A Carolina Wetlands Association
"State-of-the-Wetlands" Report
on the Carolinas' wetland resource.

Carolina Wetlands Association

http://carolinawetlands.org

CAROLINA WETLANDS PAST TO PRESENT:

How wetlands have changed in the Carolinas and their current condition, stressors, and threats.

CONTENTS

INTRODUCTION AND PURPOSE

In North and South Carolina, the U.S. Fish and Wildlife Service (USFWS) estimates there are over 7.7 million acres (over 12,000 square miles) of wetlands with 4 million acres in North Carolina and 3.7 million in South Carolina (U.S. FWS 2020a). This means that wetlands account for 12.5 percent of the land area in North Carolina and 18.5 percent of the land area in South Carolina. Most (over 85 percent) Carolina wetlands are forested, and forested wetlands are in many ways the most vulnerable wetland type.

North and South Carolina's wetlands are dominant features of the landscape today, especially across the coastal plain where 95 percent of the wetlands are located (USFWS 2020a). However, many wetlands have been lost or severely degraded since European colonization. Dahl (1990) estimated that prior to the 1780s there were 11 million acres of wetlands in North Carolina and 6.4 million acres of wetlands in South Carolina, suggesting that almost 10 million acres (over 15,000 square miles) of Carolina wetlands have been lost since the 1780s – more land area than the states of New Jersey and Connecticut combined. According to the USFWS[1], wetland loss and degradation continues to this day. For the 2004 to 2009 timeframe, the USFWS reported that the freshwater wetland habitat type with the largest decline in the conterminous United States with a 633,100 acres loss, was forested wetlands, primarily in the southeast (Dahl and Stedman 2013).

The purpose of this report is to present an overview of the state of an important but shrinking resource – wetlands in North and South Carolina. The report will establish a baseline – as a basis for seeing future trends in wetlands in the Carolinas – by addressing the following questions.

- What are the functions and benefits of wetlands in the Carolinas?
- How many wetlands do we have, what are their types, and where are they?
- How have past and current land-use practices affected our wetlands?
- What other threats/stressors are there and how can we manage them?
- What is the current condition of our wetlands?
- How do we protect and manage this valuable resource through education, conservation, restoration, and other activities?[2]

This report is current as of 2020 and will be updated as more is learned and potentially as wetlands are conserved and protected across the Carolinas in the coming years.

1 U.S. Fish and Wildlife produces wetland Status and Trend Reports, the sixth report covering the years 2009 to 2019 is currently under development.

2 More information about efforts to manage this loss and rules protecting wetlands and changes to them in recent years can be found in the Carolina Wetlands Association *Wetland Regulation, Permitting, and Mitigation White Paper* (under development).

FAST FACT

There are over 7.7 million acres (over 12,000 square miles) of wetlands in the Carolinas, with 4 million acres in North Carolina and 3.7 million acres in South Carolina.

1. WETLAND FUNCTION, BENEFITS, AND OCCURRENCE IN THE CAROLINAS

Healthy wetlands are an integral component of healthy watersheds and they provide many essential ecosystem services that benefit both human, natural communities, and watershed function. Examples of the many valuable functions and benefits wetlands provide include (NC DWR n.d., ASWM 2019)(see Figure 1):

- Wetlands are highly important for water quality because they filter water by assimilating and processing nutrients and other pollutants thereby protecting adjacent and downstream waterbodies. Even geographically isolated wetlands can act as a sink for pollutants in the landscape.
- Wetlands associated with riverine systems capture and store water, particularly during flooding events. They also slow down water, reducing erosion and sedimentation downstream, thus protecting water quality.
- Shoreline communities and natural areas are protected by saltwater marshes which trap sediments and control shoreline erosion by absorbing wave action during storm surges.
- Wetlands help regulate water supply by slowly releasing water after storm events, recharging both groundwater and surface water sources.
- Wetlands help moderate climate change by sequestering carbon from the atmosphere.
- Wetlands provide habitat for waterfowl, amphibians, reptiles, aquatic insects, fish, and other bird species. These animals use wetlands for food, shelter, and reproduction. Approximately 70 percent of the North Carolina endangered species depend on wetlands.
- Estuarine saltwater wetlands serve as nursery habitat for clams, oysters, crayfish and many types of commercially important fish.
- Wetlands provide a place for recreational activities such as birdwatching, boating, hunting, hiking, and nature study.

These benefits all have monetary value and constitute the ecosystem services that can be delivered by healthy Carolina wetlands.

Figure 1: Wetland Fuctions and Benefits, courtesy of ncwetlands.org.

FAST FACT

Wetlands protect adjacent and downstream water quality by assimilating and processing nutrients and other pollutants.

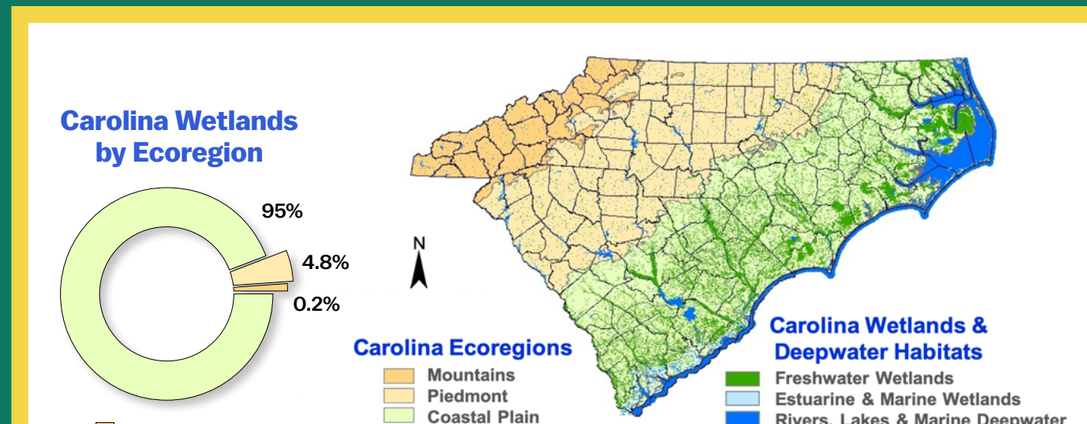

Figure 2: Wetlands in the Carolinas

Carolina wetlands are diverse habitats found across the Coastal Plain, Piedmont, and Mountain ecoregions of North and South Carolina (see Figure 2). Wetlands are transitional places where land meets water often forming in association with waterbodies or low areas that intersect the groundwater table (see next page). The depth and duration of saturation[3] combined with landscape position are key factors in determining when wetland soils[4] develop and which hydrophytic plant species inhabit them to create a particular type of wetland community (Mitch and Gosselink 2000). Landscape position (see Figure 3 on next page) and terrain are especially influential on the type and size of wetland that form. "Riverine" (or "Riparian") wetlands form near streams, creeks, and rivers; "lacustrine" wetlands form near lakes or reservoirs; and "estuarine" wetlands form near coastal areas and are influenced by tides. "Non-riparian" wetlands form on the land found between river and stream systems called the "interstream divide". These types of wetlands can form in wide low-lying "flat" areas, natural landscape depressions called "basins", or "seep" areas along slopes or hillsides where groundwater seeps out of the surface. Non-riparian basins and seep wetlands are found in all three ecoregions but "flats" are generally unique to the coastal plain (see Table 1). The coastal plain ecoregion has the highest diversity and abundance of wetlands in the Carolinas, with its low-lying terrain, vast stretches of flat land, many rivers and creeks, and extensive coastline protected by barrier islands (N.C. Functional Assessment Team 2010).

3 Soils are "saturated" when all of their pore spaces are filled with water.

4 Also known as hydric soils, wetland soils are saturated, flooded, or ponded long enough during the growing season to develop low-oxygen (anaerobic) conditions that favor the growth and regeneration of hydrophytic vegetation (Federal Register, July 13, 1994).

WHAT ARE WETLANDS?

Wetlands are transition areas in the landscape where land meets water. Hydrology, vegetation, and most importantly, soil types can be used to identify the presence of a wetland.

Wetland soils, also known as hydric soils, are saturated, flooded, or ponded long enough during the growing season to develop the anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation. Hydric soils can be identified in the field using characteristics that remain even when the wetland is hydrologically disturbed (e.g., ditched and drained) to the extent it will no longer support wetland vegetation. While wetland scientists and all federal and state agencies include this three-parameter approach to identifying a wetland, the actual "delineation" of the wetland, which demarcates a wetland boundary, can vary by who does the delineation and what the purpose is. For example, wetlands delineated by the U.S. Fish and Wildlife Service for the National Wetland Inventory include all types of wetlands found anywhere in the landscape, while, "jurisdictional" wetlands, those wetlands federally protected by the U.S. Environmental Protection Agency and regulated by the U.S. Army Corps of Engineers, has a less encompassing definition that has been subject to change in recent years.

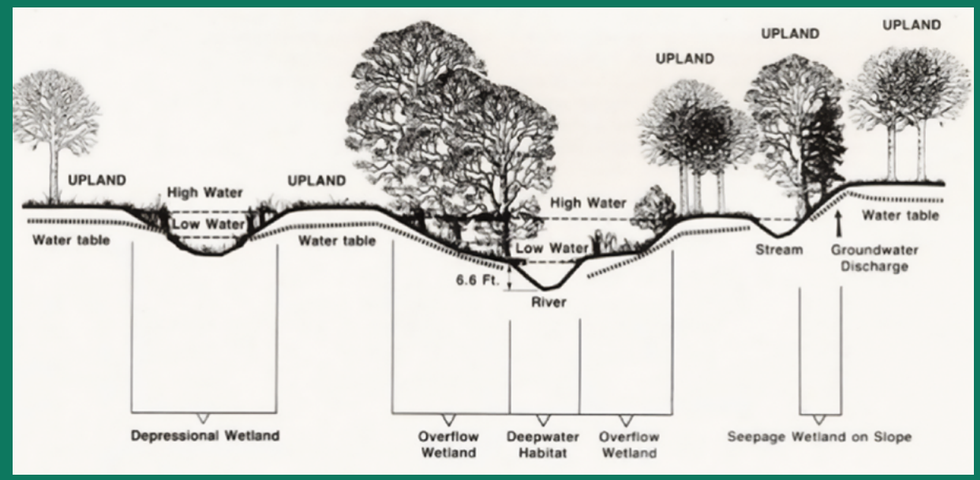

Figure 3: Diagram showing wetlands, deep-water habitats, and uplands on landscape. From Cowardin et al. 1979

FAST FACT

Wetland soils are saturated, flooded, or ponded long enough to develop the anaerobic conditions that favor the growth and regeneration of wetland vegetation.

Examples of wetland communities in the Carolinas include mountain bogs with their carnivorous plants, ferns, and azaleas (N.C. Functional Assessment), while the coastal plain is home to fire dependent open pine savannahs, vast pine flats, blue carbon salt marshes that protect miles of seashore, the enigmatic Carolina Bays (opposite) and densely shrub-covered carbon rich pocosins (see page 9). Forested riverine swamps and bottomland forests occur in all three ecoregions along major rivers and small creek systems, in low-lying areas of the floodplain where the water table is close to the land surface. The North Carolina Wetland Assessment Method (NCWAM) defines 16 different types of wetlands in North Carolina and is also applicable to South Carolina, which has similar physiography and ecoregions. The methodology uses landscape position, degree of wetness, tidal influence and/or salinity levels, dominant vegetation, soils, and other characteristics to classify and define wetland types. Table 1 lists the NCWAM wetland types found in the Carolinas, along with their occurrence in the major ecoregions (Coastal Plain, Piedmont, and Mountain) of these two states. Information on the landscape position, tidal influence, and the waterbodies the wetland type is associated with is also provided in Table 1. Appendix A provides additional information on the wetland characteristics across the Carolinas, some wetlands and associated flora or fauna are pictured in Figures 5-12.

Figure 4: Carolina Bays, Bladen County North Carolina

Carolina bays (in South Carolina or North Carolina) can be lakes or depressional (basin) wetlands (see examples in Figure 4). Bays are often cleared and drained for agriculture, silviculture, or development (Bennett and Nelson 1991; Sharitz and Gresham 1998).

CAROLINA BAYS

Found in the coastal plain landscape in North and South Carolina, Carolina Bays are elliptical depressions with a northwest/southeast orientation and a raised rim at their southeast edge.

Their origins have been mysterious since their discovery in the 1930s, but storm scouring and impact crater hypotheses are currently favored (Powell 2006; ncwetlands.org). Concentrated along the North and South Carolina border, some bays hold enough water to be shallow lakes like Lake Waccamaw, Jones Lake, or White Lake, in North Carolina, while many include wetlands with peat or black loam soils. The Carolina Wetlands Association has sponsored field trips to several bays in South Carolina, including Lewis Ocean Bay, Antioch Bay, and Woods Bay. Bennett and Nelson (1991) report county level estimates for Carolina bays in SC.

FAST FACT

The North Carolina Wetland Assessment Method (NCWAM) defines 16 different types of wetlands in North Carolina and is applicable to South Carolina.

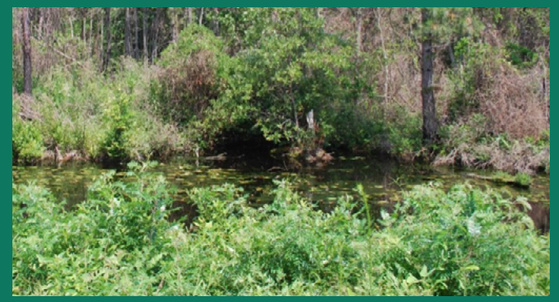

Figure 5: Figure 5a (left) short pocosin and Figure 5b (right) tall pocosin at Pocosin Lakes National Wildlife Refuge in Coastal North Carolina. Photo curtesy of Curtis J. Richardson

POCOSINS

Pocosins, an Algonquin Indian word meaning "Swamp-on-A- Hill", are evergreen shrub bogs found along the Atlantic coastal plain from Virginia to north Florida Pocosins comprise the largest extent of true bogs in the southeastern U.S. (Richardson 1983).

They are rainfall driven and thus hydrologically isolated from major rivers on the landscape. However, they are often found adjacent to estuaries and have surface hydrological connections that are linked to regional water quality and salinity gradients found in estuarine areas along the coast. Regional studies of the pocosin peatland soils in the NC Coastal Plain show they once comprised nearly 2 million acres with an estimated 325 Tg of carbon (1,193 Tg of CO_2) stored in deposits at depths up to 15 feet (Ingram and Otte, 1982; Richardson 2012). While carbon emissions from surface fires in undrained pocosin wetlands are common and occur naturally in shrub-scrub and pine woodlands at fire intervals of 20–80 years (Poulter et al. 2006), most surface fires are low severity with respect to peat combustion (Flanagan 2020). However, organic peat soils (histosols), are susceptible to deep peat muck fires if drained (Mickler 2021). North and South Carolina collectively are estimated to contain 1.4 million acres of drained pocosin peat soils that are susceptible to annual fires and currently release via decomposition an estimated 1 to 1.6 million Mg CO_2 yr^{-1} to the atmosphere (Richardson et al. 2022). Thus, restoration (rewetting) of drained fallow peatlands along the southeastern coastal plain would substantially reduce greenhouse gas emissions, reduce nutrient runoff and decrease salt water intrusion (Richardson et al. 2014; Wang et al. 2016).

Note: Figure 5a - the short stature of the vegetation (3-6 ft.), including the pond pine (*Pinus serotina*) in the background. Here the vegetation is dominated by fetter bush (*Lyonia lucida*) and Ilex sp. Peat depths are in excess of 3 ft. Figure 5b - Tall pocosin, the density and height of the shrub vegetation (> 12-15 ft). The vegetation is dominated by pond pine and loblolly bay (*Gordonia lasianthus*), and the trees are > 18 ft. in height. The peat depths are < 3 ft.

TABLE 1: NORTH CAROLINA WETLAND ASSESSMENT METHOD (NCWAM) WETLAND TYPES

Wetland Type	Estuarine, Tidal, Riverine, Non-Riverine, Lacustrine*	Coastal Plain	Piedmont	Mountains
Salt/Brackish Marsh	Estuarine & Tidal	✓		
Estuarine Woody Wetland	Estuarine & Tidal	✓		
Tidal Freshwater Marsh	Riverine & Tidal	✓		
Non-Tidal Freshwater Marsh	Riverine / Lacustrine	✓		
Riverine Swamp Forest		✓	✓	✓
Bottomland Hardwood Forest	Riverine	✓	✓	✓
Floodplain Pool		✓	✓	✓
Headwater Forest		✓	✓	✓
Bog			✓	✓
Seep	Non-Riverine, Palustrine	✓	✓	✓
Basin Wetland		✓	✓	✓
Pine Savanna		✓		
Pine Flat		✓		
Hardwood Flat		✓		
Non-Riverine Swamp Forest		✓		
Pocosin		✓		

*Estuarine – wetland is affected by salt or brackish water, contiguous with estuaries and tidal mouth of rivers.
Tidal – wetland is affected by lunar or wind tides.
Lacustrine – wetland is contiguous with lakes or reservoirs.
Riverine – wetland is associated or contiguous with flowing water (rivers, creeks, streams) and/or found in a natural geomorphic floodplain and/or a topographic crenulation. Wetland is also Riparian.
Non-Riverine – wetland is not Riverine and is found on slopes, interstream divides (flats), or depressions surrounded by uplands. Wetland is also Non-Riparian and Palustrine.

WETLAND GALLERY

Figure 6: Salt marshes at Hammocks Beach State Park, Onslow County NC, courtesy of ncwetlands.org

Salt marshes help moderate climate change through carbon storage in saturated deep organic soils and have rapidly growing vegetation that promotes carbon sequestration, the process of capturing carbon from the atmosphere (U.S. NOAA n.d.).

Figure 7: Bog Turtle, Photo by Nathanael Stanek, turtleconservancy.org

Mountain bogs provide habitat for the federally threatened bog turtle (*Glytemys muhlenbergii*; NCWRC 2006).

Figure 9: Coastal Plain Pine Savannah, Green Swamp Nature Conservancy Preserve, Brunswick County NC, courtesy of ncwetlands.org

Land managers use low intensity prescription burns to maintain the open park-like and highly diverse pine savanna vegetation.

Figure 10: Venus Flytrap (Dionaea muscipula), Green Swamp Nature Conservancy Preserve, Brunswick County NC, courtesy of ncwetlands.org

Venus Flytraps (*Dionaea muscipula*) are endemic to the pine savannah wetland habitats in coastal North and South Carolina (The Nature Conservancy 2019).

Figure 8: Riverine Swamp Forest in the Coastal Plain, Congaree National Park, Richland County, SC

Riverine swamp forests, found throughout the Carolinas, are most abundant in the Coastal Plain and are characterized by seasonal or semi-permanent flooding. Tree species such as bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*) in the Coastal Plain and overcup oak (*Quercus lyrata*) in the Piedmont and Mountains have adapted to the wet conditions of riverine swamp forests (N.C. Functional Assessment Team 2016).

Figure 11: Mountain Bog, Panthertown Bog, Jackson County, NC, courtesy of ncwetlands.org

Mountain bogs are a unique and rare wetland type found in the Blue Ridge Mountains and parts of the Piedmont (N.C. Functional Assessment Team 2016).

Figure 12: Southern Toads (*Bufo terrestris*) breeding in Mazarick Park in Cumberland County, courtesy of ncwetlands.org

Seasonally flooded isolated vernal pools and upland depression wetlands provide important breeding grounds free of fish predators for many species of amphibians (Leibowitz 2003).

The National Wetlands Inventory (NWI) uses aerial photo interpretation to map the nation's wetlands. NWI maps can be used to estimate wetland location, distribution, size, and type (USFWS 2020b). In the Carolinas, the NWI (see below and Table 2) estimates there are 7.7 million acres (over 12,000 square miles) of wetlands, with 4 million acres in North Carolina and 3.7 million acres (over 5,000 square miles) in South Carolina (USFWS 2020a). According to the NWI, wetlands account for about 12.5 percent of the land area in North Carolina and almost 18.5 percent of South Carolina. There are 7 million acres of freshwater wetlands found across the Carolinas with another 0.7 million acres of marine and estuarine wetlands located along the coast. In the Carolinas, 95 percent of wetlands are found in the coastal plain, with only 4.8 percent in the Piedmont and 0.2 percent in the Mountains (Figure 2). However, wetlands in the Piedmont and Mountains, although rare, especially deserve protection because of the important functions and services they provide as critical hydrologic components of the watershed and as wildlife habitats, including those for threatened and endangered species.

Wetlands in the Carolina coastal plain are 91 percent freshwater and 9 percent saltwater or brackish water (near the coast, USFWS 2020a). In terms of vegetative cover, 93 percent of all freshwater wetlands are mostly forested or shrub-covered, four percent are covered with herbaceous plants[5], and the other three percent are freshwater ponds, which are mapped as wetlands by the USFWS NWI. Saltwater coastal wetlands are predominantly marshes or mudflats covered with herbaceous sea grasses like cordgrasses (Spartina spp., USFWS 2020a).

The NWI has a minimum mapping unit of 0.5 acre, which means that state or region-wide acreage estimates are most likely underestimating total wetland acreage because they do not include small wetlands. The NC Division of Water Resources Wetlands Research Team obtained field-delineations of wetlands across the state and used them to assess the accuracy of NWI in North Carolina, particularly in relation to small wetlands (NCDWR 2021). They attempted to estimate the acreage of small wetlands (<0.5 ac) across the state. According to their website (ncwetlands.org), "Field-delineations included a total of 4,655 individual wetlands statewide, with sizes ranging from <0.01 – 1,271 ac. Wetland size varied across the state and tended to be much smaller in the Blue Ridge Mountains (median = 0.1 ac.; mean = 0.3 ± 0.9 ac.) and Piedmont (median = 0.1 ac.; mean = 0.4 ± 1.3 ac.). In these two ecoregions, >90% of field-verified wetlands were below the NWI minimum mapping size of 0.5 ac. Wetlands tended to be larger in the Southeastern Plains (median = 0.6 ac.; mean = 2.5 ± 6.7 ac.) and Mid-Atlantic Coastal Plain (median = 0.7 ac.; mean = 9.0 ± 51 ac.) ecoregions[6]. The relative frequency of wetlands in the field-delineated data was used to calculate an estimate of total wetland acreage statewide (3.98 million ac.) as well as for each of the four major ecoregions6. These estimates were compared to wetland acreage derived from NWI, and results suggest that NWI underestimates wetlands statewide by approximately 60,000 ac. Results by ecoregion6 were mixed, with NWI drastically underestimating wetland acreage in the Blue Ridge and slightly underestimating acreage in the Mid-Atlantic Coastal Plain. NWI greatly overestimated wetland acreage in the Piedmont and moderately overestimated in the Southeastern Plains."

NATIONAL WETLAND INVENTORY

The USFWS works with partners to provide the NWI to scientists, land managers, and other wetland practitioners with data on the distribution and type of wetlands found across the landscape.

Conducted by trained image analysts, the National Wetland Inventory (NWI) uses aerial imagery to identify and classify wetlands and deep-water habitat (U.S. FWS 2020a). Wetlands are classified by each wetland's landscape position, vegetation cover, and hydrologic regime with the "Cowardin" classification system (U.S. EPA 2020). NWI maps are developed remotely with aerial imagery and are therefore limited in their accuracy and not useable for legal jurisdictional, federal, or local government wetland boundaries (U.S. FWS 2020b). Wetland field practitioners use onsite soils, vegetation, and hydrology data to identify wetlands more accurately on the ground for regulatory jurisdictional approval and science purposes.

TABLE 2: CAROLINA WETLAND TYPES

State	National Wetland Inventory Type	Acres[1]	MI	%
North Carolina	Estuarine and Marine Wetland	295,390	462	7.3%
	Freshwater Emergent Wetland	117,708	184	2.9%
	Freshwater Forested/Shrub Wetland	3,500,569	5,470	86.9%
	Freshwater Pond	115,765	181	2.9%
	Other	343	0.5	0.01%
	Total	**4,029,775**	**6,297**	
South Carolina	Estuarine and Marine Wetland	413,244	646	11.3%
	Freshwater Emergent Wetland	187,220	293	5.1%
	Freshwater Forested/Shrub Wetland	2,964,449	4,632	80.9%
	Freshwater Pond	100,926	158	2.8%
	Other[2]	3	0	0.0%
	Total	**3,665,842**	**5,728**	
Both Carolinas	Estuarine and Marine Wetland	708,634	1,107	9.2%
	Freshwater Emergent Wetland	304,928	476	4.0%
	Freshwater Forested/Shrub Wetland	6,465,018	10,102	84.0%
	Freshwater Pond	216,690	339	2.8%
	Other	346	1	0.0%
	Total	**7,695,617**	**12,024**	

1 Wetland acres were calculated with the NWI GIS data layer accessed January 2020 (U.S. FWS 2020a), data process methods in Appendix B.
2 Other wetlands include farmed wetlands, saline seeps, and other miscellaneous wetland types

5 Herbaceous plants are plants that have no persistent woody stem above ground

6 The Southeastern Plains and Mid-Atlantic Coastal Plain Level III ecoregions have been lumped together for the purposes of the Carolina Wetland Association's State of the Wetland report. Ecoregions (ecological regions) are spatially defined regions that contain characteristic and geographically distinct natural communities and species. Ecoregions provide scientists and land managers a spatial framework for research, assessment, management, and monitoring of ecosystems and ecosystem components.

2. WETLAND HISTORY, STATUS, AND TRENDS IN THE CAROLINAS

The USFWS has produced a series of reports on the Status and Trends of Wetlands (see Appendix C) in the conterminous United States as required under the Emergency Wetlands Resources Act of 1986 (Public Law 99-645) (USFWS 2020b). The Status and Trends reports strive to "provide science-based information on the status of America's wetlands through time" and are complimentary to the NWI mapping program by providing monitoring information (USFWS 2020a and 2020c). Aerial interpretation was used to identify wetlands that have been lost completely or severely "altered" from their natural condition[7] (see Appendix C , USFWS 2020b). Before writing the first status and trends report, the USFWS also produced a special precursor report for the Status and Trends project as per a congressional directive to the Secretary of Interior in 1989 titled "Wetland Losses in the United States 1780's to 1980's" (Dahl 1990; USFWS 2020b). This report estimated that wetlands accounted for approximately a third of the North and South Carolina land cover in the 1780s: 11 million acres of the in North Carolina and 6.4 million acres in South Carolina. By the 1980s, North Carolina's wetlands were greatly reduced to just 16.9 percent of the land coverage, 5.7 million acres, indicating nearly a 50 percent decline. During the same timespan, South Carolina was estimated to have lost 27 percent of their wetlands, indicating a 23.4 wetland land coverage or 4.7 million acres (Dahl 1990)[8].

Historic wetland losses were primarily through ditching and draining in the southern colonies, including North and South Carolina. In North Carolina, the first subsistence farmers settled on small tracts of land in the rich bottomlands along the Chowan River and Albemarle Sound area in late the 1600s when choice lands in Virginia had become occupied (USGS 1996). The South Carolina coastal region known as the "Low Country" was the first area to attract European settlers who used the river systems as means of transportation to the interior (Dahl 1999). Early settlers used small hand dug ditches to drain wetlands and expand land productivity. As the colonial population grew from the early to mid-1700s, land clearing and farming for profit grew too, resulting in the conversion of many coastal plain wetlands to agriculture in the Carolinas (USGS 1996; Dahl 1999).

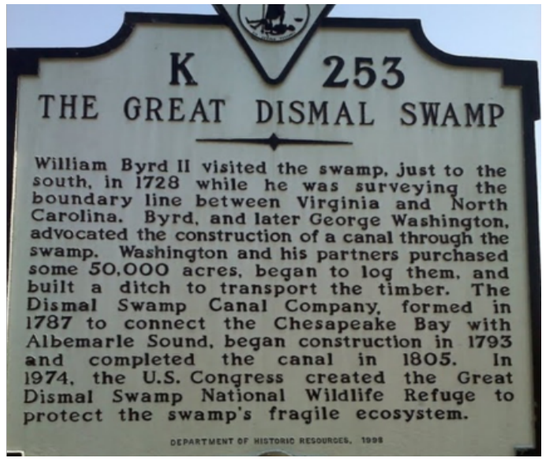

Figure 13: Great Dismal Swamp Marker, North Carolina and Virginia

Widespread drainage projects were most common in the southern colonies, including North and South Carolina (USGS 1996). One of the earliest large drainage projects was authorized by the state of South Carolina for Cacaw Swamp, located in the Low Country to the west of Charleston, in 1754 (Beauchamp 1987). By 1787 in North Carolina, a large-scale ditching and drainage project was constructed in the eastern coastal plain region with the installation of the Phelps Lake to Scuppernong River 6- mile-long drainage canal (Heath 1975). Then in 1805, the 22-mile long Dismal Swamp Canal was completed to provide transportation from North Carolina to the tidewater region of Virginia and promote the drainage of the Great Dismal Swamp for agriculture (Figure 13; Finley 2017; Heath 1975). The original extent and natural hydrology of the Great Dismal Swamp, currently 750 mi2 (Britannica n.d.), has been significantly altered through many years of substantial ditching and drainage projects and is believed to have been 10-times larger by some accounts (Finley 2017). Other large-scale North Carolina drainage projects followed in the 1830s, with funding from the North Carolina State Literary Board, to encourage settlement on swamplands, including the installation of canals around Lake Mattamuskeet, Pungo Lake, and New Lake. There were also several other historic large-scale drainage projects in North Carolina in the late 1800's and early 1900's, including draining the 43,000-acre Lake Mattamuskeet, a shallow lake in Hyde County, an effort that was later abandoned (Heath 1979). Even with these large historic drainage projects in North Carolina, Cashin et al. (1992) still estimated that about a third of the wetland alteration from the 1780s to the 1980s occurred after 1950.

Historical wetland losses in South Carolina, have not been well-documented and are not as extensive as North Carolina or some other southeastern states. Some wetland alteration and loss have occurred from natural processes like erosion or accretion (filling in with sediments), animal activity, droughts, and major storms (USGS 1996). Traditional small farms and subsistence agriculture were replaced by plantations during the colonial period, causing wetland drainage and modification to become prevalent in the region (Dahl 1999; USGS 1996). Instead of draining wetlands, some South Carolina plantation owners impounded and diked coastal marshes to convert them to rice growing operations in the 18th and 19th century. Rice farming practices were further supported by tides providing a natural form of irrigation twice a day (Lucas 1980). As early as the 1670s, rice was one of South Carolina's important commercial commodities (Salley 1919) and by 1850, South Carolina had become the largest producer of rice in the U.S. (Littlefield 1995). Commercial rice farming has since declined in the state, allowing many of these historic rice farms to revert back to tidal marshlands (Dahl 1999).

The many Carolina bays in South Carolina were originally bypassed by earlier settlers, but their rich soils eventually attracted settlers who drained and converted them to agricultural uses (Kovacik and Winberry 1987). It's been estimated that South Carolina once had 4,000 of these unique Carolina bay wetlands, distinct to this mid-Atlantic region of the country, prior to European settlement (Richardson and Gibbons 1993). A study conducted by the South Carolina Heritage program in the 1990s, showed that more than 80 percent of the Carolina bays larger than two acres in size have been significantly altered and degraded (Bennett and Nelson 1991). Another study by Sharitz and Gresham (1998) found that 97 percent of all Carolina bays in South Carolina had some disturbance from agriculture (71 percent), logging (34 percent), or both. The more extensive conversion of Carolina bays to agriculture in South Carolina started in the 1940s. Carolina bays, that were shallow enough to be drained, were very appealing to South Carolina farmers because of their highly productive organic soils with high nutrient holding capacity (Sharitz and Gresham 1998). Today, very few Carolina Bays remain undisturbed (Bebber 1988).

FAST FACT

Between the 1780's and 1980's North Carolina experienced nearly a 50 percent decline in wetland coverage and South Carolina lost 27 percent.

7 The U.S. Fish and Wildlife Status and Trends surveys evaluation define "altered wetlands" (e.g., ditched or logged) as a loss.

8 Historical wetland acreage estimates are difficult to assess due to absence of reliable historical data. Historic wetland extent was roughly estimated using various resources for the *Wetland Losses in the United States 1780's to 1980's* report: 1.) colonial and state historic land records, 2.) land use records that traced conversion of lands by use category, 3.) drainage statistics, and 4.) information on the extent of hydric soils (drained and undrained) in combination with historical wetland acreage data (Dahl 1990).

Many small mill ponds, built in the 1700 and 1800s century (Dahl 1999), altered some wetlands with increased flooding like Merchants Mill Pond, built in 1811 in Gates County, North Carolina (NC Division of Parks and Recreation 2015). However, in the 1900s, large-scale water retention dams were constructed along major rivers in the Carolinas for water supply, recreation, and hydropower. In some cases, impounding the river drowned bottomland and riverine swamp forest wetlands and changed the river's normal hydrologic regime as has happened along the upper Savannah, Santee, and Pee Dee Rivers of South Carolina (USGS 1996; Dahl 1999).

In the Carolinas, many Carolina bay, bottomland hardwood, riverine swamp forest, pocosin, wet pine flat, and pine savannah wetlands were converted to silviculture and agricultural lands in the late 1800s and early 1900s. Wetlands converted to farms or forestry operations have been significantly ditched and drained which reduces or eliminates wetland hydrologic functions (USGS 1996). In North Carolina, by the 1960s, it was estimated that more than one million miles of drainage ditches and canals criss-crossed the North Carolina coastal plain (USGS 1996).

During the 1950s to 1970s timeframe, the south sustained the greatest loss of wetlands in the country through the conversion of wetlands to managed forests and agriculture. Major losses of pocosins and Carolina bays in this period were attributed to agriculture and peat mining (Richardson 1981; Hefner and Brown 1985). Across the south, during the next 10 years, from 1970 to 1980, 3.1 million acres equal to nine percent total of the forested wetlands in 10 southern states was lost or converted to scrub-shrub wetlands, of those wetlands, nearly 1.2 million acres were in the coastal plain region of North Carolina (Hefner et al. 1994). It has been estimated that pocosin wetlands which historically covered 2,244,000 acres of North Carolina have been reduced threefold to 739,000 acres by 1980 due to agriculture, silviculture, and development (Richardson and Gibbons 1993). In 1989, 14 percent of pocosins in North Carolina were owned by corporate agriculture and 36 percent by major timber companies.

For pocosins, their deep organic peat soils can have negative impacts to adjacent streams and estuaries when ditched and drained for agriculture if they are not managed properly. These offsite effects can include decreased salinity in adjacent estuaries, increased turbidity in adjacent streams immediately after development, and increased phosphate, nitrate, and ammonia inputs into adjacent waterbodies, particularly when runoff volumes are high (Richardson 1983). These offsite issues can be minimized by managing water levels in ditches with risers that maintain water levels and slow the delivery of fresh water to downstream stream estuaries (Sharitz and Gresham 1998).

The U.S. FWS produced a South Carolina state focused Status and Trends report on wetland changes from 1982 to 1989 (see page 13). This report for South Carolina in that seven-year time-period found an average annual net loss of 2,928 wetland acres that resulted in 0.05% overall land cover reduction of wetlands from 1982 to 1989.

Forested wetlands were lost primarily to forestry operations, agriculture, and urban development. At the end of this study (1989), the state wetland coverage was estimated to be 4.1 million acres (Dahl 1999).[9]

Logging practices of historically important species like the Atlantic white cedar (*Chamaecyparis thyoides*) have also caused once common wetland types in the Carolinas to become rare. Atlantic white cedar swamps were found in peatland habitats along the outer coastal plain from New Jersey to Mississippi. The slow growing Atlantic white cedar, with its natural decay resistance qualities, was valued as a building material before the invention of man-made preservatives. Heavy logging of Atlantic white cedar swamps resulted in possibly a 50 percent tree loss and habitat alteration between 1880 and 1900 (Laderman 1989). As much as 200,000 acres of Atlantic white cedar forest have been harvested from the Great Dismal Swamp (including areas of Virginia) and the peninsula between the Albemarle and Pamlico sounds in North Carolina (USGS 1996). By the 1980's the acreage of Atlantic white cedar had decreased by at least 90 percent in the Carolinas, leaving only pockets of these once majestic swamps. Today, the largest concentration of Atlantic white cedar can be found in and around the Alligator River in North Carolina (Laderman 1989). Bald cypress trees (*Taxodium distichum*) were another valuable timber source due their durability and resistance to termites and rotting under humid conditions (Williams 1989). In the southeast, cypress trees, were an important timber source for pioneering settlers (Ewel and Odum 1984). In South Carolina, the commercial value of cypress trees was recognized in the 1800s and logging became extensive, greatly reducing stands of cypress by the 1950s (Williams 1989). Some of the wettest areas were initially inaccessible until the 1900s when virgin timber was harvested in the swamplands of the Great Pee Dee and Santee Rivers (Figure 14; Durham 1967).

LOGGING OF SOUTH CAROLINA

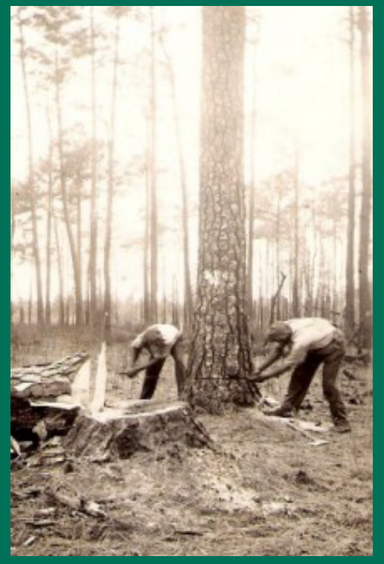

Figure 14: Logging virgin timber in South Carolina, sourced from the bornagainheartwoods.com

9 Total wetland acres were estimated in the South Carolina Status and Trends Report Study because certain wetland habitats types had not been mapped by NWI. Small Limestone Sinks and Seagrass and other Submerged aquatic vegetation wetland habitats were not included in the report. South Carolina NWI mapping was competed later in the 1990s.

3. THREATS AND STRESSORS TO CAROLINA WETLANDS

Carolina wetlands are some of the most vulnerable wetlands in the U.S. The 2002 Southern Forest Resource Assessment found that forested wetlands in the Carolinas are subject to threats from development (58 percent), agriculture (19 percent), and silviculture (13 percent), and that North Carolina was suffering the most losses when compared to other southeastern states at that time.

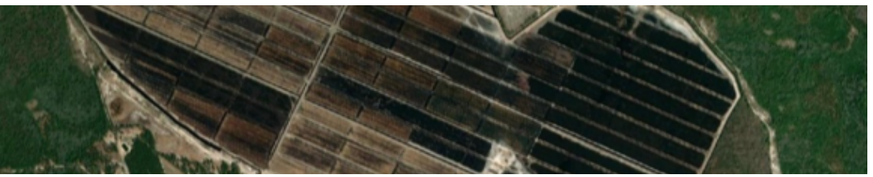

Figure 15: Drained and Altered Carolina Bays, Bladen County, NC (Google Earth 2021)

Urban and suburban development, along with agricultural and silvicultural threats, were of most immediate concern. Other areas of concern noted by the Southern Forest Resource assessment included invasive non-native species and climate change (Weir and Greis 2002).

The 2004-2009 U.S. FWS Status and Trends Report found that 80,000 acres of U.S. coastal wetlands were lost each year, which was up from the 60,000 acres per year reported in the previous five-year window. Along the Atlantic coast alone, roughly 112,000 acres of wetlands were lost between 2004 and 2009. The wetland loss was attributed to urban development pressures and increases in agriculture and silviculture (Dahl and Stedman 2013).

Sea level rise due to climate change is a looming and very real threat to coastal wetlands. Productive and dense salt marsh vegetation collects suspended sediment from the water column and over time causes the marshes to rise vertically, a process called accretion. Studies have shown salt marshes naturally keep up with sea level rise but may not be able to in the future if the rate of sea level rise increases (Northeim and RTI International n.d. and National Center for Coastal Ocean Science 2017). The destruction of this valuable resource poses other grave risks; when these habitats are damaged or destroyed, both their carbon sequestration capacity is lost and the carbon stored is released into the atmosphere (U.S. NOAA n.d.).

Many stressors to existing wetlands have the capacity to negatively impact wetland hydrologic, chemical, and biological function. For example, ditching, drainage tiles, fill, and compacted soils can affect hydrologic function. Impacts that drain or fill wetlands are especially damaging as healthy wetland hydrology is fundamental to wetland function. Drained and dried out wetlands with deep peat soils, like pocosin wetlands, can also emit carbon to the atmosphere and, if burned, that carbon release increases exponentially. During a 2008 drought, a lightning-ignited fire in Hyde County NC near Pocosin Lakes Wildlife Refuge was started on one of the many tracts of farmland converted from pocosin. The fire was costly to contain and ultimately smoldered for seven months, removing 3-5 feet of dried out peat from the ground surface (Kozak 2019). It is predicted with climate change there likely will be more frequent and intense droughts which will likely increase wildfires (Kunkel 2020). Secondly, urban and agriculture stormwater runoff can introduce chemical pollutants to wetlands. Non-native invasive plant species, vegetation removal, and vegetation replacement can also alter wetland habitat and biological function.

Vegetation removal through deforestation, especially of riparian wetlands like riverine swamp forests and bottomland hardwood forests, can decrease or eliminate the ability of wetlands to reduce flood peaks (Wolkowski and Lowery 2008). Loss of mature forested wetlands also reduces habitat for neotropical migratory songbirds and other forest dwelling species that depend on trees (WWF 2019). Certain wetland tree species, like cypress and Atlantic white cedar, are extremely slow to regenerate. However, clear-cut of early successional areas, which mimic the effects of natural fires or storm driven blowdowns, can enhance habitat for some adaptable common species like deer, rabbits, and wild turkey (NC State University n.d.). Landscapes with a mosaic of diverse mature forested and open successional wetlands and uplands offer the best variety of habitats for wildlife.

Ground-disturbing activities, such as farming, logging, road construction, and other land-altering activities, can cause wetland stress through soil compaction or the introduction of invasive plant species. Soil compaction limits water and air infiltration and causes resistance to root penetration, slowing plant growth (Wolkowski and Lowery 2008). Many invasive species displace native plant species and have little wildlife value. Examples of commonly occurring problematic invasive plant species in wetlands of the Carolinas include Chinese privet (*Ligustrum sinense*), which has colonized many forested wetlands in the Piedmont and Coastal Plain, and the common reed (*Phragmites australis*), which grows in brackish and freshwater marshes primarily in the Coastal Plain (Native Plant Society n.d.).

The U.S. EPA 2011 National Wetland Condition Assessment (NWCA) survey found the leading stressors to wetlands nationally were caused by physical disturbances to wetlands and their surrounding habitats (U.S. EPA 2016). In the NWCA (described further in the next section), "stressors" defined as measurements of indicators of stress, were assessed in a core wetland assessment area and surrounding 100-meter buffer. Study results indicated that the most commonly occurring stressors affecting wetlands in the U.S. are vegetation removal or replacement, ditching, and surface hardening (compacted soils or pavement). A biological stressor (non-native plants) and two chemical stressors (soil phosphorous concentration and a heavy metal index) were also evaluated. U.S. study results showed 27 percent of wetlands had hardened surfaces, 23 percent were ditched, 27 percent had vegetation loss or removal and another 19 percent had non-native species stressors (U.S. EPA 2016). Ditching was the most significant high stressor in North Carolina with 25.5 percent of the assessed wetlands[10] ranking as high, while 17 percent ranked high in South Carolina. In South Carolina, 22.5 percent of the assessed wetlands[11] ranked as high for vegetation removal, while only 4.3 percent ranked high in North Carolina. Other stressors of concern in the Carolina include compacted soils, fill, vegetation removal, and non-native species introduction (see Table 3 and U.S. EPA 2016).

FAST FACT

Vegetation removal through deforestation can decrease or eliminate the ability of wetlands to reduce flood peaks.

10 The National Wetland Condition Assessment assessed 47 sites in North Carolina and 40 sites in South Carolina (see section 4, Carolina Wetland Condition), therefore, 12 (25.5 percent) and 7 (17 percent) sites ranked high for ditching stress in North and South Carolina respectively.

11 In South Carolina nine sites (22.5 percent) ranked high for vegetation removal stress while just two sites (4.3 percent) ranked high in North Carolina.

TABLE 3: CAROLINA WETLAND STRESSORS – NATIONAL WETLAND CONDITIONAL ASSESSMENT

Type	Stressor Level*	High	Moderate	Low
North Carolina				
Physical	Dams	4.3%	4.3%	91.5%
	Ditching	25.5%	6.4%	68.1%
	Fill	8.5%	6.4%	85.1%
	Compacted Soil	4.3%	8.5%	87.2%
	Vegetation Removal	4.3%	12.8%	83.0%
	Vegetation Replacement	17.0%	12.8%	70.2%
Biological	Non-Native Invasives	8.5%	12.8%	78.7%
Chemical	Soil Trace Phosphorous	0.0%	27.7%	72.3%
	Heavy Metal	2.1%	0.0%	97.9%
South Carolina				
Physical	Dams	10.0%	0.0%	90.0%
	Ditching	17.5%	2.5%	80.0%
	Fill	2.5%	7.5%	90.0%
	Compacted Soil	10.0%	12.5%	77.5%
	Vegetation Removal	22.5%	10.0%	67.5%
	Vegetation Replacement	12.5%	7.5%	80.0%
Biological	Non-Native Invasives	2.5%	10.0%	87.5%
Chemical	Soil Trace Phosphorous	2.5%	75.0%	22.5%
	Heavy Metal	0.0%	5.0%	95.0%

*Various physical, biological, and chemical stress metrics were used to assess wetland sites and their surrounding buffers. Sites were classified into "High", "Moderate", and "Low" stress levels for each stressor type. For example, of the NC wetland sites with dam stressors, 4.3 % showed high stressor levels, 4.3% showed moderate stressor levels, while 91.5% showed low stressor levels. For the NC sites with ditching, 25.% showed high stressor levels, 6.4 % showed moderate, and 68.1% showed low stressor levels.

4. WETLAND CONDITION IN THE CAROLINAS

In 2011, the U.S. Environmental Protection Agency (EPA) embarked on the first national scale evaluation of the ecological condition of U.S. wetlands, the National Wetland Condition Assessment (NWCA). Close to 1,000 wetland sites were randomly chosen across the conterminous U.S. using the FWS Status and Trends data to identify forested, shrub covered, and herbaceous wetlands (U.S. EPA 2016). The number of wetland sites assigned to each state was based on the quantity of wetland acres in that state. North and South Carolina have the third and fourth highest wetland acres the conterminous U.S. behind Louisiana and Florida and were assigned 47 and 40 sites respectively. Staff working for the North Carolina Department of Environmental and Natural Resources (NC DENR, now the Department of Environmental Quality) and South Carolina Department of Health and Environmental Control (SC DHEC) contributed to the study in the Carolinas.

Biological condition was defined as "Good", "Fair", or "Poor" through the assessment of the wetland vegetation using multiple metrics. Vegetation is a major component of the biodiversity and structure of wetlands and can serve as an effective indicator of wetland condition. At national level, this study showed that just shy of half of the wetlands, 48 percent, were in good biological condition, 20 percent fair, and 32 percent poor (U.S. EPA 2016). In North Carolina, of the 47 sites assessed, 57 percent were in good biological condition, 28 percent in fair condition, and 15 percent in poor condition. In South Carolina of the 40 sites were assessed, 55 percent were in good biological condition, 30 percent in fair condition, and 6 sites in poor condition (Table 4).

U.S. EPA (2016) also described the results of an additional 4-state collaborative study of the condition of forested wetlands in Alabama, Georgia, and North and South Carolina, including the NWCA metrics and additional metrics addressing amphibians, macroinvertebrates, and surrounding land use. Focusing on the Piedmont and Coastal Plain ecoregions, the study found differences between these regions, with the coastal plain's forested wetlands being in better condition than those in the Piedmont, probably due to heavier farming and population pressures in the Piedmont ecoregion. This difference was apparent with both the amphibian and the composite wetland condition indicators, showing the value of amphibian indicators in assessing wetland health and providing clues in how to best manage wetland condition and effectively restore poor-condition wetlands. Amphibian species counts and the presence of sensitive species like the marbled salamander were useful as condition indicators and the findings support the use of the amphibian quality assessment indicator in assessing wetland health.

TABLE 4: NWCA - RESULTS FOR NC AND SC

State	Biological Condition	Number of Sites	Percent
North Carolina	Good	27	57.4%
	Fair	13	27.7%
	Poor	7	14.9%
South Carolina	Good	22	55.0%
	Fair	12	30.0%
	Poor	6	15.0%

5. CONCLUSION AND FUTURE STEPS TO PROTECT WETLANDS

Wetland coverage in the Carolinas has declined significantly since early settlement (Dahl 1990). Even in recent years, decline has continued (Dahl and Stedman 2013).

The historic conversion of many wetlands to agriculture and silviculture coupled with the expansion of urban and suburban areas, road networks, and shoreline communities have drastically changed the wetland landscape. Existing wetlands face multiple threats from future development, fragmentation, deforestation, drainage, and reductions in federal and state protection. Many stressors such as the spread of invasive species, vegetation removal, or ditching and drainage can impact the ability of a wetland to function. However, even with these losses and extreme alterations of wetlands in the Carolinas, there are still many diverse, beautiful, and highly essential wetland ecosystems remaining. Healthy wetlands are an integral component of healthy watersheds, and they provide many essential ecosystem services that benefit both human and natural communities.

Steps have been taken in the Carolinas to better protect and manage valuable wetlands through regulation, restoration, conservation, education, and advocacy. For example, North Carolina has an isolated wetland rule (15A NCAC 02H .1301) that protects wetlands not regulated at the federal level. Wetlands lost due to urban development, roadway expansions, or other reasons, often require compensatory mitigation as per federal and state permit conditions to offset impacts[12]. Compensatory wetland mitigation is accomplished through restoration, enhancement, preservation, or even creation of another wetland within the same watershed. Voluntary wetland mitigation projects can be accomplished by public and private land managers, municipalities, land conservancies, private citizens[13] and nonprofits such as watershed groups and land conservancies.

Restoration activities often occur in historic or very poorly functioning wetland areas that have been severely altered through drainage, soil compaction, or some other anthropogenic (human-caused) stressor. Enhancement activities are completed in wetlands that are hydrologically functioning but may still have other issues such as invasive species or livestock intrusion and trampling. Restoration and enhancement activities may include plugging or filling ditches, disking compacted soil for aeration, removing fill, planting native vegetation, removing invasive species, or reconnecting incised streams to floodplains to improve wetland hydrology.

Pocosin wetland restoration has been recently considered for carbon storage value. Carbon markets, used to offset carbon emissions, already exist in California and will likely become more common in other states in the future. In Hyde County, North Carolina, Duke University has spearheaded a pocosin restoration project with private partners to offset the university's carbon emissions with a goal of carbon neutrality by 2024.[14]

Many wetland acres are conserved on large and small tracts of publicly and privately owned lands in the Carolinas. Public properties are managed at the federal, state, and local government level. The North Carolina Division of Water Resources (NC DWR) has information on over 200 publicly accessible wetlands on their NC Wetlands website. The South Carolina Department of Natural Resources (SC DNR) also maintains a wetlands webpage with links to 20 SC DNR managed properties with wetlands. Additionally, the Carolina Wetlands Association has held educational field trips to over 25 of these protected wetlands through its Wetland Treasures Program. There are also numerous private conservation entities such as local land trusts and The Nature Conservancy that conserve and manage properties with wetlands. Private citizens interested in long-term protection of wetlands on their property can set up land conservation easements.

Education is the first and most important step for wetland advocacy. Educational material is available to the public on wetlands in the Carolinas. The North Carolina Division of Water Resource's NCWetlands website and South Carolina Department of Natural Resources Wetlands website both provide educational resources regarding wetlands. The NC Wetlands site also has links to several wetland research studies conducted in Carolinas. The Carolina Wetlands Association sends out a quarterly newsletter and has been working diligently to expand the educational information and resources available to the public through the web, including the following products:

- Land-owners wetland guide
- Introductory "Wetlands 101"
- Detailed descriptions of the 16 Carolina wetland types
- Glossary of wetland terms
- Links to classroom educational material
- Information on government wetland policy
- Wetland Treasure fact sheets and videos, and
- White papers on wetland topics of interest including:
  - Wetlands and Climate Change
  - Wetlands and Water Quality
  - Wetland Restoration at the Pocosin Lakes National Wildlife Refuge
  - The Importance of Small Wetlands in NC
  - Marsh Migration Corridors
- Papers on other wetland issues and topics of focus to come, including:
  - Wetlands and Carbon Sequestration
  - Wetlands and Flooding
  - Wetland Rules, Regulation, and Compensatory Mitigation
  - Wetland Ecosystem Services

The Carolina Wetlands Association will continue to advocate for wetlands through its guiding principles and practices:

- Achieving successful results and solutions through thoughtful collaborations and partnerships.
- Inspiring others to respect, appreciate, and enjoy wetlands throughout the Carolinas,
- Initiating and encouraging activities that engage a broad community in understanding, protecting and preserving our state's wetlands, and
- Committing to the highest quality work, measurable goals, and work products.

12 More information about efforts to manage wetland loss and rules protecting wetlands can be found in the Wetland Regulation, Permitting, and Mitigation White Paper (currently under development)

13 See the Landowner's Guide to Wetland Restoration on the Carolina Wetlands Association website for more information on http://carolinawetlands.org/index.php/learn/landowners/.

14 See the Carolina Wetlands Case Study: Pocosin Lakes Restoration white paper and the "Restoration Work A Test for Carbon Farming" article in the Coastal Review for more information on using pocosin restoration for carbon offsets.

FAST FACT

Existing wetlands face multiple threats from future development, fragmentation, deforestation, drainage, and reductions in federal and state protection.

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APPENDIX A – WETLAND TYPES IN NORTH AND SOUTH CAROLINA

The North Carolina Wetland Assessment Method (NCWAM) defines 16 different types of wetlands in North Carolina and is also applicable to South Carolina wetlands. The methodology uses landscape position, degree of wetness, tidal influence and/or salinity levels, dominant vegetation, soils, and other characteristics to classify and define wetland types. The Coastal Plain ecoregion supports 15 of the 16 wetland types found in the Carolinas as defined by NCWAM, while both the Piedmont and Mountain ecoregions support nine types of wetlands (Table A-1). Six types of riparian wetlands are found in all three ecoregions: riverine swamp forests, bottomland hardwood forests, floodplain pools, non-tidal freshwater wetlands, and headwater forests. Non-tidal freshwater marshes are also associated with lakes and reservoirs in the three ecoregions. Only the non-riparian basins and seeps are found in all three ecoregions, while hardwood flats, non-riparian swamp forests, pine flats, pine savannahs, and pocosins are found in the Coastal Plain exclusively. Basin wetlands, generally small in size in the Piedmont and Mountains, can range from tiny sinkholes to enormous Carolina bays in the coastal plain (see Table A-1 and Figure 4 in the main report). Seepage wetlands, another less common non-riparian wetland type, are quite variable and generally smaller in size (NC Functional Assessment Team 2016).

Three types of estuarine and/or tidally influenced wetlands are found exclusively in the coastal plain: salt/brackish marshes, estuarine woody wetlands, and tidal freshwater marshes. Coastal plain salt/brackish marshes fringe hundreds of miles of seashore in the Carolinas and range from small bands to hundreds of acres in size. "Salt" marshes are found closer to the ocean or inlet saline waters while "brackish" marshes do not have as direct a connection with the ocean (N.C. Functional Assessment Team 2016). Coastal marshes are particularly important for carbon storage and carbon sequestration, the process of capturing carbon from the atmosphere. These highly productive wetlands have rapidly growing vegetation that promotes carbon sequestration at a faster rate than other terrestrial ecosystems. Carbon is stored in the waterlogged deep peat soils that have formed over many years of natural plant growth and biodegradation (U.S. NOAA n.d.). It is currently estimated that coastal marshes account for 1-2% of the total carbon sink in the conterminous U.S. (Charpentier et al. 2010). Estuarine woody wetlands occur as a narrow band at the margins of salt/brackish marshes and are transitional in nature, receiving freshwater and occasional storm surge saltwater influences. Tidal freshwater marshes occur in the lower reaches of rivers and streams, close enough to the coast to be subject to tidal flooding; both freshwater and salt tolerant species may thrive in these marshes making them more diverse than other types of marshes (N.C. Functional Assessment Team 2016).

Coastal plain riverine swamp forests, characterized by seasonal or semi-permanent flooding, are more common in this ecoregion and can establish on both organic and mineral soils along stream and river systems. In the coastal plain, riverine swamp forests can also form at the margin of lakes. **Bottomland forests** occur in less flooded areas, often forming extensive mosaics with riverine swamp forests (N.C. Functional Assessment Team 2016). The Roanoke River floodplain of North Carolina has one of the largest intact and least disturbed bottomland hardwood and riverine swamp forests in the mid-Atlantic Region and is substantially privately owned (USGS 1996).

Floodplain pools may form in abandoned river channels (oxbows) or in localized depressions in the floodplain. **Headwater forests** form at the upper end of stream systems and are generally drier than other riparian wetland types. **Non-tidal freshwater** marshes, also transitional in nature, can be found

in small or large areas along streams and rivers, lake margins, or disturbed areas such as utility corridors. The canopy vegetation (evergreen verses deciduous) and the level of wetness are the defining differences among the four types of **coastal plain non-riparian flats**. **Hardwood flats** are forested with various oaks, black gum (*Nyssa sylvatica*), red maple (*Acer rubrum*), and other hardwood species and tend not to be as wet as **non-riverine swamp forests** which can be home to more water-tolerant species such as bald cypress (*Taxodium distichum*), Atlantic white cedar (*Chamaecyparis thyoides*), pond pine (*Pinus serotina*), and various more water-tolerant hardwoods (N. C. Functional Assessment Team 2016).

Pine savannas have an open canopy of longleaf pine (*Pinus palustris*) or pond pine, and a ground covering of low shrubs, wire grass (*Aristida stricta*), and huge diversity of herbaceous species including the endemic Venus flytrap (*Dionaea muscipula*) (The Nature Conservancy 2019). The open park like vegetation of pine savannas is maintained with frequent, low-intensity fires. **Pine flats** are successional in nature and represent altered variants of other non-riparian wetland types. Canopy vegetation may include loblolly pine (*Pinus taeda*), slash pine (*Pinus elliotti*), and various hardwood species. **Seep wetlands** in the coastal plain, like pine savannas, are dependent on a fire regime and may be dense or sparsely shrub covered. **Coastal plain basin wetlands** are quite variable both in terms of size, vegetation, wetness, and soils (N.C. Functional Assessment Team 2016). **Pocosin wetlands** are endemic to the mid-Atlantic region, found only from Virginia to South Carolina (Kozak 2019). These wetlands are densely covered with waxy evergreen shrubs and scattered trees such pond pine, loblolly bay (*Gordonia lasianthus*), and swamp bay (*Persea palustris*) and can be found on flats or in basins (N.C. Functional Assessment Team 2016). Similar to coastal marshes, pocosin wetlands are an important carbon sink due their deep organic peat soil (Kozak 2019).

Wetlands in the Piedmont and Mountains are generally more similar then in comparison to the coastal plain. **Mountain bogs** are an exception as they are typically found in the Blue Ridge Mountains but can also establish in the northern upper Piedmont, a rugged section of the Piedmont ecoregion where the landscape is starting to transition to mountains. **Bogs**, considered to be riverine, are a unique and rare wetland type formed by groundwater seepage and overland runoff on organic or mucky mineral soils in floodplains or natural drainage areas (N.C. Functional Assessment Team 2016). Bogs provide habitat to an array of carnivorous plants, ferns, and azaleas (N.C. Wetland Functional Assessment Team 2016), and the federally threatened bog turtle (NCWRC 2006).

Similar to the coastal plain, **headwater wetlands in the Piedmont and Mountains** form in the upper reaches of a watershed at the head of, or adjacent to, narrow streams. **Bottomland hardwood forests**, likely the most common and extensive wetland type in the Piedmont, form further down in the watershed adjacent to larger streams, creeks and rivers with floodplains that flood seasonally. The extent and size of the bottomland hardwood forests is dependent on the natural width of the floodplain. **Riverine swamps** can occur in wetter riparian areas of the Piedmont and Mountains. Sometimes, long established beaver activity can result in riverine swamp conditions. Excessive beaver activity may also result in these forested wetlands transitioning to non-tidal freshwater marshes. Also similar to the Coastal Plain, **floodplain pools** may form in oxbows or in localized depressions in the floodplain. **Non-riverine seeps** in the Piedmont and Mountains could be zoned with an open interior of sparse to dense herbs surrounded by a forested outer edge (N.C. Functional Assessment Team 2016).

Basin wetlands in the Piedmont or Mountains are generally smaller in size. Examples include vernal pools and small upland depression ponds (N.C. Functional Assessment Team 2016). Many of these isolated and seasonally flooded basin wetlands in the Piedmont and the Mountains provide important habitat free of fish predators for breeding frogs and salamanders (Leibowitz 2003).

TABLE A-1: NORTH CAROLINA WETLAND ASSESSMENT METHOD (NCWAM) WETLAND TYPES

Wetland Type	Estuarine, Tidal, Riverine, Non-Riverine, Lacustrine*	Coastal Plain	Piedmont	Mountains
Salt/Brackish Marsh	Estuarine & Tidal	✓		
Estuarine Woody Wetland	Estuarine & Tidal	✓		
Tidal Freshwater Marsh	Riverine & Tidal	✓		
Non-Tidal Freshwater Marsh	Riverine / Lacustrine	✓		
Riverine Swamp Forest	Riverine	✓	✓	✓
Bottomland Hardwood Forest	Riverine	✓	✓	✓
Floodplain Pool	Riverine	✓	✓	✓
Headwater Forest	Riverine	✓	✓	✓
Bog	Riverine		✓	✓
Seep	Non-Riverine, Palustrine	✓	✓	✓
Basin Wetland	Non-Riverine, Palustrine	✓	✓	✓
Pine Savanna	Non-Riverine, Palustrine	✓		
Pine Flat	Non-Riverine, Palustrine	✓		
Hardwood Flat	Non-Riverine, Palustrine	✓		
Non-Riverine Swamp Forest	Non-Riverine, Palustrine	✓		
Pocosin	Non-Riverine, Palustrine	✓		

*Estuarine – wetland is affected by salt or brackish water, contiguous with estuaries and tidal mouth of rivers.
Tidal – wetland is affected by lunar or wind tides.
Lacustrine – wetland is contiguous with lakes or reservoirs.
Riverine – wetland is associated or contiguous with flowing water (rivers, creeks, streams) and/or found in a natural geomorphic floodplain and/or a topographic crenulation. Wetland is also Riparian.
Non-Riverine – wetland is not Riverine and is found on slopes, interstream divides (flats), or depressions surrounded by uplands. Wetland is also Non-Riparian and Palustrine.

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APPENDIX B – NWI CALCULATIONS

Wetland Numbers Calculation Methodology using National Wetland Inventory (NWI) data

- National Wetland Inventory (NWI) data were downloaded from the US FWS website (https://www.fws.gov/wetlands/Data/Data-Download.html) for all of North Carolina and South Carolina on January 1, 2020.
- NWI GIS data layers include attribute fields for "wetland type" and "area". These attributes are defined in https://www.fws.gov/wetlands/Data/Wetland-Codes.html and https://www.fws.gov/wetlands/Data/Metadata.html.
- NC and SC state boundary GIS layers were used to clip the NWI data download layers since NWI state layers include polygons that cross state boundaries.
- GIS ArcMap software was used to calculate acres for each polygon in the state clipped NWI layers.
- A "Wetland_Deepwater" field was added to define wetland type polygons as a wetland - "Estuarine Wetland" or "Freshwater Wetland", or deepwater habit "Lakes, Rivers, and Marine Habitat" (see Table B1 on the next page):

TABLE B-1: WETLAND DEEPWATER FIELD FOR GIS CALCULATION

Field Wetland_Deepwater	Type WETLAND_TY
Estuarine Wetland	Estuarine and Marine Wetland
Freshwater Wetland	Freshwater Emergent Wetland
Freshwater Wetland	Freshwater Forested/Shrub Wetland
Freshwater Wetland	Freshwater Pond
Freshwater Wetland	Other*
Lakes, Rivers, and Marine Habitat	Estuarine and Marine Deepwater
Lakes, Rivers, and Marine Habitat	Lake
Lakes, Rivers, and Marine Habitat	Riverine

*Other - Palustrine Farmed (Pf)

Methodology for the calculation of the North Carolina and South Carolina state freshwater and saltwater (estuarine) wetland totals and wetland totals type (see Table 2 in the State of the Wetland Report):

1. Freshwater wetland totals for each state were calculated using the state clipped wetland acres.
2. Saltwater (estuarine) wetland totals were calculated using the original NWI wetland acres and not the state clipped data set. A map and aerial evaluation of the clipped data sets overlaid on the non-clipped original NWI dataset showed too many coastal wetlands were clipped by the state boundaries.
3. Deep water habitats (Lakes, Rivers, and Marine Habitat) were not included in wetland acres.

Methodology to calculate the Carolina Ecoregion Totals (See Figure 2 in the State of the Wetland Report):

1. North Carolina and South Carolina Level III Ecoregions GIS layers were downloaded from the U.S. EPA's Level III and IV Ecoregions by State webpage (https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-state).

2. Arc GIS software was utilized to run a spatial join with the state clipped NWI layers and Level III ecoregion state layers.
3. Arc GIS was used to calculate acres for each polygon in the state clipped NWI layers that were joined to ecoregion data. The same projection as the NWI data layer was used to calculate wetland acres.

- The state clipped ecoregion wetland acres were used to total the Mountain and Piedmont ecoregion totals.
- For the Coastal Plain ecoregion, the state clipped ecoregion wetland acres were used to total the freshwater wetlands and the original NWI wetland acres (not the state clipped data set) were used to total the saltwater (estuarine) wetlands. Saltwater and freshwater wetlands were then totaled to calculate the Coastal Plain wetlands.
- Deep water habitats (Lakes, Rivers, and Marine Habitat) were not included in wetland acres.

APPENDIX C – WETLAND STATUS AND TRENDS REPORTS

The Wetland Status and Trends reports are the monitoring component of the National Wetland Inventory Program. These reports provide critical information on recent and historical changes of wetland and deep water habitat coverage that can be used to develop federal resource policies and determine the effectiveness of current policy and management strategies (USFWS 2020b). Five national reports have been published that cover the years from the 1950s to 2009; 1950's-1970's, 1970's-1980's, 1986-1997, 1998-2004, and 2004-2009. A sixth nationwide report for the years 2009-2019 is currently being developed and is scheduled to be completed in 2022. Additionally, seven state or regional Status and Trends Reports have been produced including "South Carolina's Wetlands – Status and Trends 1982-1989". To develop these nationwide reports, monitoring data from over 5,000 randomly located four- mile square plots are analyzed remotely with aerial images. The extent of wetland coverage and wetland type and how these changed over time is determined for each plot with a portion of the plots field verified. The monitoring results are then statistically extrapolated across the region to estimate wetland cover and wetland type changes for the report years across entire nationwide study area (USFWS 2020a). The South Carolina study included 465 plots located in four physiographic ecoregions (Dahl 1999).

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The Carolina Wetlands Association promotes the understanding, protection, restoration, and enjoyment of North and South Carolina's wetlands and associated ecosystems through science-based programs, education, and advocacy.

We envision a present and future in which the Carolinas' wetlands are understood, enjoyed, valued, and protected as integral parts of our mountain, piedmont, and coastal ecosystems. They should be healthy, plentiful, and support our states' ecological, societal, and economic needs.

The Carolina Wetlands Association is a non-partisan, science- based organization advocating for wetlands.

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