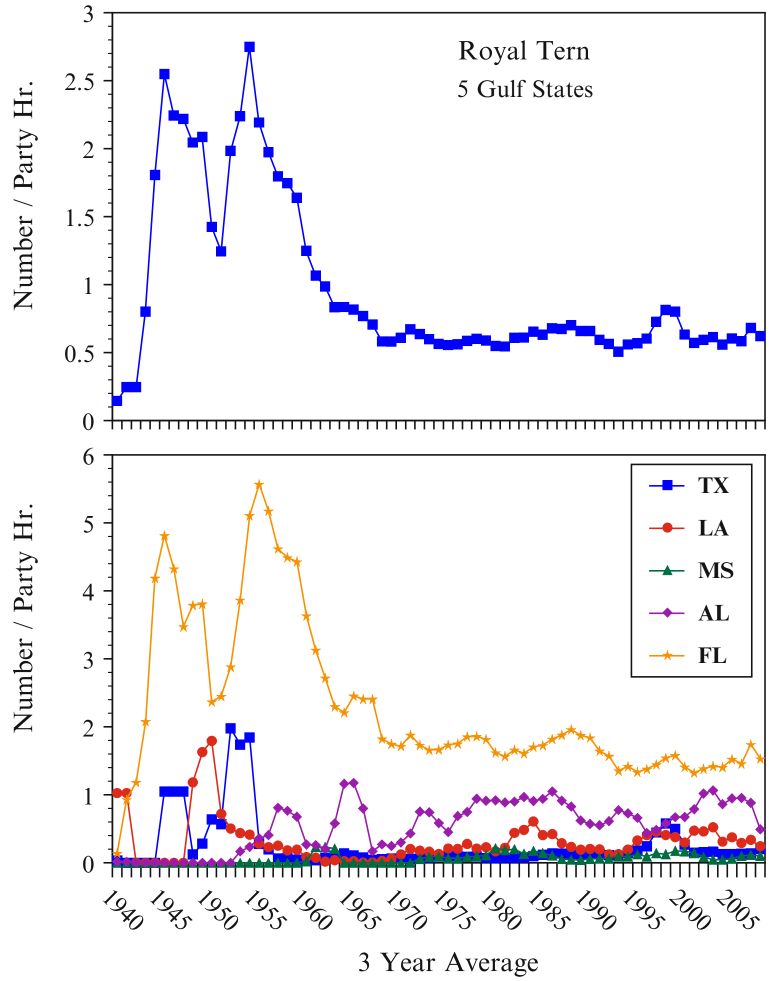

Figure 12.45. Trends in Royal Terns in the Gulf States as indicated by Christmas Bird Count data. © J. Burger.

Figure 12.46. Black Skimmers are so named because they fly just above the water surface, with the tip of their bill in the water, skimming. © J. Burger.

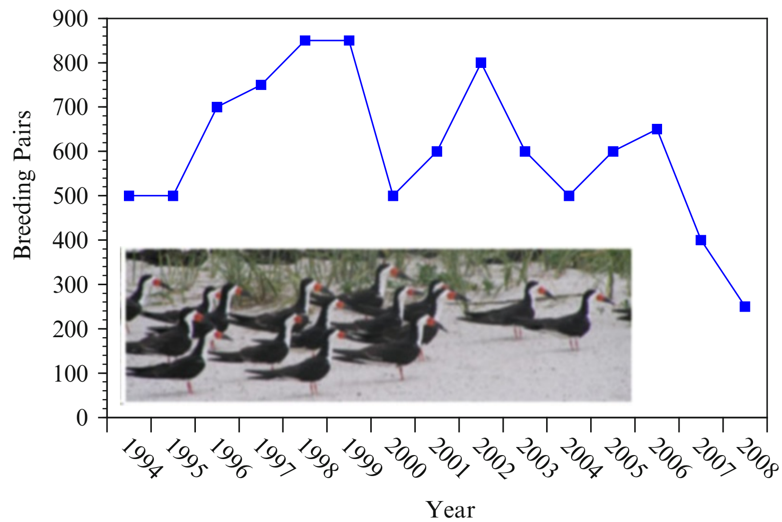

Figure 12.47. Populations of Black Skimmers nesting in Tampa Bay, showing declines. © J. Burger.

for cover (Burger and Gochfeld 1990; Gochfeld and Burger 1994). Skimmers often fail to brood chicks during heavy rains, and lose more chicks to cold stress than do terns (Burger and Gochfeld 1990).

Black Skimmer populations declined from oil and organochlorine chemicals in the 1960s and 1970s (Gochfeld 1973, 1974, 1979; Custer and Mitchell 1987). Contaminant levels in the Gulf, however, declined by the early 1980s to below effect levels in Galveston Bay (King and Krynitsky 1986). On the other hand, creation of dredge spoil islands has provided new nesting habitat for Black Skimmers—in Louisiana the numbers of nesting Black Skimmers steadily increased over the 5 years of a study examining the effect of dredge spoil on nesting (Leberg et al. 1995).

Waterbird surveys in Galveston Bay provide some trends information (Glass and Roach 1997). During this time Black Skimmer numbers remained relatively constant, although Laughing Gulls declined (Table 12.11). Trends information from Shamrock Island, Texas indicates an overall decline in the number of pairs on the island from 1973 to 1999, although the numbers did vary (Gorman and Smith 2001). The overall trend after 2000 for Black Skimmers, however, was downward (TCWS 2012), and there is interest in listing the species in Texas (D. Newstead, Coastal Bend Bays & Estuarine Program, Corpus Christi, TX, personal communication). Similarly, the number of breeding Black Skimmers declined in colonies in Louisiana from 1976 to the 1990s (Figure 12.39) (Visser and Peterson 1994). They attributed the decline to erosion of preferred nesting areas, human disturbance, and a reduction in the number of available sites, a recurrent theme for ground nesting colonial birds along the Gulf Coast.

Information from Florida also indicates statewide declines in the number of breeding Black Skimmers (Figure 12.47) (Hodgson and Paul 2010; FFWCC 2011b). Stevenson and Anderson (1994) refer to a single colony of 2,000 pairs in 1935, which is very large by current standards. By the late 1970s, the largest colony in the state was 1,000 pairs in Nassau County (Clapp et al. 1983). During the 2010 nesting season, the largest colony had only 450 pairs, and of the 19 colonies, 12 had fewer than 50 pairs each (FFWCC 2011b).

Breeding Bird Surveys show a steep decline in Alabama, Louisiana, and Florida, with Texas showing a slight increase (Figure 12.48). While there are few routes along the coast, the index

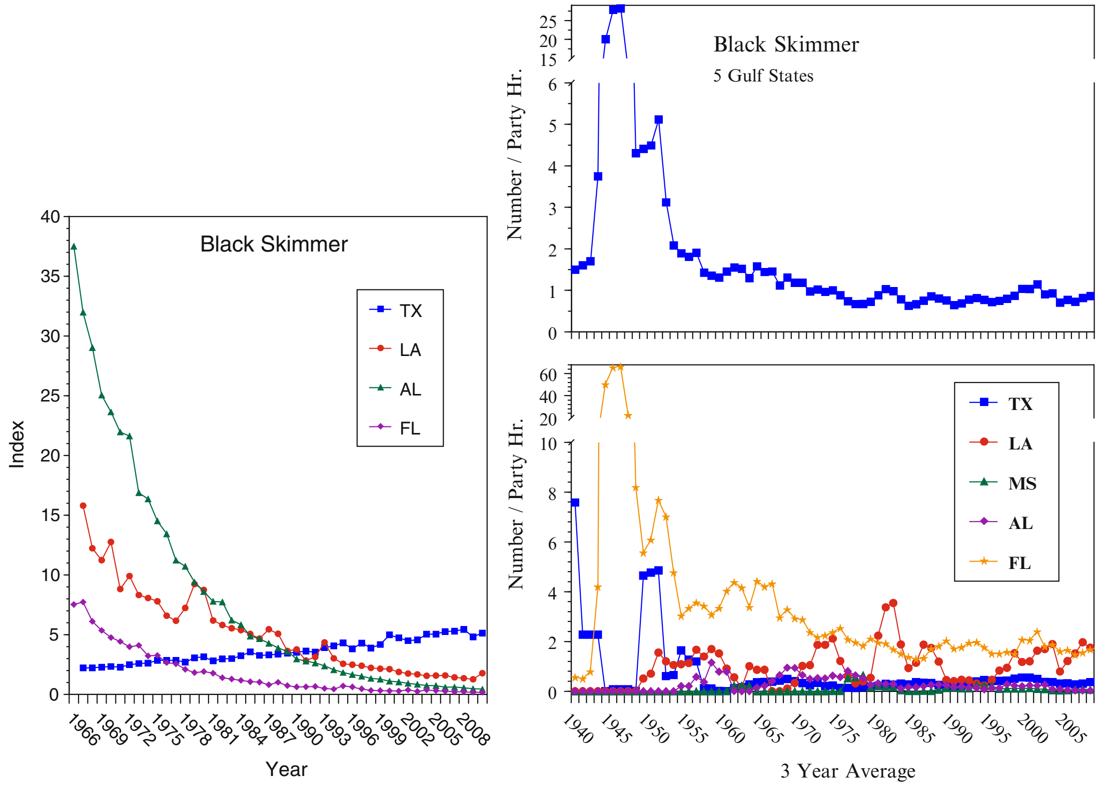

Figure 12.48. Breeding Bird Survey data for Black Skimmer for the Gulf States (*left*) and Audubon Christmas Count Data (*right*). © **J. Burger.**

provides information, which corroborates the breeding data reported from individual colonies. Using Christmas Bird Counts from 1965 to 2011 as a database, Niven and Butcher (2011) reported that wintering Black Skimmers showed a significant decline of 2.2 % per year along the northern Gulf. Three-year running averages show similar trends (Figure 12.48).

Resiliency in Black Skimmers is intermediate as they delay breeding until they are 3 or 4 years old, lay an average of three eggs, and probably live an average of 10–15 years (Burger and Gochfeld 1994). Since they nest on ephemeral habitats (sandy beaches) or those exposed to flood tides (marshes), reproductive success is often very low.

12.6.2.15 Seaside Sparrow

Seaside Sparrows are small, fairly nondescript brown birds that skulk in grassy vegetation, often running through the grasses (Figure 12.49). They are habitat specialists of salt and brackish marshes and occur in small, localized populations along the Atlantic and Gulf coasts (Post et al. 2009). At least five subspecies breed along the Gulf Coast: *Ammodramus maritimus mirabilis* (southern tip of Florida), *A. m. peninsulae* (northern Florida Gulf Coast), *A. m. juncicota* (Alabama), *A. m. fisheri* (Louisiana Seaside Sparrow, to Texas), and *A. m. sennetti* (southern Texas coast) (Post et al. 1983, 2009). Subspecies are separated by expanses of open water and unsuitable habitat. Seaside Sparrows breeding along the Gulf area residents, while those nesting in the northeastern United States migrate to the southern Atlantic and do not

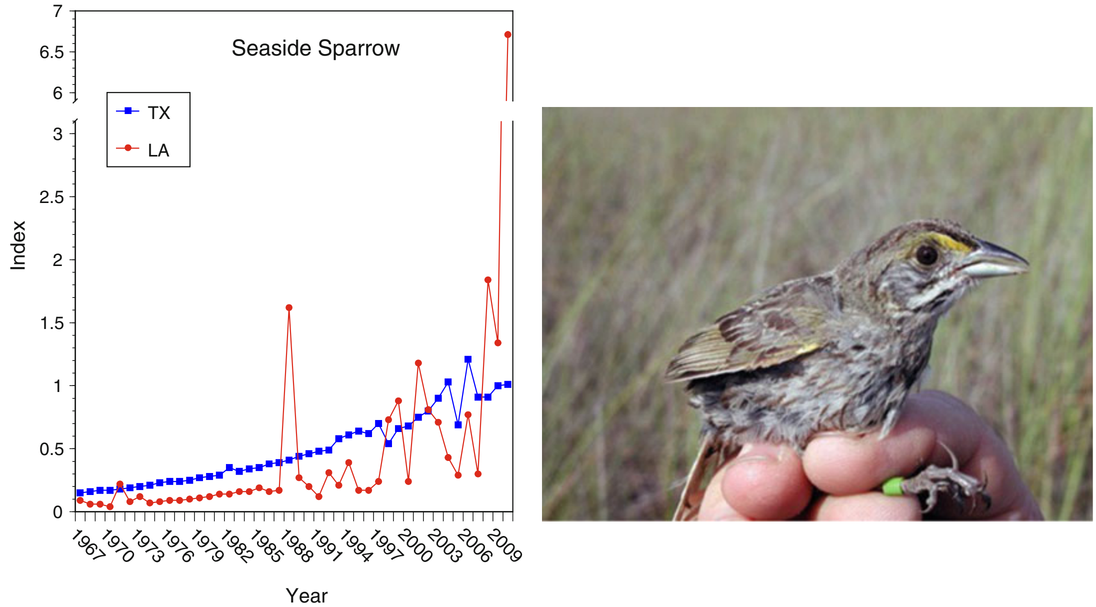

Figure 12.49. Breeding Bird Survey data for Seaside Sparrow for the Gulf States. © **J. Burger. Photo by USFWS (2012b).**

migrate to the Gulf. Distribution of breeding Seaside Sparrows is not uniform, leading to the suggestion that they are semicolonial (Post et al. 2009).

Seaside Sparrows forage on grasshoppers, crickets, caterpillars, flies, moths, spiders, snails, mollusks, and small crabs, such as Fiddler Crabs, and grass seeds (Imhof 1962). They nest solitarily, occurring in relatively small, localized populations (Post et al. 2009). Although they sometimes occur with Sharp-tailed Sparrows (*Ammodramus acuticauda*), in some places, such as Alabama, they nest in wetter places than the latter species (Imhof 1962). In resident populations, such as those in the Gulf, females may remain all year on the male's territory, retaining the same mate from year to year (Post et al. 2009). Females lay 4–6 eggs, and the female incubates alone. Eggs and chicks are vulnerable to predation and tidal flooding (Post et al. 2009).

Seaside Sparrows are good indicators of the presence of healthy expanses of salt marsh; Louisiana Seaside Sparrows reside exclusively in brackish and saline marshes along the northern Gulf and are representative of the threats faced by species that breed and winter in these marshes. They are considered a species of management concern throughout their range because of habitat loss and alteration and human disturbance (Cowan et al. 1988; Greenlaw 1992). Responses to burning are unclear because the effects relate to timing (Gabrey and Afton 2000). Sparrows evolved with lightening-induced natural fires that create mosaic patterns, leaving some places unburned. In contrast, anthropogenic burning often involves large, continuous patches. Gabrey and Afton (2000) concluded that management should maintain a mosaic of burned and unburned marsh to provide adequate refuges for sparrows.

Breeding Bird Survey data for Seaside Sparrows indicate increases in Texas and Louisiana, but it is unclear how reliable these data are, given the difficulty of locating this species (Figure 12.50). Christmas Count data for the U.S. Gulf States indicates declines (Figure 12.50).

Resiliency is intermediate to high because they start breeding the spring after their hatching year, lay 2–5 eggs (modal of three in the south), and have a potential life span of 8–9 years (Post et al. 2009). Little life history information is available for *A. m. fisheri*, the species that

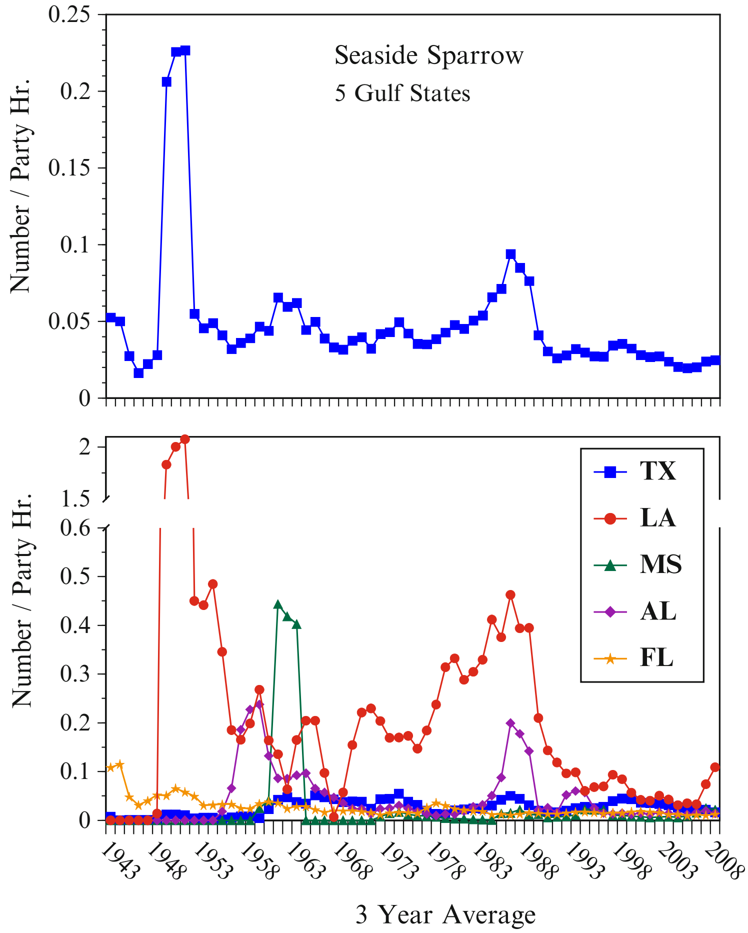

Figure 12.50. Trends in Seaside Sparrow wintering populations using 3-year running averages computed from Christmas Bird Count data. © **J. Burger.**

occurs from Louisiana to southern Texas. Recovery is likely low, given the loss of marshland and tidal/storm flooding while nesting.

12.6.2.16 Comparisons Among Indicator Species

It is also useful to compare indicators. Two examples illustrate variations among species: Breeding Bird Surveys for the Gulf of Mexico and habitat use by water birds at Laguna Madre in Texas (Anderson et al. 1996). These were chosen because they include many different species of birds.

The Breeding Bird Surveys, conducted by the U.S. Bird Banding Laboratory, provide useful data on trends (Figure 12.51). The Banding Laboratory produces maps that indicate whether populations are increasing or decreasing.[3] The data provide trends information that corroborates, for the most part, individual studies conducted in states and regions. A glance at Figure 12.51 shows that Osprey and Royal Tern are increasing in the U.S. Gulf, while Mottled Duck and Clapper Rail are declining in several states. There are some shifts, where populations

[3] Available at http://www.mbr-pwrc.usgs.gov/bbs.

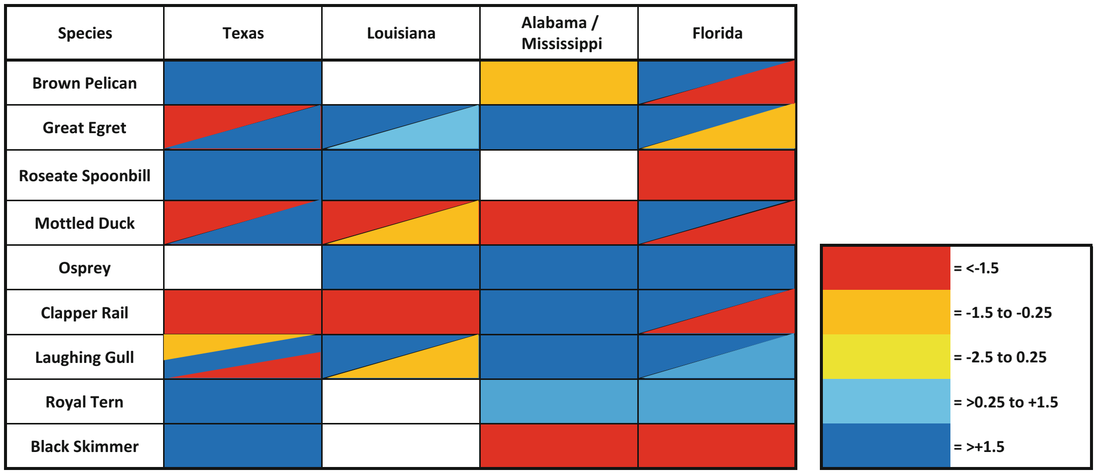

Figure 12.51. Interspecific comparison of population trends data for the indicator species from the Breeding Bird Surveys Conducted along the Gulf Coast (Bird Banding Laboratory, from their web site). Shown are general trends, in percent change per year (from 1966 to 2010). For some regions, two trends are given because there is variation within the coastal area. © J. Burger.

appear to be declining in some parts of the Gulf, and increasing elsewhere, including Brown Pelican and Black Skimmer. Furthermore, there are no data for Reddish Egret and Seaside Sparrow, both species of concern for the Gulf. However, these are long-term trends, and the trend over the last 10–15 years may differ, as is clear from the temporal patterns provided in the indicator accounts. The indicator accounts show that Black Skimmer is declining and that Laughing Gull has declined over the last 20 years.

Laguna Madre (in Texas) is the second example. More than four million birds (100 species) use the Laguna Madre in mid-winter, including 35 species of shorebirds, 20 species of wading birds, and waterfowl (Muehl et al. 1994; ABC 2011). Anderson et al. (1996) examined bird use of 82 different wetland types between the Rio Grande and Galveston Bay, and found clear differences in both the diversity and types of habitats used. Some groups used many different habitat types (Gallinule and Coots), while others such as rails and grebes used few habitat types (Table 12.12). Differences among species, however, are of interest; Table 12.12 lists habitat uses of the indicator species (calculated from data in Anderson et al. 1996). There were interspecific differences in the number of habitats used, even within a group of closely related species. For example, Spoonbills used only 16 habitats, while Snowy Egret used 52. They drew the following conclusions: (1) cormorants and pelicans used wetlands with less than 30 % vegetation; (2) gulls, terns, and skimmers used estuarine and lacustrine wetlands with less than 30 % vegetation; (3) grebes and rails used palustrine aquatic-bed rooted vascular wetland types; (4) herons, egrets, and bitterns used lacustrine and estuarine wetlands; and (5) shorebirds used estuarine intertidal wetlands.

12.6.3 Indicator Species Groups

The Gulf of Mexico plays a critical role in nesting or migratory behavior of some avian groups, including pelagic seabirds, migratory hawks, wintering waterfowl, nesting colonial birds, and Nearctic-Neotropical migrants. Some of the species that make up these groups have been discussed in the previous section as indicator species, but here they are reviewed briefly because of their overall importance in the Gulf. Many of these groups are monitored separately by state agencies.

Table 12.12. Habitat Use of Waterbirds at Laguna Madre in Texas (calculated from Anderson et al. 1996)

Species	Number of Wetland Types Used	Total Birds	Total Flocks (Mean Flock Size)	Flocks/Number of Wetland Types
Brown Pelican	10	86	26 (3.3)	2.6+
Great Egret	49	1,901	631 (3.0)	12.9+
Reddish Egret	14	145	107 (1.4)	7.6
Roseate Spoonbill	16	611	81 (7.5)	5.0
Snowy Plover	8	185	15 (12.3)	1.9
Piping Plover	8	29	11 (2.6)	1.4
Laughing Gull	34	14,331	313 (45.8)	9.2+
Royal Tern	9	107	20 (11.9)	2.2
Least Tern	19	328	68 (4.8)	3.6
Black Skimmer	8	1,569	18 (87.2)	2.2–

12.6.3.1 Pelagic Seabirds

Much of the focus in this chapter and by state and federal agencies, scientists and others, deals with birds that concentrate along the coasts. It is far easier to census birds nesting there than it is to study pelagic seabirds. However, many seabirds mainly use the open, pelagic zones of the Gulf of Mexico. Seabirds do not simply migrate over or around the Gulf, but instead use the open waters of the Gulf for wintering and foraging. The Gulf waters also provide foraging habitat for more tropical-nesting species, some of which use the Campeche Banks for breeding (Tunnell and Chapman 2000), such as frigatebirds and boobies, and for North Atlantic-nesting species, such as Northern Gannet (see section below).

Of all the birds considered, the distribution and behavior of pelagic species are the most affected by prey availability and oceanic features (Hunt 1990; Schneider 1991; Ribic et al. 1997; Schreiber and Burger 2001a, b; Zuria and Mellink 2005). In the Gulf of Mexico, the Loop Current and eddy systems greatly affect distribution of seabirds in the northern region (Ribic et al. 1997). Prey is not evenly distributed over the open ocean; individual prey patches are often small and interspersed (Hunt and Schneider 1987). Foraging seabirds can search for prey by (1) looking for the presence of feeding birds (plunge-diving) as a signal of prey availability (Simmons 1972; Gotmark et al. 1986; Gochfeld and Burger 1982), (2) looking for other seabirds flying in the same direction, presumably toward a prey patch, (3) watching birds that return to a colony with food (Gaston and Nettleship 1981), (4) searching for particular oceanographic conditions, and (5) returning to known foraging areas.

Whether or not to associate with marine mammals is another decision foraging seabirds make (Burger 1988b, c). Foraging with mammals (whales, dolphins) can make prey fish more available and identify large expanses of zooplankton; it can also result in competition or interference foraging (Pierotti 1988a). Marine birds and mammals can interact in at least five ways: (1) birds can have passive associations; (2) birds can be attracted to the same resource; (3) birds can be actively drawn to marine mammals because they drive prey to the surface; (4) birds can be attracted to marine mammals to scavenge on by-products of mammal foraging; and (5) birds can actively avoid marine mammals that might prey on them; for example, Orcas eat diving birds (Pierotti 1988b).

Seabirds often forage over schools of prey fish that have been forced to the surface by predatory fish, such as bluefish (*Pomatomus saltatrix*) or tuna (Safina and Burger 1985, 1988;

Au and Pitman 1988). Such schools are usually ephemeral as prey fish soon scatter and swim away from the surface; usually there is no direct competition among the seabirds foraging above them (Burger 1988b, c).

Interactions between seabirds and fisheries include foraging near boats on fish in nets, foraging behind boats on prey churned up by fishing operations, foraging on discarded offal from factory ships, and feeding on offal near onshore facilities (Furness et al. 1992). Some seabirds panhandle food around docks. Many of the interactions among birds, marine mammals, predatory fish, and fisheries operations are described fully in chapters in Burger (1988c; 2017) and in Schreiber and Burger (2001a).

Interactions with fisheries are an ongoing concern for many diving seabirds (Forsell 1999; Gilman 2001; Gilman et al. 2005). The National Marine Fisheries Service Pelagic Observer Program observed 6,949 longline sets from 1992 to 2005 in the U.S. Atlantic longline fishery, which included the Gulf of Mexico (Hata 2006). In 52 sets, 114 seabirds were captured (69 % were dead upon retrieval). Gulls were the most common birds caught, followed by unidentified seabirds, shearwaters, and gannets (Hata 2006). Hata (2006) concluded that seabird mortality was less in Gulf waters than elsewhere.

12.6.3.1.1 Baseline Continental Shelf Surveys in 1979 and 1980–1981

A pilot study was conducted of seasonal distribution and abundance of marine mammals, sea turtles, and marine birds to make effective decisions about oil and gas development in the Outer Continental Shelf of the U.S. Gulf Coast (Fritts and Reynolds 1981). The continental shelf varies from 185 to 215 km wide off West Florida and the Yucatán coasts, to 25 km off the Rio Grande (Texas), and 13 km near Veracrúz, Mexico. They conducted aerial surveys in Florida and Texas because of the presence of major shipping lanes; surveys conducted from August to December 1979 extended 222 km perpendicular to the coast. The survey units were off Brownsville Texas; Corpus Christi, Texas; Tampa Bay, Florida; and Naples, Florida. During this time, they identified 14 bird species, and 14 categories of birds (i.e., dark terns). There were remarkably few birds on these transects. However, several conclusions were drawn: (1) terns were the most common species and were observed in all four survey areas in both August and November; (2) boobies, shearwaters, and petrels were observed mainly off Texas in August; (3) pelicans were observed off south Florida; and (4) gulls were observed mostly in November in all four survey areas.

Terns accounted for the following percentages: (1) 66 % (South Texas, August); (2) 65 % (South Texas, November); (3) 76 % (North Texas, August); (4) 35 % (North Texas, November); (5) 68 % (North Florida, August); (6) 75 % (North Florida, November); (7) 64 % (South Florida, August); and (8) 89 % (South Florida, November). Royal Terns were the most abundant of the terns (Fritts and Reynolds 1981). More birds were counted near shore than in pelagic waters.

A more extensive survey, conducted using the same methodology from May 1980 to April 1981, identified 68 bird species (Fritts et al. 1983). The four study areas extended into pelagic waters from Brownsville, Texas; Marsh Island, Louisiana; Naples, Florida; and Merritt Unit, Florida. The diversity of birds was similar in all four study sites, but was 3 times greater in the subunit off Louisiana than in Texas or South Florida (Table 12.13). These are perhaps the best data on bird distribution in the Gulf pelagic waters, and they can be used to understand species, and seasonal and geographical differences.

The most common species were Royal Tern, Laughing Gull, and Herring Gull. Numbers of Royal Terns were highest right after the breeding season, when young birds were flying. Laughing Gulls breed along the Gulf, but do not go as far offshore during the breeding season. Herring Gulls do not breed in the Gulf and they build up in February before migrating north to breeding colonies (Figure 12.52).

Table 12.13. Survey Data of Marine Birds from 1980 to 1981 in Four Study Sites in the Northern Gulf of Mexico (after Fritts et al. 1983)[a]

Species	Brownsville, Texas	Marsh Island, Louisiana	Naples, Florida	Merritt Island, S. Florida
Common Loon	0	1	130	3
Cory's Shearwater	28	7	6	149
Audubon's Shearwater	4	1	45	60
White-Tailed Tropicbird (+ unidentified)	0	1	1	3
American White Pelican	453	395	0	139
Brown Pelican	21	1	243	987
Masked Boobies	7	2	0	2
Northern Gannet	29	303	30	14
Double-crested Cormorants	4	92	219	2
Magnificent Frigatebird	1	0	96	13
Unidentified Jaegers	2	1	2	139
Herring Gull	193	1,304	193	0
Ring-billed Gull	40	133	54	29
Laughing Gull	503	2,493	221	0
Franklin's Gull (all in April)	52	0	0	225
Common (type) Terns	22	64	441	249
Sooty Tern	4	2	224	36
Bridled Tern	14	1	9	360
Royal Tern	841	1,638	2,294	22
Sandwich Tern	1	89	9	2
Black Tern	35	170	948	22
Total	**2,246**	**6,698**	**5,170**	**2,708**

Transects were out from the coast on the continental shelf. Given are the total number of each species sighted in transects from June 1980 through April 1981. © J. Burger
[a]Fritts et al. (1983) also conducted some opportunistic surveys, and recorded tropicbirds, Brown Boobies, and one unidentified Jaeger.

12.6.3.1.2 Surveys in the Northern Gulf in the Mid-1990s

Ribic et al. (1997) made four offshore cruises in the northern Gulf during four seasons ($N = 194$ transects). Data were taken between the 100 and 2,000 m isobaths in the northern Gulf of Mexico, off the coast from Texas to Florida (from about 96° west, to 88°). No species of bird was observed in all four seasons. Skuas predominated, with Pomarine Skuas being the most common. They were present in all seasons except the summer when they breed in the Arctic. During winter, the most common birds were Pomarine Skua, Herring Gull, and Laughing Gull. Overall, fewer birds were observed in the spring; Band-rumped Storm Petrel (*Oceanodroma castro*) was the most common and was observed only in the spring. Herring Gulls and Laughing Gulls were observed in winter, nearly all birds were observed in spring, and all terns were observed in summer and were more likely to be seen outside of the eddies. Pomarine Skua was more likely to be seen in the eddies (Ribic et al. 1997).

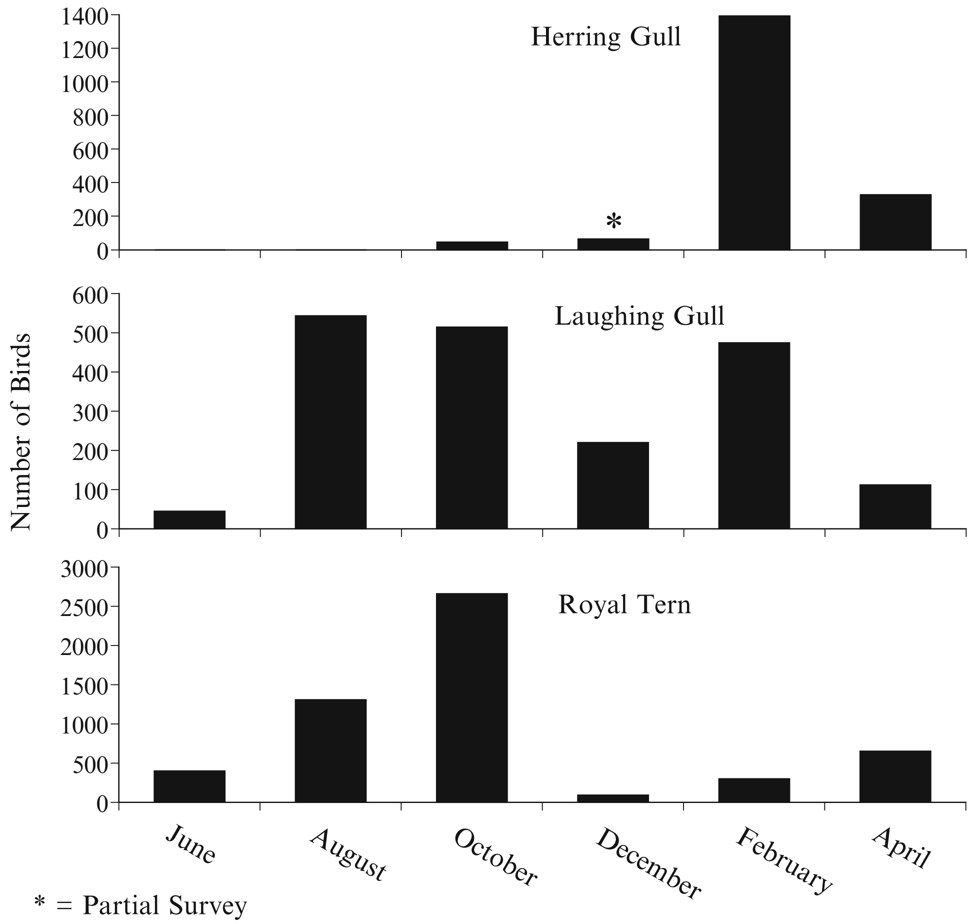

Figure 12.52. Seasonal abundance of seabirds observed from 1980 to 1981 in four transect study sites in the Northern Gulf of Mexico (after Fritts et al. 1983). © J. Burger.

12.6.3.1.3 Pelagic Surveys from 1996 to 1997 in the Northern Gulf of Mexico

As part of the GulfCed II Program, three cruises were conducted in spring, and mid- and late summer, mainly off Louisiana (Hess and Ribic 2000; Davis et al. 2000). The spring cruise spanned 44 days and covered 6,401 km of both the oceanic Gulf and continental shelf, the mid-summer cruise was 17 days and covered 2,500 km (track line in the Gulf that included eddies), and the late summer cruise was 16 days and covered 2,015 km (Hess and Ribic 2000). During the spring cruise, 5,918 seabirds were recorded during 334.8 effort hours. Terns were the most abundant group; Sooty Terns were the most abundant tern (Hess and Ribic 2000). All the other, more pelagic seabirds were much more rare in abundance. The majority of gulls observed were Laughing Gulls. About the same overall percentage of species groups were observed in the mid/late summer as in the spring. Overall the number of birds per effort hour varied by season, with the lowest level occurring in May to June (0.61 sightings per effort hour for all birds), and the highest level occurring in August to September (26.41 sightings per effort hour, mainly due to terns). Shearwater numbers were highest in August to September (1.30), Storm Petrels were highest in August (1.84), frigatebirds were highest in August (1.06), Sulids (boobies) were highest in February (0.60), tropicbirds were highest in August–September (0.03), jaegers were highest in February (1.05), gulls were highest in February (2.23), and terns were highest in August and September (24.6) (Hess and Ribic 2000).

12.6.3.1.4 Northern Gannet as an Example of a Migrant Pelagic Seabird in the Gulf

Northern Gannets, plunge-divers that breed in dense colonies on offshore rocky islands only in the North Atlantic, are a good example of a pelagic seabird that uses the Gulf of Mexico. Unlike many of the indicator species, they are only migrants to the Gulf, and adults return north to breed, although immatures may remain in the Gulf all year. And like other pelagic seabirds, it is difficult to census their numbers in the Gulf—the Gulf is vast and seabirds are spread out. Banding studies indicated that less than 15 % of gannets went to the Gulf of Mexico, but recent work with light sensitive geolocators deployed on gannets from four colonies indicated that 27 % went to the Gulf (Montevecchi et al. 2011). Thus the Gulf plays an important role in their life history and it might do so for other pelagic birds such as petrels and phalaropes.

Gannets breed in only six colonies on islands in the Gulf of St. Lawrence, and on the Atlantic coast of Newfoundland; they winter from New England south along the Atlantic into the Gulf of Mexico (Mowbray 2002). They nest in very dense, noisy colonies on offshore rocky islands, or precipitous cliffs. They are monogamous, mate for life, use the same nest site every year and lay only one egg, and both parents care for the young. Suitable nesting habitat seems to be limiting as adults remain on the colony site defending their nest sites well into October; their young depart weeks earlier. Since nest sites are scarce, there is pressure for adults to return to the colony sites (and leave the Gulf waters) as soon as possible (Figure 12.53).

They migrate south along the Atlantic coast and into the Gulf of Mexico (Mowbray 2002), south to Texas, Tamaulipas, and sometimes Veracruz (Howell and Webb 1995). Once considered a vagrant along the Texas coast, recent efforts to scour nearshore waters revealed them gliding over the Gulf in surprising numbers (Eubanks et al. 2006). Offshore from Mississippi, flocks of several hundred have been observed from boats (Turcotte and Watts 1999). Land-based sightings depend not only on observer care but also on weather and wind conditions.

Gannets are known for their high dives in which they plunge from 20 m or more straight down to the water surface. Once underwater they either catch prey directly or chase prey, using their feet and wings for propulsion (Stevenson and Anderson 1994). They are generalist and opportunistic foragers that exploit a diverse prey base along the continental-shelf waters (Mowbray 2002; Montevecchi 2008; Montevecchi et al. 2009). Foraging trips away from breeding colonies in the North Atlantic average between 196 and 452 km (122 and 280 mile)

Figure 12.53. Northern Gannets breed in dense colonies on offshore rocky islands with steep cliffs (*left*, St. Mary's Colony in Newfoundland, © J. Burger). They are strong flyers and plunge-dive for fish (flight photo by Marie C. Martin (CUNY), courtesy of NOAA 2012).

(Garthe et al. 2007), suggesting the potential for wide-ranging habitat use in the Gulf. Furthermore, changes in oceanography and the distribution and abundance of prey resources have resulted in gannets shifting diet from warm water pelagic fish to cold water fish (Montevecchi and Myers 1997). These findings imply that slight shifts in oceanographic conditions can have a massive effect on seabird distribution and foraging. While these shifts have been shown in the north Atlantic, changes in the Gulf may have similar effects on the wintering distribution of Northern Gannets.

Northern Gannets are relatively uncommon off the northeast coast of Mexico, and in Tamaulipas and Veracruz (Mowbray 2002), although global warming may result in decreasing their abundance in the southern Gulf. Most Gannets arrive in late November on the southern Atlantic Coast, and it is likely they arrive in the Gulf in December. The phenology of when breeding adults leave for colonies farther north is unclear, and some proportion of the immatures may remain year round in the Gulf, which is relevant because Northern Gannets normally breed at 5 years of age (Cramp and Simmons 1977; Mowbray 2002).

Using Christmas Bird Counts from 1965 to 2011 as a database, Niven and Butcher (2011) reported that wintering Northern Gannets showed a significant increase of 6.6 % per year in the Gulf region. Thus, the Christmas Bird Count data corresponds to the increases reported for the breeding colonies (Nettleship and Chapdelaine 1988; Chardine 2000; Mowbray 2002). Northern Gannets have a relatively low resiliency because they delay breeding until they are 3–6 years old (most are 5–6 years old); young have high mortality during the first year. Females lay only one egg, although reproductive success can be high, and they have an average life expectancy of 16 years (Mowbray 2002). Despite this, their breeding populations are increasing rapidly, and most recent estimates are that breeding Northern Gannets increased 52 % between 1984 and 1999 (Nettleship and Chapdelaine 1988; Chardine 2000; Mowbray 2002), which suggests increasing numbers in the Gulf.

12.6.3.1.5 Summary of Pelagic Seabird Use of the Northern Gulf of Mexico

Distribution of seabirds was examined in several studies involving multiple cruises to survey marine mammals, sea turtles, and seabirds. These studies form a picture of relatively low densities of seabirds out in the continental shelf of the northern Gulf of Mexico. Most seabirds foraged in flocks (except Loons), and most of these flocks contained many species. Larger flocks of seabirds fed with predatory fish and marine mammals than fed in the absence of them. The most pelagic seabirds (boobies, gannets, frigatebirds, petrels, shearwaters) were not very abundant. Royal Terns, Laughing Gulls, and Herring Gulls were the most abundant species. Seasonal use varied. Species that breed along the Gulf Coast were more common most of the year (e.g., Royal Tern, Laughing Gull), while species that breed farther north (e.g., Herring Gull, Common Loon) were not common in the spring and summer. Similar data are needed for the southern Gulf (Campeche), as well as for the pelagic waters of the Gulf.

12.6.3.2 Migratory Hawks

The U.S. Gulf Coast is not noted for migrant hawks. However, central Veracruz is the most important migratory pathway in the world for hawks (Ruelas et al. 2000; Zalles and Bildstein 2000), and some of these hawks migrate across the Gulf, while others follow the eastern Mexican coast down through Veracruz (Inzunza et al. 2010). As with many other migrants, hawk migration is partly dependent upon wind speed, wind direction, and the passage of cold fronts (Woltmann and Cimpreich 2003). Average counts (±standard deviation) from 1992 to 2004 at Veracruz were as follows (Inzunza et al. 2010): Turkey Vulture (1,897,679 ± 387,839),

Table 12.14. Counts and Significant Trends for Migrant Hawks at Four Sites Around the Gulf (after Smith et al. 2008)

Species	Florida Keys	Smith Point, Texas	Corpus Christi, Texas	Veracruz, Mexico
Turkey Vulture	–	1,529 (56)	20,996 (57)	1,988,826 (23)
		0.0	16.9	5.7
Osprey	1,154 (24)	65 (20)	167 (30)	2,969 (28)
	9.0	4.7	7.2	2.8
Mississippi Kite	19 (92)	4,320 (51)	7,020 (40)	155,651 (46)
	–	10.0	5.4	15.4
Sharp-shinned Hawk	2,971 (47)	2,913 (40)	1,076 (33)	4,542 (55)
	−12.8	−4.2	−2.6	−7.5
Cooper's Hawk, Accipter cooperi	536 (54)	1,125 (14)	663 (45)	2,529 (33)
	7.3	−1.0	3.2	1.9
Broad-winged Hawk	3,737 (28)	38,643 (73)	609,719 (45)	1,919,949 (13)
	6.1	8.2	−6.7	3.1
Swainson's Hawk	82 (60)	298 (98)	6,209 (77)	915,104 (32)
	–	10.0	18.5	13.6
American Kestrel, *Falco sparverius*	2596 (41)	1,334 (28)	506 (38)	8,252 (95)
	−8.8	−2.9	6.7	0.0
Peregrine Falcon	1,826 (28)	89 (20)	155 (37)	745 (42)
	6.9	5.8	3.2	3.2
Total raptors[a]	**13,981 (19)**	**51,275 (57)**	**639,551 (41)**	**5,260,871 (19)**

Only raptors with counts over 600 were included. Given is the mean number of hawks (coefficient of variation). The second line for each species gives percent change over the period from 1995 to 2005.
[a]Includes all raptors, even those not included in the table.

Mississippi Kite (157,199 ± 87,640), Broad-winged Hawk (1,932,255 ± 287,822), and Swainson's Hawk (819,419 ± 280,788).

Raptor populations surveyed from 1995 to 2005 at four locations (Florida Keys, Smith Point and Corpus Christi in Texas, Veracruz in Mexico) showed significant declines in some species and significant increases in others (Smith et al. 2008). Species that increased significantly at one or more sites included Turkey Vulture (*Cathartes aura*), Osprey, Swallow-tailed Kite (*Elanoides forficatus*), Mississippi Kite (*Ictinia mississippiensis*), Swainson's Hawk (*Buteo swainsoni*), Zone-tailed Hawk (*Buteo albonotatus*), and Peregrine Falcon (*Falco peregrinus*). Northern Harriers (*Circus cyaneus*) and Sharp-shinned Hawks (*Accipiter striatus*) declined at all sites (Table 12.14) (Smith et al. 2008).

It is often difficult to ascertain population trends for migrating species because shifts in migration patterns may not be readily evident without data from large geographical areas. For example, Farmer et al. (2008) reported declines of North American Kestrel, and long-term increases of Bald Eagle, Merlins, and Peregrine Falcons. However, they attributed the declines to changes in migration patterns (Farmer et al. 2008). Some species, such as Swallow-tailed Kites, are not monitored at hawk watches in North America, making counts along the Gulf Coast particularly important (Smith et al. 2008). Swallow-tailed Kites breed in scattered

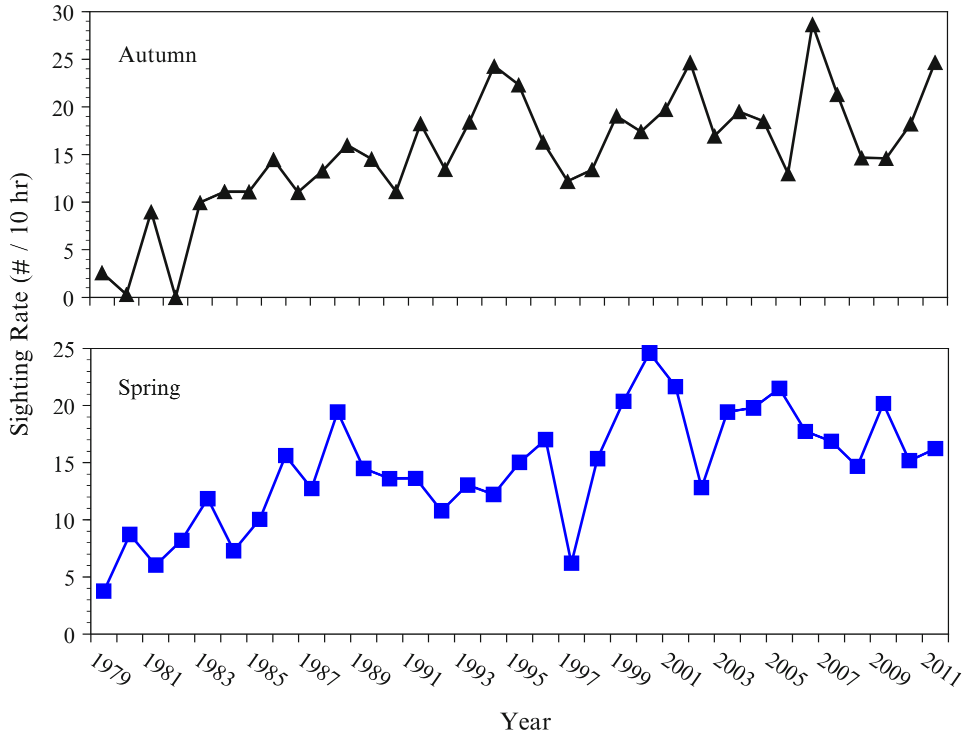

Figure 12.54. Sightings of Peregrine Falcon per 10 h of observation at the South Padre Island (Texas) hawk watch (after Seegar et al. 2011). © **J. Burger.**

locations in South Carolina, coastal Mississippi, Alabama and Louisiana, and southern Mexico into South America (Meyer 1995).

The south Texas and Tamaulipas coast are wintering areas for Peregrine Falcons (Enderson 1965; McGrady et al. 2002). The Padre Island Peregrine Falcon Survey, conducted since 1977, provides trends information (Figure 12.54). Because counting migrating hawks is dependent upon observation time, data are given as number of falcon sightings per 10 h time periods. Numbers have varied, but appear to have increased.

12.6.3.3 Wintering Waterfowl

One quarter of dabbling ducks once wintered in Louisiana (Palmisano 1973), and two-thirds of the Central Flyway waterfowl population also did so (Bellrose 1988). However, the Gulf Coast is no longer the chief wintering area for North American waterfowl because of coastal marsh habitat loss, sea level rise, and freshwater inputs that have reduced available habitat (Palmisano 1973; Link et al. 2011). Such steep declines require intensive study, management of hunting and habitat, and possible additional protection for nocturnal roost sites (Link et al. 2011), as well as manipulation of water levels (Bolduc and Afton 2004). Even so, 19 % of waterfowl wintering in the United States use marshes of the Louisiana Gulf Coast (Michot 1996). Migratory waterfowl also concentrate in coastal Mexico (Gallardo et al. 2004).

Texas is the top waterfowl harvest state in the Central Flyway and is in the top five hunting states in the United States Texas accounted for 42 % of the total duck harvest and 47 % of the goose harvest in the Central Flyway (TPWD 2011). Although the number of waterfowl hunters is declining nationally, Texas hunter trends have remained stable. Coastal habitat protection is a

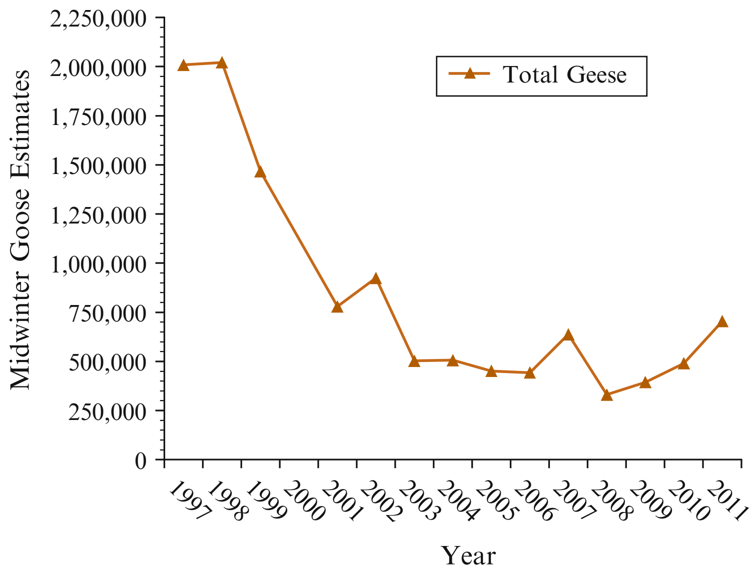

Figure 12.55. Trends in total numbers of geese counted by the Texas Parks and Wildlife Department (after TPWD 2011). Counts include Canada Geese, Snow Geese, and White-fronted Geese. © J. Burger.

prime concern of both the Texas Parks and Wildlife Department and the Gulf Coast Joint Venture (GCJV), a regional partnership of organizations and individuals that are concerned with waterfowl and other migratory bird populations and their habitats between Mobile Bay in Alabama and the Rio Grande in Texas (TPWD 2011). More than 1.9 million ducks winter along the Gulf Coast of Texas.

Status and trends data are available for the Texas Gulf from 1997 to 2011 (TPWD 2011). Populations of geese declined during this period (Figure 12.55). In 1997 and 1998 more than two million geese were counted, and by 2001 the numbers had declined to less than a million along the Texas coast (Figure 12.55). This area supported over 552,000 geese annually from 2001 to 2009 (TPWD 2011). Canada Geese numbers declined from over 30,000 to fewer than 7,000 in the last 3 years.

The TPWD (2011) data provide an overview of the relative numbers of ducks (Figure 12.56) as well as trends. Texas Gulf Coast prairies and marshes (mid-Texas coast) have many more ducks than the southern Coastal Sand Plains; yearly average of 1,500,000 compared to the 15-year average of 82,913 (TPWD 2011). Pintail and Gadwall were the two most common dabbling ducks in both regions, while other species, such as shovelers, were less common. Redhead and Scaup were the most common diving duck in the Prairies and Marsh region; only Scaup was most common along the southern coast. The Texas Gulf Coast also provides year-round habitat for Mottled Ducks, Black-bellied Whistling Ducks, Fulvous Whistling Ducks, and to a lesser extent, Blue-winged Teal (TPWD 2011).

The number of dabbling and diving ducks varied by year, and there appears to be a decline in the last 3 years for both groups (Figure 12.57). Although there was a decline from 1999 to 2001 for dabbling ducks, it was not as great, and no similar decline was found for diving ducks. The recent declines may be due to habitat loss caused by severe hurricanes and storms; hurricanes of 2004 and 2008 adversely affected available habitat for wintering waterfowl along the Texas and Louisiana coasts (TPWD 2011).

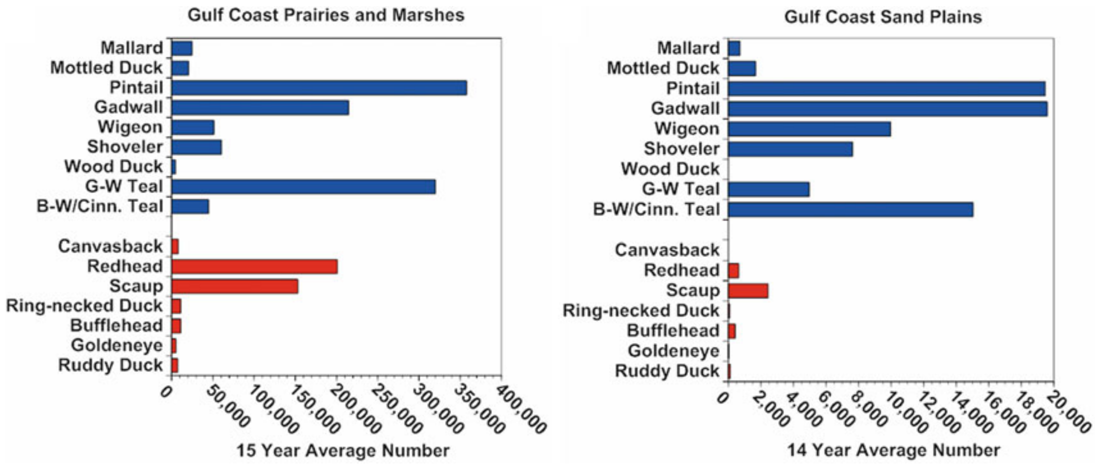

Figure 12.56. Mean number of waterfowl over a 14- or 15-year period in the Texas Gulf Coast (in winter) (after TPWD 2011). © J. Burger. G-W Teal = Green-winged Teal; Cinn. Teal = Cinnamon Teal.

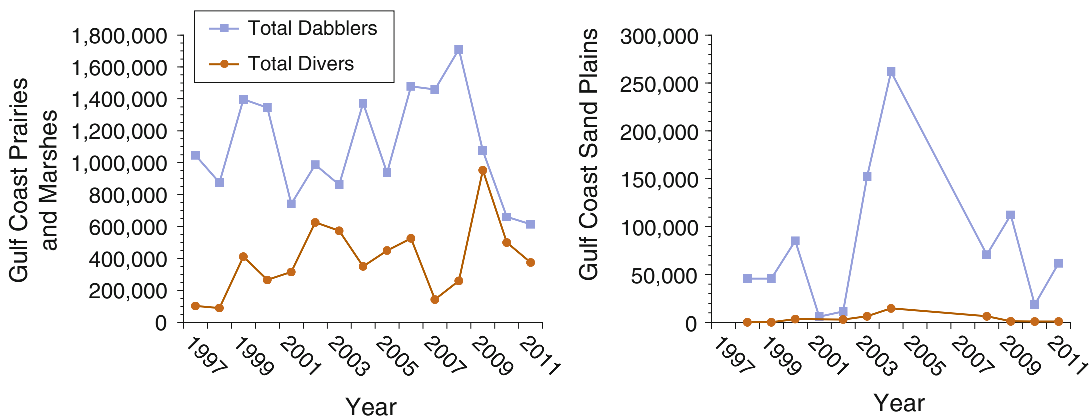

Figure 12.57. Mean number of total Dabbling Ducks and Diving Ducks surveyed along the Texas Gulf Coast (winter counts) (data from TPWD 2011). © J. Burger.

Wintering waterfowl populations have declined precipitously in the Mobile Tensaw Delta in Alabama (Figure 12.58). Surveys conducted by Lueth (1963) showed a significant decline in populations from 1939 to 1949, and data from the Alabama Wildlife and Freshwater Fisheries Department (AWFWF 2005) show these declines have continued to 2004. These data form a picture of severe waterfowl population declines in the Mobile-Tensaw Delta (Lueth 1963; Beshears 1979; Goecker et al. 2006; MBNEP 2008).

12.6.3.4 Nesting Colonial Birds

Nesting colonial waterbirds, an important component of the avifauna of the Gulf Coast, nest in abundance on the marsh islands, sandy beaches, and islands with low shrubs in coastal environments. A large number of colonial nesting birds occur throughout the Gulf, including 14 species of herons, egrets, ibises, spoonbills, and storks, as well as ten species of gulls, terns,

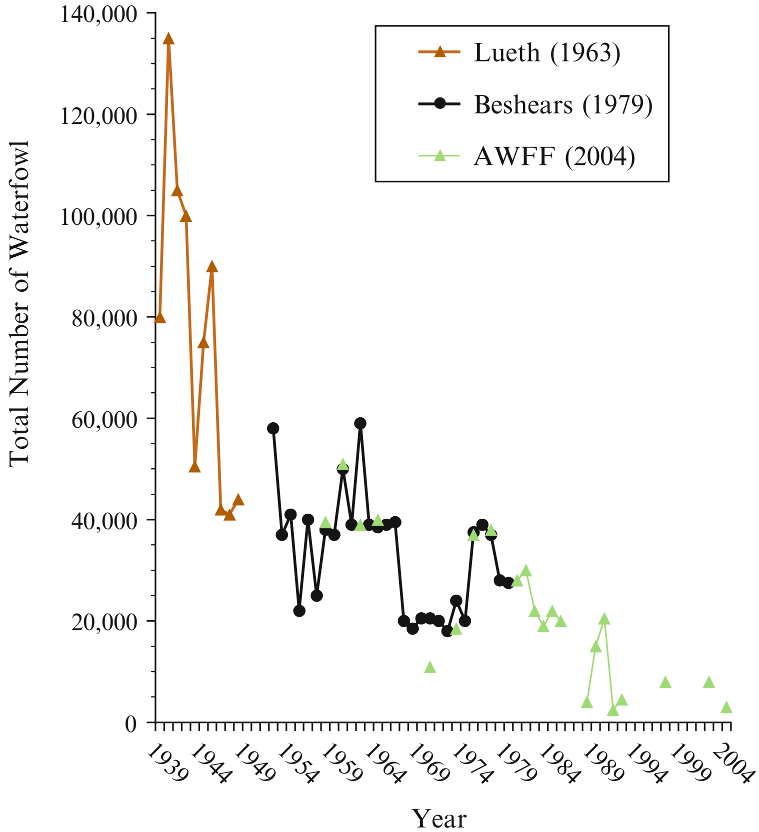

Figure 12.58. Decline in waterfowl in the Mobile-Tensaw Delta in Alabama (data from several sources, compiled in Goecker et al. 2006). © J. Burger.

and a skimmer (Table 12.4) (Gallardo et al. 2009). The northern Gulf Coast alone contains a substantial percentage of the U.S. breeding populations of a number of species, such as Reddish Egret, Sandwich Terns, and Black Skimmers, as well as significant portions of U.S. breeding gulls and other terns (Visser and Peterson 1994).

Nesting colonial birds have long been considered indicators of ecosystem health (Furness 1993; Burger 1993, 2006a, b; Erwin and Custer 2000; Burger and Gochfeld 2004b). Some colonial birds (White Ibis) are noted for their yearly shifts in colony sites and population numbers, although others use the same site for decades or longer (Frederick and Spalding 1994; Schreiber and Burger 2001a). Thus, regional estimates are most useful for species that shift sites. With marsh-nesting species, such as Forster's Tern and some Laughing Gulls, shifts due to tidal or wind flooding are usually within a local area or section of the marsh.

Two areas will serve as examples of colonial nesting birds along the northern Gulf of Mexico, one in Louisiana, and one in Texas. The Barataria-Terrebonne Estuarine system in southeastern Louisiana contains more than four million acres of wetlands and is vulnerable to wetland loss (Lindstedt 2005).

Over the last 50 years, this system has lost 47–57 km^2 (18–22 mi^2) per year (Lindstedt 2005). In 2001, 24 species of colonial birds nested in the Barataria-Terrebonne Estuaries, with as many as 37 colonies of Great Egret, 31 colonies of Snowy Egret (likely in the same colonies), and 18 of Little Blue Heron (Lindstedt 2005). Tricolored Heron (Louisiana Heron) occurred in 10 colonies,

Table 12.15. Colonial Birds That Nested in the Barataria-Terrebonne Estuary in Southeastern Louisiana

Species	Number of Colonies	Number of Pairs	Average Conspecific Pairs/Colony
Great Blue Heron	12	753	63
Little Blue Heron	18	987	55
Tricolored Heron	10	107	11
Black-crowned Night Heron	7	180	26
Great Egret	37	4,616	125
Cattle Egret	7	1,187	170
Snowy Egret	31	5,295	171
Brown Pelican	3	3,910	355
Laughing Gull	11	7,730	702
Black Skimmer	3	175	58
Roseate Spoonbill	6	352	59
Forster's Tern	6	1,230	205
Royal Tern	6	1,005	168
Gull-billed Tern	1	145	145
American Anhinga	3	25	8
White Ibis	7	7,630	1,090
Dark Ibis	12	2,922	244

Although these data are from 2001, they indicate relative abundance (after Michot et al. 2003; Lindstedt 2005). Species with fewer than 25 pairs are not included in the table. © J. Burger

Roseate Spoonbills occurred in only six colonies, and Reddish Egret was not reported (Table 12.15). Species associate with one another, so total colony size is much larger; the egrets usually nest together, along with herons and Night Herons.

Long-term trends also were examined in Galveston Bay Estuary from 1973 to 1990 (Gawlik et al. 1998). Approximately 50,000 nesting pairs of 22 species of colonial waterbirds used Galveston Bay annually since the 1970s, which represents about 30 % of the nesting colonial birds on the Texas coast. This area is also the most important wintering area for ducks and geese in the central flyway (Hobaugh et al. 1989). Laughing Gulls, a species with low annual variability, dominated the assemblage. In contrast, White Ibis and Sandwich Tern were both highly variable and abundant. Trend analysis showed that Roseate Spoonbill, Snowy Egret, and Black Skimmer declined significantly, while Neotropical Cormorant and Sandwich Tern increased significantly; the other 13 species showed no significant trends (Gawlik et al. 1998).

It seems clear from this review of the birds of the Gulf of Mexico that two types of information complement each other: local surveys and regional (up to Gulf-wide). Local surveys of one or two colonies are useful, especially when long-term data are available. Surveys from the same general area of the coast sometimes produce different results (Table 12.16), requiring careful interpretation in light of individual species characteristics. However, the two surveys were at different times, and may actually present a picture of regional shifts. Furthermore, when two different surveys from different areas produce the same result (Brown Pelican increased in both; Night Heron, Great Blue Heron decreased) it is likely to be real. In no case did a species show opposite trends. When the trends were not congruent (e.g., no trend, and increase), further investigation is necessary. For example, some species showed an increase from 1956 to 1992, but no trend thereafter. Data showing no trend should be examined further by conservationists.

Table 12.16. Trends in Colonial Waterbirds Reported for Galveston Bay (after GBST 2012) and Corpus Christi Bay (after Chaney et al. 1996) in Texas

Species	Corpus Christi Bay (1956–1992)	Galveston Bay (1990–2009)
Brown Pelican	Increase	Increase
Cattle Egret	Increase	No trend
Black-crowned Night Heron	Decrease	Decrease
Great Blue Heron	Decrease	Decrease
Snowy Egret	No trend	No trend
Tricolored Heron	No trend	Decrease
White Ibis	Increase	No trend
White-faced Ibis	No trend	Decrease
Reddish Egret	Increase	No trend
Roseate Spoonbill	Increase	No trend
Laughing Gull	Increase	No trend
Royal Tern	Increase	No trend
Forster's Tern	Increase	No trend
Least Tern	Decrease	No trend
Sandwich Tern	Increase	Decrease
Black Skimmer	Decrease	No trend
Neotropical Cormorant		Decrease

This illustrates the problem of examining colonial waterbirds in a small geographical area, and not for the same time periods.

Finally, understanding trends is a matter of using a "weight of evidence approach"—when all data sets indicate the same trend, it is likely real (Burger 2003). Conservation of colonial waterbirds is a matter of protection from human disturbance and predators, prevention of habitat loss, and insurance of sufficient foraging and nesting habitat, particularly for wading birds (Kushlan 2000a, b; Hafner et al. 2000; Pineau 2000; Clay et al. 2010). Active habitat management and augmentation are essential.

12.6.3.5 Neotropical Passerine Migrants

Migratory Passerines are often ignored when considering birds in the Gulf of Mexico because the focus is often on seabirds and waterbirds. Yet, the narrow band of wooded barrier islands and forested coastlines provides the departure point for Passerines crossing the Gulf of Mexico (Moore 1999). Each year billions of landbirds migrate between the northern and southern hemisphere, and many cross the Gulf of Mexico (Stevenson 1957; Moore 2000a, b). While it is an extremely important migratory pathway for Nearctic-Neotropical migrants, the Gulf of Mexico is also a formidable barrier for these migrants (Rappole 1995). Nearctic-Neotropical migrants are those that breed in the North Temperate zone and winter in the tropics (Shackelford et al. 2005), including mainly songbirds (Passeriformes), although they also include some shorebirds, terns, cuckoos, and others.

The objective of this section is to provide an overview of Nearctic-Neotropical migrants in the Gulf of Mexico and associated coastal lands, rather than in more upland habitats, such as wood plantations and bottomland hardwood forests (Wilson and Twedt 2003), and the coastal habitats of Veracruz and the Yucatán (Mackinnon et al. 2011). A number of monographs and edited books deal with neotropical migrants, including DeGraaf and Rappole (1995), Kerlinger (1995), Rappole (1995), Able (1999), Moore (2000b). Greenberg and Marra (2005), and further, Jahn et al. (2004) provide a system-wide approach to new world migration that is particularly applicable to the Gulf.

Migrants have three choices for flying between North America and Central/South America: (1) a circum-Gulf route through eastern Mexico and Texas, (2) a trans-Gulf route to the Yucatán Peninsula and the Mexican coast, and (3) a circum-Gulf route through Florida and West Indies (Stevenson 1957; Langin et al. 2009). Since migration takes place over a relatively small time scale, but a large spatial scale, different factors affect migration patterns. On a small spatial scale, habitat (amount and quality, prey availability) is critical, while on a broader scale, weather and winds become critical (Moore 2000a). Wind patterns are generally favorable for birds to migrate across the Gulf in the spring, usually determined by studies with radar (Gauthreaux 1971, 1999; Gauthreaux et al. 2006). Migration patterns are not static, but shift from year to year and season to season, depending upon prevailing winds (Barrow et al. 2005).

Analyzing data from 10 radar stations from Key West, Florida to Brownsville, Texas, Gauthreaux et al. (2006) showed that in the spring: (1) northbound migrants approached the northern Gulf Coast at between 1,000 and 2,500 m above ground; (2) the longitudes of peak arrivals were similar over the 4-year period (near longitude 75° west, northern Texas/western Louisiana); (3) wind trajectories over the Gulf of Mexico had relatively little influence on the longitude of peak arrival; (4) the longitude where the greatest density of trans-Gulf migrants arrived on the northern coast was relatively constant from year to year; and (5) on occasion, strong winds or storms displaced migrants, but migrants seemed to have a preferred route they followed. These conclusions suggest that conservation efforts should concentrate on the preferred routes and landing locations. These findings are intriguing and suggest the potential to develop conservation priorities for suitable habitat for northbound Nearctic-Neotropical migrants, especially when coupled with data from birds fitted with geolocators.

Neotropical migrants face several decisions with respect to the Gulf of Mexico, including which route to follow, when to migrate, where to make landfall before crossing the Gulf, where to make landfall after crossing the Gulf, and how long to stop at stopovers on either side of the Gulf. Passage across the Gulf is long, and birds often arrive in the Louisiana northern Gulf Coast with little fat (Yong and Moore 1997), making coastal lands critical for increasing fat stores and continued survival. Peak numbers of spring Passerine migrants occur from mid-April to early May, and radar studies indicate that nearly all the Passerine migrants arrive from directly over the Gulf of Mexico (Gauthreaux 1971). A bad storm or hurricane can kill 40,000 migrants on one day, if it occurs during a peak time when migrants are arriving from their northward flight across the Gulf (Wiedenfeld and Wiedenfeld 1995). The coastal habitats used by migratory Passerines are extremely important because estimates suggest that most Nearctic-Neotropical migrant Passerines are unable to reach northern breeding sites in a single flight without stopping (e.g., thrushes) (Yong and Moore 1997).

Passerines that are lean upon arrival often remain longer before departing for breeding grounds farther north (Moore and Kerlinger 1987). Length of stay in Louisiana after a trans-Gulf flight is related to fat-depletion upon arrival; lean birds (Parulinae warblers) remained longer than fat ones, but if weather is favorable, birds continue to migrate (Moore and Kerlinger 1987). For migrant Passerines using the northern Gulf Coast, suitable stopover habitat is a critical feature. Migrant densities were most strongly related to forest cover within a 5 km radius; this feature influenced where migrants made landfall (Buler et al. 2007). Indeed along the coast of Mississippi, northbound songbirds made landfall in resource-rich habitats within 18 km (11 mile) of the coastline (Buler and Moore 2011).

While radar is used to determine patterns of migration across the Gulf (Gauthreaux et al. 2006), data from banding stations are used to assess ecology of migrants, including timing (Moore et al. 1990; Marra et al. 2005), stopover duration (Moore and Yong 1991), and habitat use (Moore et al. 1990). Stable isotope techniques are used to connect the wintering and breeding grounds of Nearctic-Neotropical migrants (Hobson and Wassenaar 1997; Hobson et al. 2007; Hobson 2005; Kelly 2006b; Langin et al. 2009). The recent development of small geolocators makes it possible to follow migration routes of small birds, although they must be captured to remove the geolocator to obtain the data (Stutchbury et al. 2009; Burger et al. 2012b). This combination of techniques has revolutionized the understanding of migration, especially across the Gulf of Mexico and will continue to do so.

12.6.3.6 Audubon Christmas Bird Counts Along the Northern Gulf of Mexico

Niven and Butcher (2011) examined the status and trends of birds wintering along the U.S. northern Gulf of Mexico using the Audubon Christmas Counts from 1965 to 2011. Methods are described in the Methods section above. Their initial goal was to examine trends in light of the Deepwater Horizon oil spill, but there was not enough time between the spill and the counts to reflect the effects, if any, from the oil spill. To be on the conservative side, in Table 12.17 only the species with a significant decline of more than 2 % per year, and the species with a significant increase of over 2 %, are listed.

Table 12.17. Trends in Birds/Party Hours for the Northern Gulf of Mexico from 1965 to 2010 (developed from Niven and Butcher 2011)

Species	% Change	Taxonomic Group
Canada Goose	−7.0 (−2.63)	Anseriformes
Eared Grebe	−6.5 (−4.66)	Podicipediformes
Canvasback, *Aythya valisineria*	−5.6 (−3.85)	Anseriformes
American Wigeon	−5.2 (−3.62)	Anseriformes
Wilson's Plover	−4.8 (−2.93)	Charadriifformes
Northern Pintail	−4.0 (−2.67)	Anseriformes
Bonaparte's Gull, *Larus philadelphia*	−3.8 (−1.58)	Charadriiformes
King Rail	−3.2 (−1.69)	Gruiformes
Red-breasted Merganser, *Mergus serrator*	−2.8 (−1.82)	Anseriformes
Herring Gull	−2.6 (−1.85)	Charadriiformes
Red-winged Blackbird	−2.5 (−1.47)	Passeriformes
Boat-tailed Grackle	−2.3 (−0.14)	Passeriformes
Long-billed Curlew	−2.3 (−1.40)	Charadriiformes
Horned Grebe, *Podiceps auritus*	−2.3 (−0.74)	Podicipediformes
Western Sandpiper	−2.3 (−0.83)	Charadriiformes
Red Knot	−2.3 (−0.18)	Charadriiformes
Black Skimmer	−2.2 (−1.04)	Charadriiformes
American Woodcock, *Scolopax minor*	−2.1 (−0.21)	Charadriiformes
American Bittern	−2.1 (−1.12)	Pelecaniformes

(continued)

Table 12.17. (continued)

Species	% Change	Taxonomic Group
Seaside Sparrow	−2.0 (−0.71)	Passeriformes
Black-bellied Whistling Duck, *Dendrocygna autumnalis*	22.7 (18.6)	Anseriformes
Ross's Goose, *Chen rossii*	13.7 (10.5)	Anseriformes
Glossy Ibis	10.9 (7.9)	Pelecaniformes
Black-necked Stilt	10.4 (6.7)	Charadriiformes
Osprey	7.1 (6.5)	Accipitriformes
Northern Gannet	6.6 (2.2)	Suliformes
Hooded Merganser	5.9 (4.8)	Anseriformes
Roseate Spoonbill	5.9 (4.4)	Pelecaniformes
White Ibis	4.5 (3.1)	Pelecaniformes
White-faced Ibis	4.3 (1.3)	Pelecaniformes
American White Pelican	4.1 (2.4)	Pelecaniformes
Peregrine Falcon	4.0 (3.0)	Falconiformes
Bufflehead, *Bucephala albeola*	4.0 (1.9)	Anseriformes
Sandhill Crane	3.8 (2.4)	Gruiformes
Bald Eagle	3.8 (2.8)	Accipitriformes
Brown Pelican	3.7 (2.6)	Pelecaniformes
Greater White-fronted Goose, *Anser albifrons*	3.6 (1.0)	Anseriformes
Blue-winged Teal	3.5 (2.3)	Anseriformes
Anhinga	3.5 (2.9)	Charadriiformes
Marbled Godwit	3.5 (1.8)	Charadriiformes
American Oystercatcher	3.4 (2.0)	Charadriiformes
Laughing Gull	3.0 (2.1)	Charadriiformes
Palm Warbler, *Dendroica palmarum*	2.9 (1.8)	Passeriformes
Double-crested Cormorant	2.8 (2.0)	Suliformes
Wood Stork	2.8 (0.3)	Ciconiiformes
Merlin, Falco columbarius	2.5 (1.8)	Falconiformes
Black-crowned Night Heron, *Nycticorax nycticorax*	2.3 (1.3)	Pelecaniformes
Pied-billed Grebe	2.3 (1.6)	Gaviiformes
Common Moorhen	2.2 (0.8)	Gruiformes
Great Egret	2.1 (1.6)	Pelecaniformes
Sedge Wren	2.1 (0.9)	Passeriformes

Birds are given in decreasing order of change. For % change, the 95 % credible lower limit of decrease or increase is shown in parentheses. © J. Burger

Niven and Butcher (2011) reported that among the 20 species that declined by at least 2 % per year, 13 had the center of their ranges in the Gulf, and four declined in the Gulf, but were increasing elsewhere (Canada Geese [*Branta Canadensis*], American Wigeon, Bonaparte's Gull, Boat-tailed Grackle). These birds may be moving their wintering ranges farther north with global warming (Niven et al. 2009). Several species with winter ranges south of the northern Gulf of Mexico coast also declined (Eared Grebe [*Podiceps nigricollis*], Wilson's Plover, Long-billed Curlew, Western Sandpiper, Red Knot, Black Skimmer and American Bittern [*Botaurus lentiginosus*]). Remarkably, these were mainly shorebirds, reflecting a general decline in shorebirds worldwide (Withers 2002; Morrison et al. 2006). Surprisingly, Canada Geese showed the greatest decline.

While a 2 % per year increase or decline may not seem significant in terms of overall population dynamics, it is when an average of 2 % per year change for 40 years. Second, although there are methodological and interpretational difficulties with Christmas Bird Count data, the results are both consistent and robust over a long period of time. And finally, the changes make sense in terms of possible effects of global warming, and threats to birds that use coastal beaches (habitat losses, erosion, human disturbance, pets, and pollution).

12.7 DISCUSSION

12.7.1 Management

While this chapter does not address management specifically, management actions are discussed throughout as one of the factors affecting birds in the Gulf of Mexico. Management, however, is a complex mix of actions (dredging, hydrological control, diking, wetlands for aquaculture) aimed at improving the coastal environment for people, actions to improve ecosystem structure and function (e.g., terracing), and actions to aid particular species groups (burning for waterfowl habitat). There are management programs to restore large ecosystems in place as part of the larger Gulf of Mexico system. For example, a massive federal and state effort to restore the Everglades ecosystem features many of the prominent Gulf of Mexico species, such as White Ibis, Roseate Spoonbill, and other colonial-nesting species (Ogden et al. 2003, 2005; Frederick and Collopy 1989; Gawlik 2006). Managing for birds is difficult because it often involves trade-offs whereby a given action is positive for one species, but negative for another. Several examples have been provided in this chapter: (1) differences in salinity (affected by water control) favor some marsh species over others; (2) vegetation removal is positive for bare-sand nesting species, but not for those requiring some sparse or dense vegetation; and (3) large expanses of bare sand may encourage larger terns to nest, forcing smaller terns (e.g., Least Tern) out of otherwise optimal habitat.

Many agencies and organizations are devoted to protection and conservation of birds in general, and of coastal waterbirds in particular (e.g., SE U.S. Regional Waterbird Conservation Plan, Hunter et al. 2006; U.S. Shorebird Conservation Plan, USFWS 2004; U.S. Shorebird Conservation Plan for Lower Mississippi/Western Gulf Coast, GCPWG 2000). There are plans for particular species, such as the U.S. Fish & Wildlife Service Recovery Plans and 5-year reviews for the Piping Plover (USFWS 1999, 2003, 2009b), and the Whooping Crane Recovery Program (USFWS 1986, 2012c). Canadian provinces also produce plans for species of concern, such as the Piping Plover (White and McMaster 2005).

Status reports have been developed by the U.S. Fish & Wildlife Service for groups of birds, such as seabirds (Fritts and Reynolds 1981; Fritts et al. 1983), waterfowl (USFWS 2011), and waterbirds (Anderson et al. 1996). There are also status reports for individual species, such as Red Knot (Niles et al. 2008), American Oystercatcher (Clay et al. 2010), and Black Skimmer

(FFWCC 2011b), as well as national or international surveys (e.g., Haig et al. 2005; Elliott-Smith et al. 2009). Monitoring plans for species of concern, such as for the delisting of Brown Pelican (USFWS 2009a), have also been established. In addition, the Service develops Habitat Suitability Index Models for some species, such as Roseate Spoonbill (Lewis 1983), and evaluates the effect of offshore development on rare, threatened, and endangered species (Woolfenden 1983).

Management plans are developed for species groups such as for Colonial Waterbird Management (Coste and Skoruppa 1989), and federal agencies develop conservation strategies (MMNS 2005). Other organizations also produce assessment and trends documents. These include the Environmental Assessments by Natural Heritage Programs for the Mississippi Gulf Coast (NPS 2008), and the National Estuary Program for Texas (Tunnell and Alvarado 1996; Chaney et al. 1996) and for Alabama (MBNEP 2008), as well as for specific areas like Barataria-Terebonne (Condrey et al. 1996). Several states have breeding bird atlases (Kale et al. 1992 for Florida) and/or conduct annual surveys for waterfowl (TPWD 2011), colonial waterbirds (TCWS 2012), and shorebirds (Sprandel et al. 1997).

There are reports by management agencies whose major function is not bird protection, but have an additional mandate to protect species and the environment that relate directly to the Gulf of Mexico. The U.S. Army Corps of Engineers, tasked with beach nourishment, has incorporated creation of bird habitat in its management documents (Golder et al. 2006; Guilfoyle et al. 2006; Wilson and Vermillion 2006). The Bureau of Ocean Energy Management, Regulation, and Enforcement (formerly U.S. Minerals Management Service, U.S. Department of Interior) examined interactions between migrating birds and offshore oil and gas platforms (Russell 2005). The National Renewable Energy Laboratory considers bird movements and behavior in relation to wind energy developments (Morrison 2006).

Status evaluations are aimed at informing managers to guide policymakers and managers in making decisions. For example, the Galveston Bay Status and Trends Project (GBEP 2006) evaluates water and sediment quality, fisheries, habitat, data gaps, and indicators of bay health, using 20 years of trends data. The ratings for status of indicator species go from poor (significantly decreasing) to stable, to good (significantly increasing). Their report lists the following ratings: *poor* (Black-crowned Night Heron, Great Blue Heron, Tricolored Heron, White-faced Ibis, Laughing Gull, and Neotropical Cormorant), *stable* (Reddish Egret, Roseate Spoonbill, Snowy Egret, White Ibis, Black Skimmer, Least Tern, Royal Tern and Sandwich Tern), and *good* (only Brown Pelican). This is an excellent method of informing policymakers and the public at a glance.

All of these documents deal with status, threats, and management actions needed to restore, recover, or protect vulnerable populations. Specific methods depend upon the species, habitat, legal constraints (e.g., Endangered Species laws), geography, and species (or group) vulnerabilities.

12.7.2 Patterns of Population Changes

Several types of evidence help determine whether birds or groups of birds are increasing or decreasing, including data from Breeding Bird Surveys, Audubon Christmas Counts, Federal Species Surveys (Piping Plover, Snowy Plover), state inventories (waterfowl in Texas, colonial waterbirds in Texas), and local or refuge surveys. For some indicator species, the trends are clear and different surveys indicate the same patterns (e.g., increases in Brown Pelican, declines for Mottled Duck), but for others, the evidence is conflicting. Thus, the data in this chapter can be examined with a weight of evidence approach, whereby the different types of data are examined in total to determine population status and trends in the Gulf (Burger 2003; Krimsky 2005; Laiolo 2010). Thus, if all (or almost all) data sets suggest that a given species is increasing, it is likely that it is. Conversely, if all evidence suggests that a species is declining, it likely is. The quality of the data enters the deliberations, as does other factors, such as the temporal and spatial scale of the data, measurement error (or variability), and environmental variability.

Table 12.18 provides an overview of population trends in Breeding Bird Surveys (all North America), Breeding Bird Surveys for the Gulf States, Christmas Bird Counts for the Gulf (Niven and Butcher 2011), and from individual studies of species in the Gulf. Species in green denote an increasing population, from Gulf-based evidence (although the whole line is green), and red indicates an overall population decrease in the Gulf. Black indicates variable, and generally stable populations. A more in-depth analysis of status and trends up through 2015 can be found in Burger (2017).

Table 12.18. Comparison of Trends Data from Different Sources

Species	Breeding Bird Surveys (all na) % Change/Year	Breeding Bird Surveys from Gulf States	Audubon Christmas Bird Count % Change/Year (Gulf States)	Other Breeding Surveys or Reports from Gulf States
Common Loon	0.8	NA	1.6	Breeding populations probably stable to increasing generally, stable in the mid-west (Evers 2004; Evers et al. 2010)
Brown Pelican	6.5	Increases in Texas, and Alabama, and in part of Florida	3.7	Significant increases in Pelicans along coast 1970–2000 (Shields 2002). Increases in Galveston Bay (GBEP 2006; GBST 2012), Corpus Christi Bay (Chaney et al. 1996) and Queen Bess (Visser and Peterson 1994; Lindstedt 2005)
Whooping Crane	NG	NG	NG	Dramatic increases from 1938 to 2008 (USFWS 2012c; WCCA 2012)
Great Egret	3.1	Increases or stable in other Gulf states	2.1	Increases in Texas, but possible declines in some parts of Florida (McCrimmon et al. 2011)
Reddish Egret	NG	NG	1.6	Very variable number of breeding pairs from Shamrock Island, Texas, 1974 to 1999 (Gorman and Smith 2001), increase in Corpus Christi Bay (Chaney et al. 1996)
Roseate Spoonbill	8.8	Increases in Louisiana and Texas, with declines in Florida	5.9	Increased in Texas (Chaney et al. 1996; Dumas 2000) and in Florida Bay (Powell et al. 1989). Numbers at individual colonies very variable from 1974 to 1999 (Gorman and Smith 2001)

(continued)

Table 12.18. (continued)

Species	Breeding Bird Surveys (all na) % Change/Year	Breeding Bird Surveys from Gulf States	Audubon Christmas Bird Count % Change/Year (Gulf States)	Other Breeding Surveys or Reports from Gulf States
Mottled Duck	−3–3	Declines in all states, with small increases in parts of Texas and Florida	1.2	Midwinter counts show stable in Texas (TPWD 2011). Data from Mexico shows declines from 1983 to 2000 (Perez-Arteaga and Gaston 2004)
Osprey	2.8	Increases in gulf states with data	7.1	Only migratory counts, which indicated that they increased significantly in Florida Keys and Texas, with no increases in Veracruz (Smith et al. 2008)
Clapper Rail	−1.1	Declines in Texas, Louisiana and part of Florida (increase in part of Florida and in Alabama)	−0.2[a]	No trends data except BBS and Christmas Counts
Snowy Plover	NG	NG	−0.2[a]	Winter numbers higher in 2006 than 2001 (Elliott-Smith et al. 2009)
Piping Plover	NG	NA	−1.4[a]	Winter numbers vary, higher in 2006 than 1996 and 2001, but 2006 still lower than 1991 (Elliott-Smith et al. 2009)
Laughing Gull	4.8	Declines in Texas, both increases and declines in Louisiana, and increases in the other Gulf States	3.0	Declined in Galveston Bay from 1973 to 1996 (Glass and Roach 1997), varied from 1973 to 1999 in Shamrock Island, but highest in 1992, then declined in Texas (Gorman and Smith 2001; GBEP 2006), declined in Louisiana from 1976 to 1993 (Visser and Peterson 1994). Declines in Christmas Count data since 1990 bear examination. Recent data indicates declines in Gulf States
Royal Tern	−1.5	Increases in all Gulf states with data	0.5[a]	Declined from 1985 to 1993 in Louisiana (Visser and Peterson 1994), increased and declined on Shamrock Island (Gorman and Smith 2001), and increases at Corpus Christi Bay (Chaney et al. 1996)

(continued)

Table 12.18. (continued)

Species	Breeding Bird Surveys (all na) % Change/Year	Breeding Bird Surveys from Gulf States	Audubon Christmas Bird Count % Change/Year (Gulf States)	Other Breeding Surveys or Reports from Gulf States
Black Skimmer	−3.6	Major declines in Florida, Louisiana, and Alabama, with slight increase in Texas	−2.2	Declines in Louisiana from 1976 to 1993 (Visser and Peterson 1994). Statewide declines in Florida (FFWCC 2011b), and at Shamrock Island, Texas from 1974 to 1999 (Gorman and Smith 2001), and declines at Corpus Christi (Chaney et al. 1996)
Seaside Sparrow	3.9	NG	−2.0	No breeding trends data

NG = not given in the relevant paper(s). NA = Breeding Bird data not given for birds that do not breed in the Gulf. Green = increasing trends and Red = declines from all sources. Black = no trend or conflicting trends. © J. Burger
[a]Stable or uncertain (not significant)
Sources: U.S. Breeding Bird Survey data from Sauer and Link (2011); Gulf is from U.S. Bird Banding laboratory; Christmas Bird Count data are from Niven and Butcher (2011); other sources refers to several different papers. Sauer and Link (2011) data are given as % change/year using hierarchical models. Christmas Bird Count data are reported as % change using hierarchical models.

12.7.3 Recovery and Population Dynamics

For any complex system, it is possible to catalogue biodiversity (number of species by taxa). For some species, there are estimates of current population sizes, and perhaps trends in populations. From this review, however, it is clear that even for the key indicator species or groups, current data on population sizes for the entire Gulf are usually sparse. No Gulf-wide surveys are taken at the same time using the same methodology. However, even if sufficient surveys of populations for key species were available, this information does not necessarily provide a picture of the health of the system, predict emergent ecosystem problems, or predict future trends. This is especially true for the Gulf of Mexico because of both short-term (storms, hurricanes, tides, pollution, habitat loss, human disturbance) and long-term stressors (habitat loss, subsidence, global climate change, sea level rise). Detailed information about trophic levels, food web interactions, energy flow, and forcing functions are needed to predict emerging ecosystem change (Brown et al. 2006). This information is not available for the Gulf ecosystem, although the chapters in this series begin to bring together some of this information. However, sufficient information is available to support an integrated weight of evidence evaluation of the health of avian populations in the Gulf of Mexico.

The available database includes (1) natural history information (age of first breeding, clutch size, incubation period, parental-care period, and life span); (2) status and trends for key indicator species or species groups; (3) effects of natural and anthropogenic stressors on habitat use, and; (4) effects of social interactions (predators, competitors) on habitat use. These factors provide information on whether populations can recover quickly or not.

Information on long-term recoveries is available for the species that were devastated during the plume-hunting days of the late 1800s to the early 1900s (herons, egrets, terns), or by exposure to pesticides (Osprey, Brown Pelican), which provides insights into recovery potential. Finally, the long-term sustainability of bird populations in the Gulf is a matter of balancing the needs of people, society, economics, and the fish and wildlife ecosystems that reside there. It will ultimately depend upon the ability of governments and people to balance these different needs.

12.8 SUMMARY OF BIRDS IN THE GULF OF MEXICO

The Gulf of Mexico is a complex mosaic of habitats influenced by political, economic, sociological, and biological factors, as well as global change, sea level rise and land subsidence, tides, storms, and hurricanes. The ecosystem in the Gulf of Mexico is a matrix of tropical, subtropical and temperate habitats that include different land masses and different land margin interfaces. There are large peninsulas (Florida, Yucatán), large islands (Cuba), barrier islands, open water, and an array of offshore islands or keys, barrier beaches, sandy and gravel beaches, mangroves, salt marshes, and brackish marshes that intergrade to freshwater marshes, swamps, and more upland habitats.

The Gulf of Mexico is one of the most important places for birds in the Western Hemisphere. Birds from North America funnel over or around the Gulf of Mexico on their migratory flights; birds from both the south and the north come to winter along the Gulf or on the open water, and many species breed there. Thus, the coastal areas around the Gulf of Mexico serve as a hotspot of diversity. Several conclusions can be drawn for the Gulf as a whole:

- Most birds that use the saltwater to brackish ecosystems are seabirds, herons and egrets, shorebirds, waterfowl, gulls, terns, and specialized marsh species (Clapper Rail, Seaside Sparrow).
- About 31 % of the 395 species in the Gulf have been recorded in all areas of the Gulf.
- A higher diversity of species is found in the southern part of the Gulf compared to the north.
- A high percentage of some colonial nesting species for North America nest in Louisiana and Texas than elsewhere along the Gulf, including Reddish Egrets, Sandwich Tern, Black Skimmer, Royal Tern, Forster's Tern, and Laughing Gull, as well as Snowy Plover and Roseate Spoonbill.
- Several seabirds, such as boobies and Magnificent Frigatebirds primarily nest in the southern Gulf of Mexico, on the Campeche Banks.
- One of the greatest impacts on avian populations in the Gulf is habitat loss (either because less is available, or what is available is no longer suitable), followed by human disturbance.
- Populations of birds in the Gulf have varied in the last 50 years; some have increased and some have declined.

For the Gulf of Mexico it is necessary to distinguish between habitat availability and habitat suitability. Habitat availability is whether habitat is present and available that meets the needs of the species or species groups, such as open sandy beaches for shorebirds to feed; salt marshes for Clapper Rail and Seaside Sparrow to breed and forage; isolated islands with suitable vegetation for Brown Pelicans, terns, skimmers, herons and egrets to nest; and bare sandy beaches for Snowy Plover to breed and forage. Habitat suitability, however, refers to whether the habitat will actually meet the needs of birds with respect to providing adequate places to forage, roost, breed, and migrate, free from predators, human disturbance, high tides and storm tides, and other weather-related events. Habitat must meet the species requirements in terms of vegetation, elevation, and physiognomy, while habitat suitability relates to whether the habitat is usable in terms of predator isolation, and freedom from human disturbance. The factors that affect suitability often relate to exposure to elements (storms, tides, winds, hurricanes, floods, and over the long term, sea level rise), exposure to predators and people, degree of competition from conspecific and interspecific interactions, presence of pollutants, and physical disruptions. In short, the habitat must allow survival and reproduction. In many cases, suitable habitat is only available on islands or cays isolated from the mainland.

Habitat loss is a major factor affecting bird populations in the Gulf. Loss of habitat affects all birds, whether residents, migrants, or wintering birds. It also affects all aspects of their daily needs for breeding and nesting, foraging, and having sufficient safe places to roost. Loss of habitat is most severe at the land margin, where the land meets the sea. And it is most severe where anthropogenic activities occur, where land is modified and is no longer usable, or where land is completely developed.

Pollutants have affected behavior and populations of birds in the Gulf, although to a far lesser degree than habitat loss and modification. In the 1950s and 1960s, DDT had a great effect on fish-eating birds, such as Osprey, wading birds, and Brown Pelicans, all of which declined dramatically. Pelicans were hit especially hard, and were largely extirpated as a successful breeding bird from some regions. Mercury has affected behavior and reproduction in both resident birds (Great Egrets and other fish-eating birds), and migrants (Common Loon). Oil, while it can cause immediate mortality and chronic injury, has not been demonstrated to permanently affect any populations of birds in the Gulf. Plastics and fishing lines cause mortality, particularly in seabirds foraging in the Gulf, but the long-term effects are unclear.

Understanding avian assemblages that use the Gulf of Mexico entails examining several different factors: migrant versus resident, solitary versus colonial nester, ground versus tree nester, method of foraging, and location of foraging. The 15 indicator species examined illustrate all of these different lifestyles and behavioral patterns. Obviously nesting on the ground exposes nests, eggs, and chicks to ground predators, tidal flooding, and human disturbance, while nesting in trees exposes birds to aerial predators but usually protects them from mammalian predators. Nesting on low islands prevents mammalian predators from surviving because high tides or severe storms in the winter wash them away, but nesting there exposes birds to flooding from high tides and storms during the breeding season. Further, the indicators illustrate different life strategies; some delay breeding, have small clutch sizes, long parental care, and long life spans (Common Loon, Royal Tern). Other species breed when they are 1 year old, have large clutches, and short life spans (Mottled Duck, Clapper Rail). These factors determine how fast a species can recover from any stressor, whether natural or man-made.

The indicators illustrate a range of population trends: some are increasing; some are decreasing. In some, the variation from year to year is so great that it is difficult to ascertain trends. In others, fidelity to colony sites is so low that it is nearly impossible to census them accurately, and often their populations fluctuate wildly from year to year, depending upon water levels. Nonetheless, for the 15 indicator species, several lines of data indicate decline over the last 45 years for Mottled Duck, Clapper Rail, and Black Skimmer, and clear increases for Brown Pelican, Great Egret, Osprey, and Laughing Gulls, although data from the last 15–20 years indicate that Laughing Gull is declining.

Overall declines seem to be due to habitat loss, coupled with human disturbance and other disruptions to beach, salt marsh, and coastal environments. Dramatic increases are often due to laws and regulations (endangered species laws, cessation of the use of pesticides, e.g., Brown Pelican, Osprey), to specific management practices (Whooping Crane, Piping Plover), to habitat creation (Brown Pelican), inadvertent management (dredge spoil islands for Snowy Plover and other beach nesting species), and possibly to global warming (more northern movement of southern species, such as Roseate Spoonbill).

The avian communities of the Gulf of Mexico are varied and diverse, largely because of the diversity of habitats, the richness of the marine-land interface, the presence of a gradient from tropical to temperate, and the geography of the Gulf, which places it as the funnel point for Nearctic-Neotropical migrants. Changes in the avian community occur because of short-term and long-term stressors, which render habitat either suitable or unsuitable. Habitat loss in the Gulf, which is continuing at an alarming rate due to both natural and anthropogenic causes, will result in changes to the bird communities that can only be countered by protection and management, and that require monitoring to assess the overall health of avian communities. Finally, the needs and requirements of the avian communities must be viewed within the context of the human communities that also thrive along the Gulf Coast. And management, protection, and conservation of birds must be designed with the human dimension in mind.

ACKNOWLEDGMENTS

BP sponsored the preparation of this chapter. This chapter has been peer reviewed by anonymous and independent reviewers with substantial experience in the subject matter. I thank the peer reviewers, as well as others who provided assistance with research and the compilation of information. In particular, I want to thank my able research assistants, Taryn Pittfield, Sheila Shulka and Christian Jeitner who helped with literature reviews, data extraction and figure design, as well as in countless other ways. M. Gochfeld read drafts and provided many useful references, knowledge, and experience. I also thank Jason Wells, ENVIRON International Corporation, for developing the habitat maps of the Gulf of Mexico with emphasis on those used by birds.

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APPENDIX A: HABITAT MAPS FOR GULF OF MEXICO, WITH EMPHASIS ON THOSE USED BY BIRDS

It is difficult to determine the amount of habitat available for birds in the Gulf of Mexico, partly because of changing habitat (quality, type, and quantity) and variable and changing requirements of birds. However, some habitat types or land cover types are unusable (such as developed lands). This appendix provides maps of habitat type (land cover) using the National Land Cover database from the National Geospatial Management Center, developed by Jason Wells, ENVIRON International Corporation, Houston, Texas in consultation with the author. Land Cover was determined for 10 mile (16.1 km) and 25 mile (40.2 km) from the coastline. Methodology is described below as well as the land cover types used (USDA, National Geospatial Management Center; accessed 28 March, 2012). The maps for each state follow, with the 10- and 25-mile area shown by dotted lines (see Figures A.1, A.2, A.3, A.4, and A.5).

Methods for GIS Maps That Follow (Wells 2013).

Data sources used:

Analytical/Operational Layers:

National Land Cover Dataset. 2006. United States Geological Survey. (raster).

Detail County Lines. 2010. ESRI Data and Maps 2010. (dtl_cnty_ln.sdc, polyline).

Base Layers:

Detail States. 2010. ESRI Data and Maps 2010. (dtl_st.sdc, polygon). Nations data layer. 2010. ESRI Data and Maps 2010. (nation.sdc, polygon).

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World Transportation. 2012. ESRI—Streaming data for ArcGIS Desktop. Copyright:© 2011 ESRI, DeLorme, NAVTEQ, TomTom.

World Imagery. 2012. ESRI—Streaming data for ArcGIS Desktop. Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community.

Software used:

ESRI ArcGIS Desktop. ArcInfo 10.0 Service Pack 4 (Build 4000) with Spatial Analyst Extension.

GIS Procedures:

For analytical purposes, the data resources were preprocessed or normalized to a consistent datum and projection. Since we were attempting to gain aerial estimates of land cover classes by state, our choice was to use the North American Datum 1983 (based on the Geodetic Reference System GRS 1980 spheroid) and NAD 1983 Albers projection using meters as the unit of measure. For mapping display purposes, the geographic coordinate system—WGS 1984 was used with projection “on-the-fly” from ArcGIS 10.

We chose operational GIS layers for this analysis as the National Land Cover Dataset (NLCD 2006) and a polyline feature class from ESRI Data and Maps 2010 called Detailed County Lines. The NLCD was used to derive comparative areal estimates of land cover classification by coastal state within 10 and 25 miles of coastal shoreline and the coastal shoreline was derived from the Detailed County Lines feature class.

The classification types comprising the NLCD:

- Developed open lands
- Developed low intensity lands
- Developed medium lands

- Developed high intensity lands
- Deciduous forest
- Evergreen forest
- Mixed forest
- Pasture/hay
- Cultivated crops
- Shrub/scrub
- Grassland/herbaceous
- Emergent herbaceous wetlands
- Woody wetlands
- Barren land
- Perennial ice/snow (not applicable)
- Open water

Datasets for NLCD 2006 were accessed by Internet download from USDA/NRCS—National Geospatial Management Center on March 28, 2012 for the states bordering the Gulf of Mexico (Texas, Louisiana, Mississippi, Alabama, and Florida). The horizontal datum referenced for these datasets was North American Datum of 1983 (NAD83) using the GRS1980 spheroid. The planar horizontal coordinate system used for the NLCD was Universal Transverse Mercator (UTM) spanning the zones 14–17 (TX-14, LA-15, MS-16, AL-16, FL-17).

We derived the coastal boundary layer for the Gulf of Mexico by extracting the relevant line type from the Detailed County Lines feature class. The attributes for this polyline feature class included line classification types of Coastline, County, International, Shoreline, and State. Using the "Select by Attributes" Tool in ArcGIS, we selected the Coastline type. The Detailed County Lines feature class included the coastlines of the Pacific and Atlantic Oceans and Gulf of Mexico. We used the "Select by Polygon" Tool to select and reduce the feature class extent representing the coastal shoreline of the Gulf of Mexico; from the Texas USA/Mexico border to the Florida Keys, along the Straits of Florida, and to the northern portion of Biscayne Bay, Miami, Florida.

The Detailed County Lines feature class has a native geographic coordinate system of WGS 1984. To reduce errors and enhance processing speed, we exported the selected and reduced shoreline feature class elements to a new feature class [dtl_cnty_ln_GOM] and converted the new feature class to NAD 1983 Albers using the transformation method NAD_1983_-To_WGS_1984_5.

This new layer formed the basis for our clipping buffer zone polygon layer of 10 and 25 miles inland from the coast, respectively. We used the ArcGIS Buffer Wizard to create new feature class polygons representing areas of 10- and 25-mile radius of the coastline.

To assist with understanding how NLCD classification types varied by state, we split the 10- and 25-mile buffer polygons at each of the state borders (e.g., Texas and Louisiana, Louisiana and Mississippi, Mississippi and Alabama) leaving new polygon features class elements of 10- and 25-mile buffer distance for Texas, Louisiana, Mississippi, Alabama, and Florida (western Florida around southern Florida to northern Miami).

The NLCD rasters were collected by state and combined into a single mosaic using the ArcGIS Raster Mosaic Tool and subsequently reprojected to NAD 1983 Albers. Once the mosaic was completed for the GoM states, the new mosaic dataset was clipped to the 25-mile buffer using the Clip Raster Tool creating a new smaller raster. This was done to reduce geoprocessing time for later operations by eliminating the majority of inland areas not relevant to this analysis.

Reclassification of the new 25-mile clipped NLCD mosaic was done to combine existing similar classifications of "Developed" areas that would be tabulated to aerial assessments by state. The classifications of Developed Open Lands (21) and Developed Low Intensity Lands (22) were combined into one Developed Open/Low Lands classification and the Developed Medium Intensity Lands (23) and Developed High Intensity Lands (24) were combined into one Developed Medium/High Intensity Lands classification. To perform the reclassification of the 25-mile clipped mosaic NLCD, the Reclassify Tool from the Spatial Analyst Extension was used. The areal extent evaluation for NLCD classification by state within 10 or 25 miles of the coastline used the following classification groups:

- Developed open/low intensity lands
- Developed medium/high intensity lands
- Deciduous forest
- Evergreen forest
- Mixed forest
- Pasture/hay
- Cultivated crops
- Shrub/scrub
- Grassland/herbaceous
- Emergent herbaceous wetlands
- Woody wetlands
- Barren land
- Open water

We assessed the areal extent of newly derived NLCD classification types by state using the Zonal Tabulate Area Tool from the Spatial Analyst Extension of ArcGIS. Inputs for geoprocessing using this tool were the 25-mile clipped/reclassified mosaic NLCD raster and the 10- or 25-mile buffer feature classes (split by state border) as the "feature zone" with attribute of STATE_NAME as the zone field. The NLCD mosaic was used as the input raster with classification "Value" as the Class Field. The result of Zonal Tabulate Area Tool is cross-tabulation containing the summation of the areas (square meters) from NLCD classification type by 10- or 25-mile buffer zone by state. This areal extent is not a true three-dimensional area since no topographic dataset was included.

For visualization purposes, the NLCD mosaic was further reclassified and reduced to the following classifications:

- Developed open/low/medium/high intensity
- Deciduous/evergreen/mixed forest
- Pasture/hay/cultivated crops
- Shrub/scrub—grassland/herbaceous
- Emergent herbaceous wetlands
- Woody wetlands
- Barren land
- Open water

Background for the National Land Cover Dataset:

National Land Cover Dataset (2006). United States Geological Survey.

"National Land Cover Database 2006 (NLCD2006) is a 16-class land cover classification scheme that has been applied consistently across the conterminous United States at a spatial resolution of 30 m. NLCD2006 is based primarily on the unsupervised classification of Landsat Enhanced Thematic Mapper + (ETM+) circa 2006 satellite data." This classification is based on the Anderson Land Cover Classification System.

Class/Value	National Land Cover Dataset—Classification Description
Water	Areas of open water or permanent ice/snow cover
11	*Open water*—areas of open water, generally with less than 25 % cover of vegetation or soil
12	*Perennial ice/snow*—areas characterized by a perennial cover of ice and/or snow, generally greater than 25 % of total cover
Developed	Areas characterized by a high percentage (30 % or greater) of constructed materials (e.g., asphalt, concrete, buildings, etc.)
21	*Developed, open space*—areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 % of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes
22	*Developed, low intensity*—areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20–4 % percent of total cover. These areas most commonly include single-family housing units
23	*Developed, medium intensity*—areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50–79 % of the total cover. These areas most commonly include single-family housing units
24	*Developed high intensity*—highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/ industrial. Impervious surfaces account for 80–100 % of the total cover
Barren	Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the green vegetated categories; lichen cover may be extensive
31	*Barren land (rock/sand/clay)*—areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15 % of total cover
Forest	Areas characterized by tree cover (natural or seminatural woody vegetation, generally greater than 6 m tall); tree canopy accounts for 25–100 % of the cover.
41	*Deciduous forest*—areas dominated by trees generally greater than 5 m tall, and greater than 20 % of total vegetation cover. More than 75 % of the tree species shed foliage simultaneously in response to seasonal change
42	*Evergreen forest*—areas dominated by trees generally greater than 5 m tall, and greater than 20 % of total vegetation cover. More than 75 % of the tree species maintain their leaves all year. Canopy is never without green foliage
43	*Mixed forest*—areas dominated by trees generally greater than 5 m tall, and greater than 20 % of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 % of total tree cover
Shrubland	Areas characterized by natural or seminatural woody vegetation with aerial stems, generally less than 6 m tall, with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included
52	*Shrub/scrub*—areas dominated by shrubs less than 5 m tall with shrub canopy typically greater than 20 % of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions

(continued)

Class/Value	National Land Cover Dataset—Classification Description
Herbaceous	Areas characterized by natural or seminatural herbaceous vegetation; herbaceous vegetation accounts for 75–100 % of the cover
71	*Grassland/herbaceous*—areas dominated by gramanoid or herbaceous vegetation, generally greater than 80 % of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing
Planted/ cultivated	Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75–100 % of the cover
81	*Pasture/hay*—areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 % of total vegetation
82	*Cultivated crops*—areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 % of total vegetation. This class also includes all land being actively tilled
Wetlands	Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al. (1979)
90	*Woody wetlands*—areas where forest or shrubland vegetation accounts for greater than 20 % of vegetative cover and the soil or substrate is periodically saturated with or covered with water
95	*Emergent herbaceous wetlands*—areas where perennial herbaceous vegetation accounts for greater than 80 % of vegetative cover and the soil or substrate is periodically saturated with or covered with water

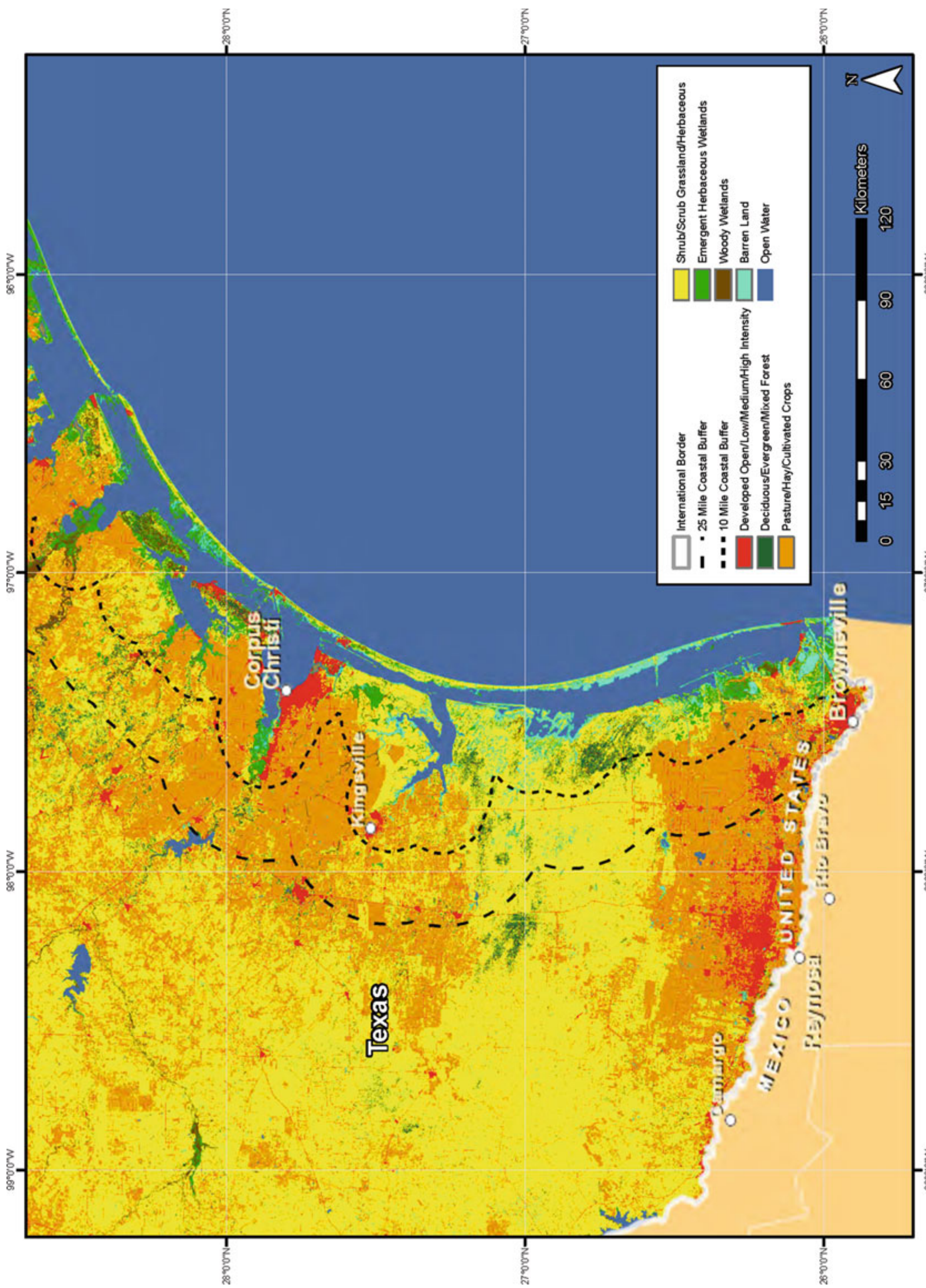

Figure A.1. Texas.

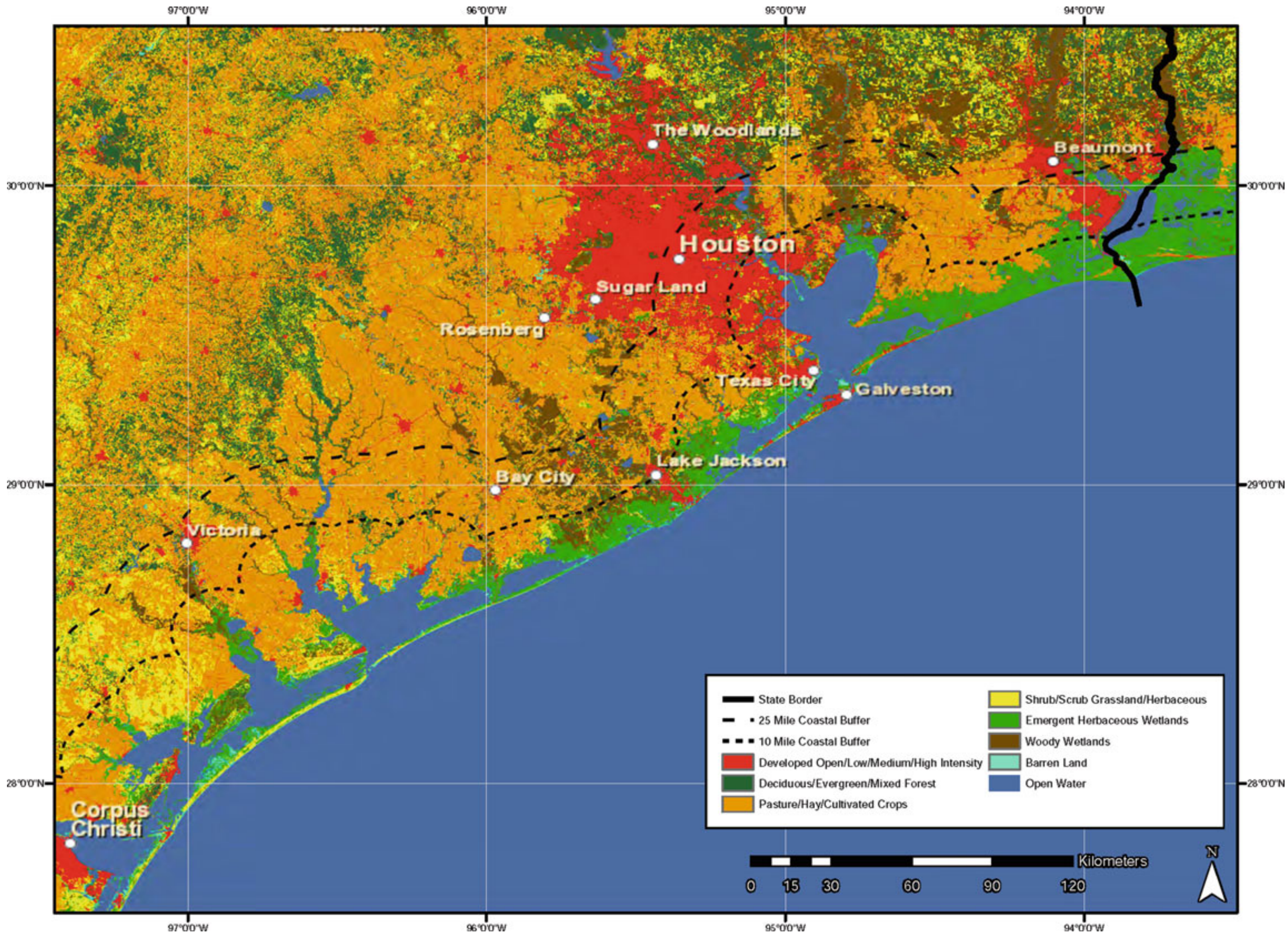

Figure A.2. Texas.

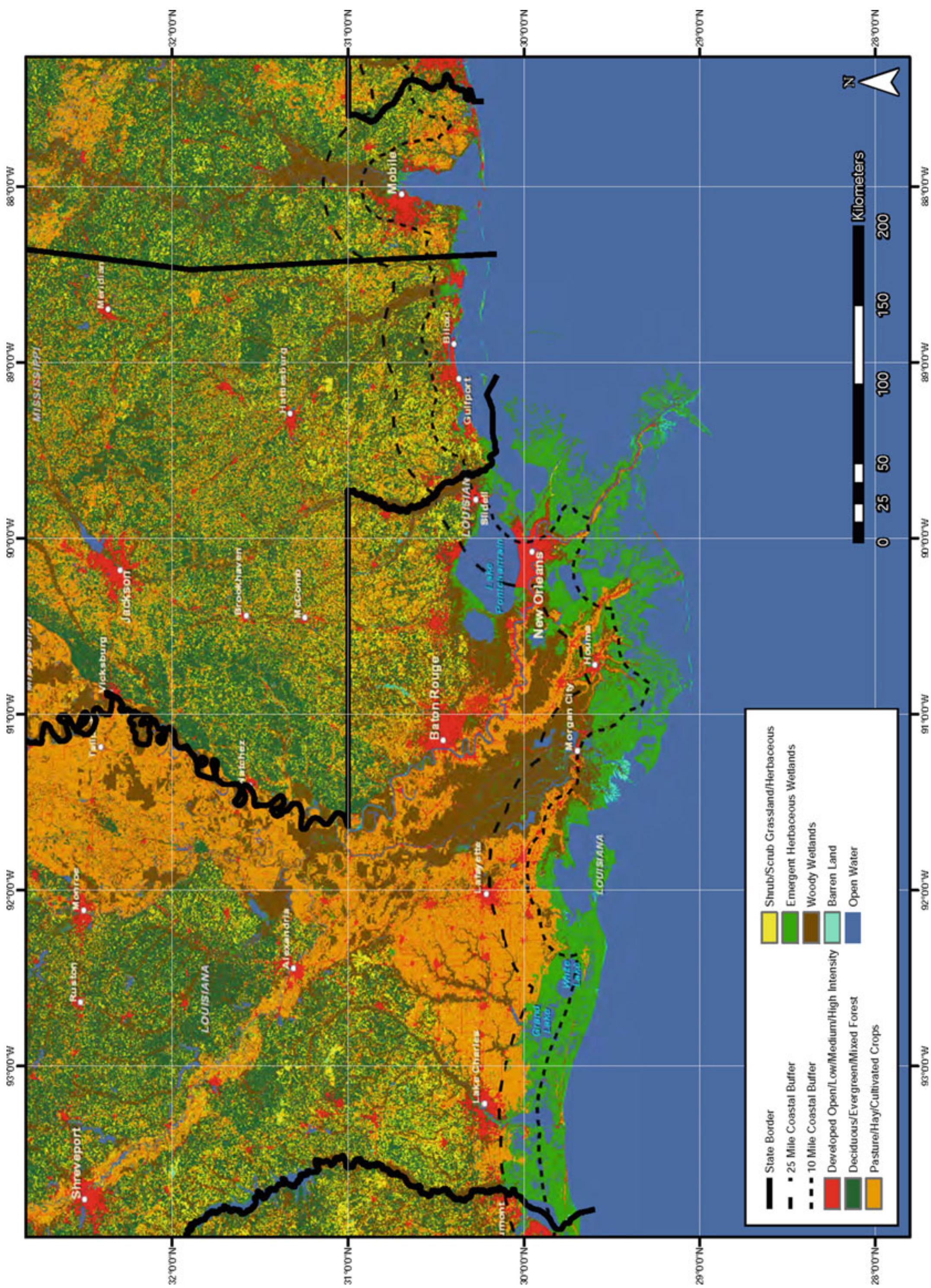

Figure A.3. Louisiana/Mississippi.

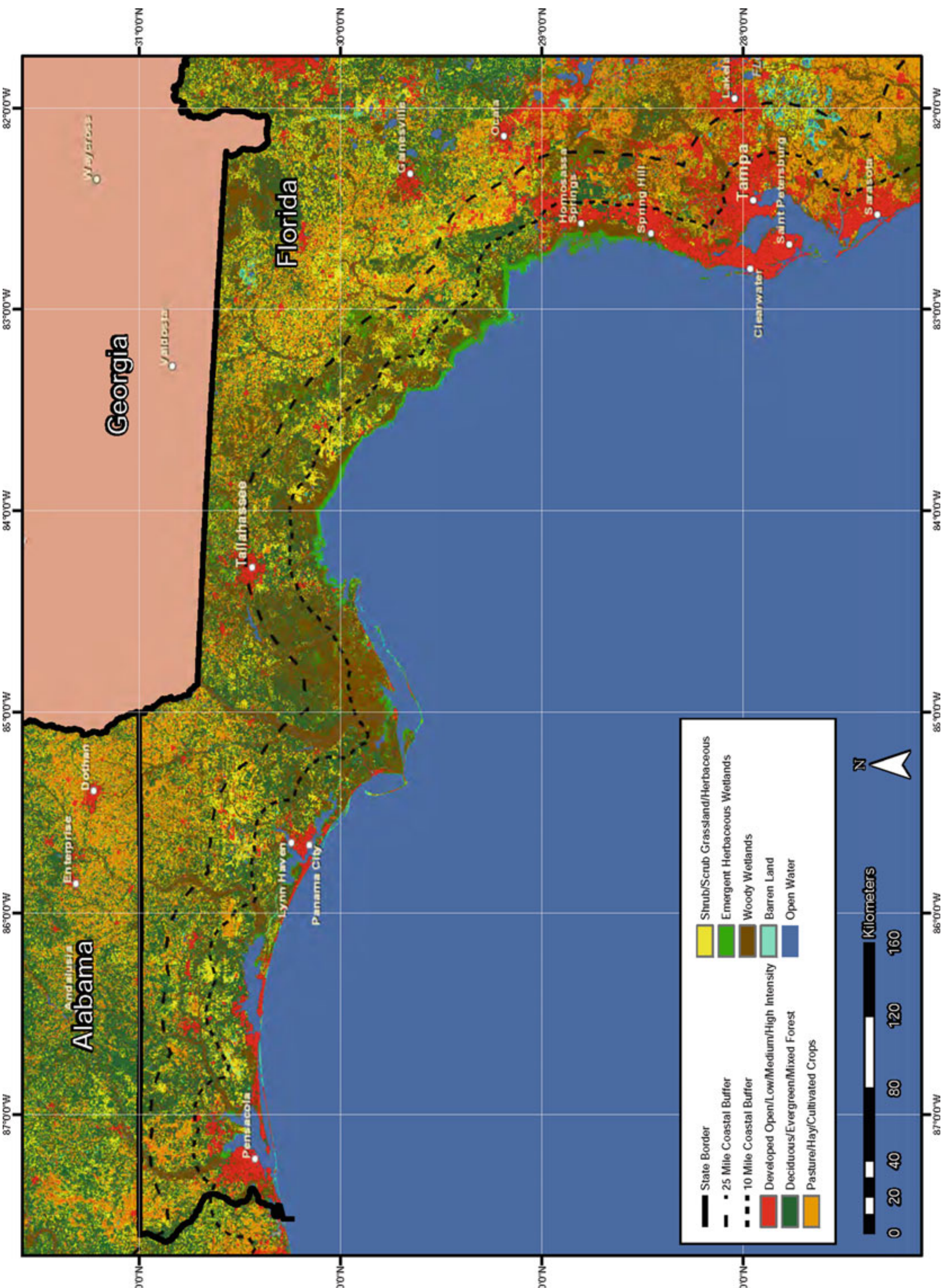

Figure A.4. Alabama/Florida.

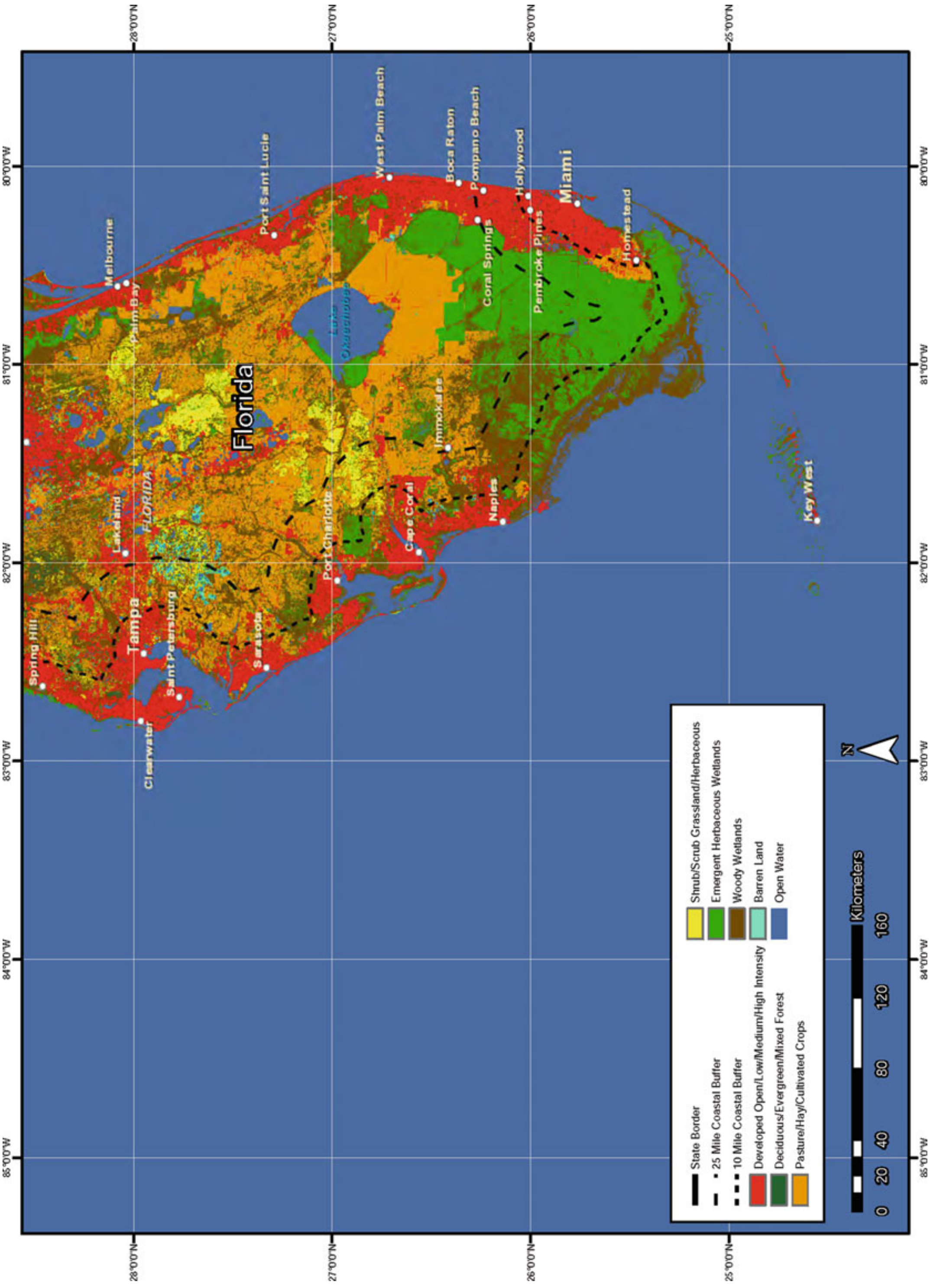

Figure A.5. Florida.