E.O. 305 Section 3a

Methodology to Update Wetland Maps & Determine Sacketts Effect

8/12/2024

North Carolina Department of Environmental Quality (DEQ) Executive Order 305 Wetlands Workgroup

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Executive Summary

When the *Sackett v. EPA* Supreme Court Case narrowed definitions of protected wetlands at the federal jurisdictive level, North Carolina Governor Cooper passed Executive Order 305, tasking DEQ and other state departments with various initiatives to increase knowledge of natural and working lands with the overarching goal of ecosystem protection. The purpose of this document, in accordance with Executive Order 305, is to address knowledge gaps about natural and working lands through efforts described in the order. In this report DEQ evaluates and proposes a method to produce an updated wetland map for North Carolina and proposes three methods for evaluating the potential effect of the Sackett decision on wetlands.

DEQ proposes to use and update the most accurate existing wetland mapping data, specifically the National Wetland Inventory (NWI), Division of Coastal Management (DCM) Wetland Data, and North Carolina Department of Transportation (NCDOT) Wetland Mapping Using Artificial Intelligence (AI) and Machine Learning. The NWI is the only comprehensive statewide mapping effort for North Carolina. The DCM Wetland Type Maps includes data in 40 coastal counties. The NCDOT wetland mapping effort uses machine learning, Light Detection and Ranging (LiDAR), and field delineations to produce maps that identify the probability of being jurisdictional under the Clean Water Act. NCDOT's mapping efforts are in process and currently incomplete but are promising. The efforts are yielding higher accuracy results in the mountain and piedmont regions, which have been historically difficult to map. This project proposes to combine the NWI and DCM data into a base map for North Carolina. Once the base map is created, current 1-meter resolution landcover data and NCDOT wetland AI machine learning data can be used to update the base map to produce an updated wetlands map for the state of North Carolina.

The methods proposed for evaluating the effects of Sackett include a method to evaluate risk based on wetland type, a method based on Hydrogeomorphic (HGM) class, and a Geographical Information System (GIS) method that evaluate hydrological connectivity.

I. Background

On May 25, 2023, the United States Supreme Court released its decision in Sackett v. Environmental Protection Agency (EPA). In Sackett, the Court reduced the reach of the Clean Water Act (CWA) by narrowing the criteria for which certain wetlands and waters may qualify as "waters of the U.S." (WOTUS). The Court concluded that wetlands and waterbodies that have no surface connection to navigable waters or other waters of the U.S. are, themselves, not waters of the US. The Sackett decision eliminated the federal protection status for approximately 50% of the nation's wetlands. There are 25 states that exclusively rely on federal rules, 6 states with limited state rule protection, and 19 states and the District of Columbia with broad state protection. The states that rely on broad state protection are fully protected by state law, while those who are not are either working to obtain protection through bills and other regulatory programs or are not moving forward to seek protection at all. North Carolina was one of the 6 states that had limited state protection, but that limited protection was eliminated shortly after the Sackett decision when North Carolina legislature passed the 2023 Farm Bill (SB582) that limited state wetland jurisdiction to be no more stringent than the federal jurisdiction.

Executive Order 305

On February 12, 2024, Governor Roy Cooper issued Executive Order 305. Executive Order 305 sets goals for the State of North Carolina to diligently protect, restore, and enhance natural and working lands that (i) facilitate carbon sequestration, (ii) strengthen ecosystem and community resilience, (iii) support biodiversity, (iv) provide vital ecosystem functions and services such as clean water and protection from floods, (v) support military training operations, (vi) facilitate tourism and enhance the State's economy, or (vii) provide opportunities for hunting, fishing, boating, and other recreational activities. By 2040, Executive Order 305 set goals for the State of North Carolina to permanently conserve 1 million new acres of North Carolina's natural lands with special focus on wetlands, restore or reforest 1 million new acres of North Carolina's forests and wetlands, and plant 1 million trees in urban regions of the state.

Executive Order 305 also set four specific tasks to the North Carolina Department of Environmental Quality: (1) feasibility of obtaining land cover data, (2) develop methodology to update wetland maps and determine Sackett Effect, (3) publish boundary maps of special wetlands, and (4) create a research project that outlines the values, costs, impacts of Natural and Working Lands, and benefits of conservation. This paper focuses on the second task of developing a methodology to update existing wetland mapping data for North Carolina and the methods that may be used to evaluate the potential acres of wetlands that have been affected by the Sackett decision.

Wetlands in North Carolina

The Clean Water Act defines a wetland as "areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted to life in saturated soil conditions." Wetlands comprise approximately 17% of North Carolina's total acreage (Hefner and Brown, 1985). Historically, North Carolina contained about 11 million acres of wetlands. Today, most estimates believe that North Carolina has about 5.7 million total acres, about 85 to 95% of these are located in the Coastal Plain (Wilson, 1962). Nearly one-third of the wetland alterations in the Coastal Plain have occurred since the 1950's. Most conversions have resulted from the transformation of wetlands into managed forests and agriculture. Approximately 70 percent of the rare and endangered plants and animals in the State are wetland dependent (USGS, 1996). According to the North Carolina Division of Coastal Management (DCM) (1999), 50 percent or more of the current landscape is comprised of wetlands in the North Carolina Coastal Plain. Wetlands are known to be of great ecological importance, for instance, their relationship to coastal water quality, estuarine productivity, and wildlife habitat makes this particular ecosystem quite diverse (Sutter & NCDCM, 1999).

Mapping Wetlands in North Carolina

Identifying wetlands that are subject or jurisdictional under the Clean Water Act has been a source of regulatory, political, legislative, and judicial debate throughout the history of North Carolina. Wetlands have been under litigation and have resulted in multiple U.S. Supreme Court Decisions over the last 30 years, the most recent being the Sackett decision.

There have been multiple efforts to identify and map wetlands in North Carolina. Table 1 shows a history of the significant wetland identification mapping efforts in North Carolina.

Table 1. Wetland Inventories for North Carolina

Year	Authors	Type of Wetland Mapping Effort
1860	Emmons	Swamplands owned by State of NC, swamplands in NC
1867	NC Literary Board	Swamplands
1883	Kerr	Principle Tracts Claimed by Board of Education
1889	Shaler	Freshwater Morasses
1916	Pratt	Swamp Overflowed Lands
1923	Gray et al.	"Land Mostly Too Rough…"
1949	Wooten and Purcell	Land Feasible to Drain
1956	Shaw and Fredine	20 wetland Types
1962	Wilson	Wetlands in 41 Coastal Counties
1967	Burdick	Marshlands
1968	Spinner	Marshlands
1974	Knight and McClure	Swamps and Bottomlands
1982	USFWS	Yadkin-Pee Dee River Basin
1981	Richardson et al.	Pocosins in 41 Counties
1982	East Carolina University	Atlas Project - Albemarle-Pamlico
1982	National Wetlands Inventory (USFWS)	Statewide - all wetland types
1999	NC Division of Coastal Management	40 Coastal Counties - all wetland types
2024	NCDOT	Jurisdictional Probability Maps – In process

The National Wetland Inventory maps produced by the U.S Fish and Wildlife Service (USFWS) is the only comprehensive statewide mapping effort for North Carolina. The DCM Wetland Type Maps were a significant upgrade in accuracy to the National Wetland Inventory maps but are only located in the 40 coastal counties of North Carolina. In recent years, NCDOT has experimented with using machine learning, LIDAR, and field delineations to produce wetland maps that identify the probability of being jurisdictional under the Clean Water Act. NCDOT's Wetland Predictive Modeling Program/AI Mapping uses ArcGIS data, LiDAR data, NCDWQ Headwater Stream Spatial Datasets, and other supporting spatial data to create high-level wetland maps. NCDOT has run the model statewide but is still reviewing and analyzing the results. This new technology is promising and can potentially improve upon the NWI maps in the Piedmont and Mountains. On the coast, the DCM wetland type data remains the most accurate and comprehensive source of wetland mapping in North Carolina. DCM conducted a thorough accuracy assessment of the DCM wetland type data that concluded 89.74 % of mapped wetlands were jurisdictional. The overall mapping accuracy was 81%. The overall mapping is lower due to the number of wetlands not captured by the DCM's mapping effort (meaning that the DCM data underrepresented actual wetlands in the field). Coastal marshes, freshwater marshes, bottomland hardwoods, swamps, and pocosins were mapped with the greatest accuracy (97% or higher), while headwater forests, hardwood flats, and managed pine wetlands were less accurate (between 65% and 75%). (Sutter & NCDCM, 1999).

Initial Evaluations of Sackett Decision

After the Sackett decision, politicians, natural resource agencies, and environmental organizations across the country began conducting analyses to determine the effects on wetlands jurisdiction. In 2023, The

North Carolina Department of Environmental Quality conducted two analyses using the DCM Wetland Type Data to predict the potential effects of Sackett:

1. Wetland Type Risk Analysis – DEQ identified the wetland types most likely to be affected by Sackett and grouped them into categories of high, moderate, or low risk.
2. Hydrogeomorphic (HGM) Risk Analysis – DEQ identified the risk to wetlands based on their HGM class. Wetlands that are riverine and estuarine are lower risk, headwater system HGM classes are moderate risk, and nonriverine classes are expected to be at higher risk. These risk associations correlate with their relative probability to be jurisdictional under the revised WOTUS definitions post-Sackett.

DEQ's initial analyses showed that between 57 and 64 percent of wetlands were at risk after analyzing both DCM's Used Wetland Type and HGM data. The results of these analyses were similar to other efforts. In 2024, the Environmental Defense Fund concluded that 63 to 66 percent of wetlands were at risk. The Environmental Defense Fund used the National Wetland Inventory data and its Cowardin Classifications to assess probabilistic risk (NCDEQ, 2024). Table 2 shows the total acreage and risk levels for the Used Wetland Type analysis from the DCM data. Table 3 shows the total acreage and risk levels for the HGM analysis from the DCM data. Although each assessment used different approaches, the similar results support the idea that the effects of the Sackett decision are significant.

Table 2: 2023 DEQ Analysis Results using DCM Wetland Types to Assess Risk

Total Acreage	Risk Levels
1,504,530	Low Risk
367,672	Moderate Risk
2,490,397	High Risk
4,362,599	Total

Table 3: 2023 DEQ Analysis Results using DCM HGM Classifications to Assess Risk

Total Acreage	Risk Levels
1,553,782	Low Risk
40,653	Moderate Risk
2,798,345	High Risk
4,392,780	Total

Wetland Protection Trends in the U.S.

The workgroup evaluated the wetland protection trends in the United States, both pre- and post-*Sackett v. EPA*. Only bills deemed applicable to the scope of this report were included. The general consensus is that the *Sackett v. EPA* Supreme Court decision significantly reduced wetland protections under the Clean Water Act. The Sackett case ruled that the Clean Water Act jurisdictional wetlands have a 'continuous surface connection' with a relatively permanent body of water that is, or is connected to, 'traditional interstate navigable waters' (Supreme Court of the United States 2023). Many states had comprehensive wetland protection policies and standards prior to the *Sackett v. EPA* Supreme Court case. According to the Environmental Law Institute, nineteen states have state laws that regulate waters and wetlands (California, Connecticut, Florida, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Oregon, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia, Washington, and Wisconsin). Most of these states utilize wetland permitting programs to facilitate these laws and protections (McElfish 2022). The other 31 states historically have relied on federal laws and regulations to protect wetlands.

Figure 1. Wetland Protection in US.

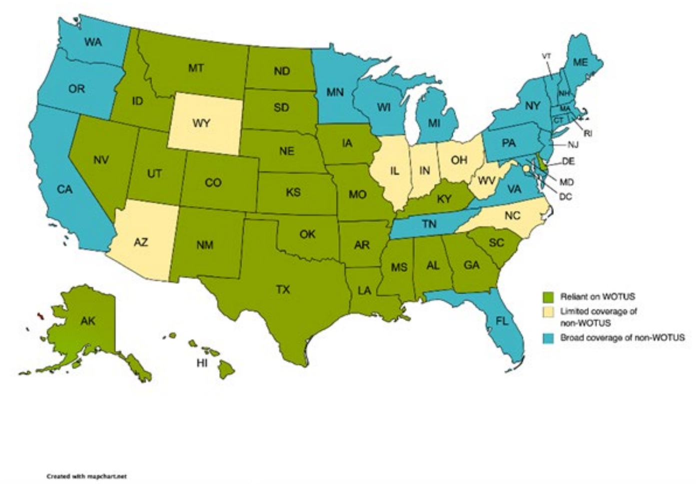


Figure 1 (McElfish 2023) on the left, provided by Environmental Law Institute, depicts the three categories of states according to their state wetland protections. States shaded in green are considered 'reliant on WOTUS,' meaning that, historically, these states have relied on federal laws and regulations to protect wetlands. States shaded in tan are considered to have 'limited coverage of the non-WOTUS,' meaning that, historically, these states have covered some wetlands not protected federally in their own states policies. States shaded in blue are considered to have 'broad coverage of non-WOTUS,' meaning that they do not rely on federal protections for wetlands in their states.

Some states have been rapidly introducing legislation to protect wetlands within their state boundaries since protections were reduced in *Sackett v. EPA*. In the State of Illinois, the Wetlands and Small Streams Protection Act, S 3669/H 3586, is pending. The bill aims to strengthen protections for wetlands (NCSL 2024). Similarly, the Forests Wetlands and Prairies Act (S 2781) has been sent to the Governor of Illinois for signature. This bill aims to develop a grant program for restoration of various ecosystems (NCSL 2024). The State of Indiana enacted S 246 into law and creates new rulemaking for wetland classification requirements (NCSL 2024). Similarly, H 1383, which relates to updated wetland definitions and rulemaking, has been sent to the Governor of Indiana for signature (NCSL 2024). New Mexico is in the process of developing a new wetland permitting program (New Mexico Wetlands Program 2024). Hawaii has adopted SR 192/HR 194, the West Maui Wetlands Bill, to promote collaboration between local, state, and federal government entities to protect wetlands statewide (NCSL 2024). The state of Tennessee adopted S 629, which updates wetland permitting regulations in the state (Tennessee General Assembly, n.d.). The State of Colorado, enacted H 1379 this year. This bill essentially created a state dredge and fill program to regulate wetlands that lost protections in the *Sackett* ruling (NCSL, 2024).

The State of Arizona received a $25 million dollar stipend from the federal government to protect the wetlands in the state (U.S. Department of the Interior, 2024). New Hampshire's H 472 creates wetland permit exemptions after a natural disaster or flooding event, and this bill was sent to the NH Governor in May (NCSL 2024). In the State of New Jersey, NJ A 3106, which would allow municipally managed Blue Acres lands to aid in freshwater wetlands mitigation projects, is pending committee signature (NCSL 2024). In the State of New York, NY S 9379/A 9712 is pending. This bill aims to ban pesticides from being applied in local freshwater wetlands that meet established criteria (NCSL 2024). The State of Vermont enacted VT S 213, which creates new regulations of wetlands, implements a goal of a net gain of wetlands acreage in the state, and requires Vermont Significant Wetlands Inventory maps to be updated and revised annually (NCSL 2024). In the State of Virginia, H 357 is pending committee approval. This bill mandates that the Virginia Department of Environmental Quality (VA DEQ) establish workgroups to develop strategies to protect existing wetlands in the state and other wetland restoration efforts in response to *Sackett v. EPA* and the climate change phenomenon at large (NCSL 2024).

Some states that had previous statewide protections independent of the *Sackett v. EPA* Supreme Court ruling are still working to substantiate their wetland protections and requirements. In the State of California, CA A 828 is pending. This policy adds the requirement of including a Groundwater Sustainability Plan, which includes wetlands and other water systems, onto an existing state law (NCSL 2024). CA A 2875 is also pending. An ambitious policy, A 2875 aims to ensure a no net loss, long-term gain for wetlands in the state at large (NCSL 2024). The State of Massachusetts has S 457/H 906 pending approval of committee. This bill aims to implement more wetland restoration in the state (NCSL 2024). The State of Colorado attempted to pass S 127, a similarly ambitious bill that would have implemented a permitting program for regulating pollutants into water sources and established a wetland protection commission and division (NCSL 2024).

Since *Sackett v. EPA,* some states have introduced bills to protect wetlands at the state level but have failed. Delaware failed to modify their wetlands program in S 290 (NCSL 2024). New Hampshire attempted to enact NH H 1503 to exclude certain areas in the state from the definition of a 'wetland,' but the bill failed (NCSL 2024). In Tennessee, H 1054 attempted to prohibit the TN Department of Environment and Conservation from implementing standards classifying real property as a wetland, unless said wetland is protected under federal law, but this bill also failed (NCSL 2024). TN H 2149 attempted to categorize an ephemeral wet weather conveyance as a non-wetland, also failing (NCSL 2024).

Connecticut also has failed attempts to implement new wetland rulemaking. H 5218 aimed to revise wetland provisions and incorporate a wetland training program (NCSL 2024). The State of Minnesota failed to modify existing wetland rulemaking in S 4876/H 5011, the Wetland Conservation Act, which relates to updated wetland permitting processes (NCSL 2024). MN H 350/S 3559 attempted to modify provisions for wetland management, wetland banking and conservation management, and other rulemaking modifications, but failed (NCSL 2024). MN S 4629/S 4666 attempted to increase funding for a local road wetland replacement program, but the bill also failed (NCSL2024). The State of Florida attempted to disallow counties from implementing their own wetlands protections, but this bill failed. However, Florida passed H 1379, which increased conservation funding for state lands and established greater protections for various ecosystems in the state (Florida Senate, n.d.). The State of Wisconsin failed to pass A 254 regarding a wetland assured delineation program, but WI S 255 was enacted, which aims to prohibit reduction of public wetland access (NCSL 2024). In the State of Mississippi, S 2647 failed in the legislature. This bill aimed to create an advisory board that would ensure habitat protection, water quality, storm protection, and more (Mississippi State Legislature, n.d.).

Table 4. Trackable State Legislative Bills, most of which were obtained from the NCSL Environment and Natural Resource Policy Database, 2023-2024.

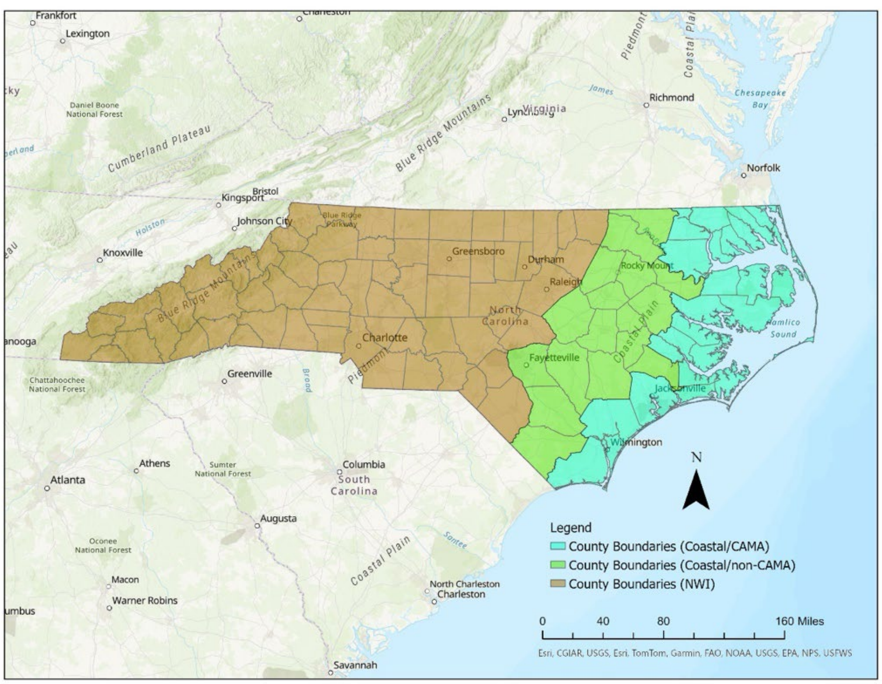
State	Status	Topic/Effect
California	A 828 pending	No net loss, long-term gain for wetlands in the state
California	A 2875 pending	Inclusion of Groundwater Sustainability Plan
Colorado	S 127 failed	Pollutant regulation permitting program, wetland protection commission and division
Colorado	H 1379 enacted	Requires a commission to create a dredge and fill (permitting) program to regulate wetlands.
Connecticut	H 5218 failed	Revise wetland provisions, incorporate wetland training program
Delaware	S 290 failed	Wetland program modification
Florida	S 1240 failed	Disallow counties from implementing their own wetland protections
Florida	H 1379 passed	Increases conservation planning and funding for state lands, establishes greater protections for various basins and river lagoons in the state.
Hawaii	SR 192/HR 194 passed	Local, state, and federal wetland protection collaboration
Illinois	S 3669/H 3586 pending	Strengthen wetland protections
Illinois	S 2781 sent to Governor for signature	Ecosystem restoration grant program
Indiana	S 246 enacted	Wetland classification requirements
Indiana	H 1383 sent to Governor for signature	Wetland definitions and rulemaking
Massachusetts	S 457/H 906 pending	Wetland Restoration
Minnesota	S 4876/H 5011 failed	Modify existing wetland rulemaking and permitting processes
Minnesota	S 3559/H 350 failed	Modify existing wetland management, banking, and conservation management procedures
Minnesota	S 4629/S 4666 failed	Increase funding for local road wetland replacement program
Mississippi	S 2647 failed	Create a Technical Advisory Board to develop an annual comprehensive plan for habitat protection, water quality, and more.
New Hampshire	H 1503 failed	Wetland permit exemptions
New Hampshire	H 472 sent to Governor	Exclude some areas from being classified as a wetland
New Jersey	A 3106 pending signature	City-managed Blue Acres lands aid in freshwater mitigation projects

New York	S 9379/A 9712 pending	Pesticide banning in local freshwater wetlands
Tennessee	H 1054 failed	Prohibit state from implementing real property wetland classification standard
Tennessee	H 2149 failed	Categorize ephemeral wet weather conveyance as a non-wetland
Tennessee	S 629/H 1057 enacted	Updates wetland permitting in the state.
Vermont	S 213 enacted	Wetland regulations, net gain of wetlands acreage, updating/revising of VT Significant Wetlands Inventory Maps
Virginia	H 357 pending	VA DEQ workgroups to develop wetland protection strategies
Wisconsin	A 254 failed	Wetland assured delineation program
Wisconsin	A 255 enacted	Prohibit reduction of public wetland access in state

II. Establishing an Existing Wetland Basemap for North Carolina

The workgroup evaluated the available wetland data for North Carolina. Two datasets stand above the rest: 1) the North Carolina Division of Coastal Management Wetland data sets and 2) the U.S. Fish & Wildlife National Wetland Inventory data sets. The workgroup proposes to combine these two data sets as shown in Figure 2 to establish the basemap from which to apply additional enhancements to improve the accuracy for wetland mapping for North Carolina. Detailed backgrounds and summaries for each of these data sources are summarized below.

Figure 2: Source Data for Basemap (NWI counties and DCM Wetland data (Coastal counties)).



NC Division of Coastal Management Wetlands Mapping Background

In the 1990s, the North Carolina Division of Coastal Management (DCM) developed a five-year strategy (DCM, 1992b) for improving wetlands protection and management in the coastal area using funds provided under the Coastal Zone Enhancement Grants Program established by 1990 amendments to §309 of the federal Coastal Zone Management Act (CZMA). The §309 Program is administered by the Office of Ocean and Coastal Resource Management (OCRM) in the National Oceanographic and Atmospheric Administration (NOAA), U.S. Department of Commerce. Funds provided under this Program were used to establish the wetlands conservation, protection, and mapping initiatives at DCM. The work was also partially funded by a separate grant from the U.S. Environmental Protection Agency (EPA) for a Wetlands Advance Identification project in Carteret County, North Carolina.

The key element of DCM's strategy for improving wetlands protection was the development of a Wetland Conservation Plan for the North Carolina coastal area. The Plan has several components:

- Wetlands Mapping & Inventory
- Functional Assessment of Wetlands
- Wetland Restoration Identification & Prioritization
- Coordination with Wetland Regulatory Agencies
- Potential Coastal Area Wetlands Policies
- Local Land Use Planning

The first step outlined in the Wetland Conservation Plan was to describe the type, location, and extent of the wetland resource, which provides a factual basis for policy and decision-making. To address this, DCM developed an extensive Geographic Information System-based (GIS) wetlands mapping program, which produces GIS wetland data by wetland type for the entire coastal area of North Carolina. Using the GIS coverage, paper maps can be generated for areas within any boundaries available in GIS format.

DCM Wetland Definitions & Identification

In North Carolina there are two laws that define wetlands. Section 404 of the Federal Water Pollution Control Act ("the Clean Water Act") defines wetlands as "areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation adapted to life in saturated soil conditions." The North Carolina Coastal Area Management Act (CAMA) defines "coastal wetlands" as "any salt marsh or other marsh subject to regular or occasional flooding by tides, including wind tides (whether or not the tidal waters reach the marshland areas through natural or artificial water courses), provided this shall not include hurricane or tropical storm tides." Coastal wetlands contain at least one of 10 specified species of marsh plants. The wetlands defined by these two laws, "404 wetlands" and "coastal wetlands," are the only wetlands directly regulated by state or federal agencies in North Carolina.

There are several limitations to relying on only a technical or legal definition in wetland management. Comprehensive wetland maps indicating where "404" or coastal wetlands occur or are likely to occur can be an invaluable tool as guidance for planning and policy-making purposes. While a definition of wetlands is necessary from a regulatory standpoint, a planning tool that shows the location and type of wetlands could improve wetland impact through avoidance and minimization, thus improving the ability to make planning and policy-making decisions. For example, with only a technical definition, a landowner or developer is less able to determine in advance whether wetlands are present in a given area. This makes decision-making and land use planning more difficult and time-consuming because, legally, wetland delineations and determinations require on-site field visits. Wetland delineations include an on-site assessment of wetland criteria present including vegetation, soils, and hydrologic conditions that must meet certain requirements to qualify as a wetland. Wetland delineations or "jurisdictional calls" must be verified and approved by a representative from the U.S. Army Corps of Engineers or, for coastal wetlands, a representative from the NC Division of Coastal Management.

Relying solely on a technical definition effectively limits wetland protection from land use planning where the objective is to guide development into areas best suited for it and away from ill-suited areas. Environmental considerations play a significant role in land use decision-making and are one of the major objectives of the local land use planning mandated by the NC Coastal Area Management Act. Yet, except for areas obviously recognizable as wetlands, a technical definition does not provide local governments with the information needed to guide development away from ecologically important wetlands.

DCM's Wetland Mapping

The chief value of broad scale wetland mapping is to provide guidance for planning and policy-making purposes. The limitations of remotely sensed wetland maps from a regulatory perspective, however, do not lessen their value for the other purposes discussed above. Whether the plans are for development projects or general land use management, knowing in advance where wetlands are likely to exist with a high degree of confidence can be of great value. As users realize that, for regulatory purposes, on-site wetland delineation is still required, wetland maps based on remotely sensed data are a useful planning tool. Having at least a close approximation of the extent and location of wetlands in various categories will provide a sound basis for wetland policy decisions. These planning and policy-making applications form the context of DCM's wetland mapping as a component of the Wetland Conservation Plan.

In application, however, the question of the relationship of mapped wetlands to jurisdictional wetlands under the §404 Program remains significant. If the primary interest in avoiding wetland impacts is to avoid the difficulties and limitations of the wetlands regulatory program, then this is a very pertinent question. DCM conducted an accuracy assessment to provide users with the various accuracies of this product. As described in the rest of this report, DCM's wetland mapping was based on an analysis of overlays of several data sets that indicate the likely presence or absence of wetland characteristics on a given site. It is highly probable that any area identified as a wetland by DCM will be functioning as a wetland and that portions or all of the area will, indeed, be a jurisdictional wetland as defined in the 1987 *Corps of Engineers Wetland Delineation Manual* (Environmental Laboratory, 1987).

A general difficulty of relating mapped wetlands to jurisdictional boundaries is that jurisdictional boundaries are the result of political decisions and are subject to change. In the past 30 years, the generic wetland definition upon which boundary delineation is based has changed at numerous times. For example, the boundaries changed with the introduction of the 1987 Manual (Environmental Laboratory, 1987); again, when the 1989 Manual (Federal Interagency Committee for Wetland Delineation, 1989) was introduced; and still again with the return to the 1987 Manual. The boundaries have also changed with each major U.S. Supreme Court Case (e.g., Rapanos, Tulloch, Sackett). Each time the jurisdictional boundaries have changed. Continuing controversy over wetlands regulation make additional changes in the definition of jurisdictional wetlands, and thus the boundary, probable.

It is important to recognize that the wetland to upland transition is often a broad continuum and that placement of a delineated wetland boundary is subjective to some extent. Impacts to areas immediately adjacent to wetlands often have direct impact on the wetland's ability to function. In the final analysis, however, a specific boundary line somewhere along the continuum between dry land and open water is arbitrary (Mitsch and Gosselink, 1986). A regulatory program that must decide on a daily basis whether a given spot is within or beyond its jurisdiction must incorporate such an arbitrary line and specify as precisely as possible how it is to be located in the field. How closely this line relates to the presence or absence of wetland functions depends upon many factors and varies from site to site.

DCM's wetland mapping objective was to identify areas greater than one acre in size that are highly likely to display specific wetland characteristics and to perform wetland functions. Areas smaller than one acre could not be reliably identified with the remotely sensed data and interpretation techniques used. If the objective of wetland management is to protect wetland functionality, then the DCM wetland mapped areas should be considered worthy of protection. How stringently they will be protected under the §404 or other regulatory programs is a separate, political decision.

DCM's Method of Overlay Analysis

When developing methods for mapping, DCM quickly realized that the 9000+ square mile coastal area was too large for any exhaustive field mapping effort. To efficiently map the coastal area, DCM found it necessary to use existing data compatible with Geographic Information Systems (GIS). A review of the existing data revealed that most are not applicable for one of two reasons: (1) available wetlands data are based on older photography or (2) more recent data are not classified with the intent of wetlands identification. Both of these data types, used independently, are inappropriate for use in a coastal area wetlands conservation plan. In addition, the classification schemes used in the existing methods are either too complex or not focused on wetlands. The primary data layers selected for use were the US Fish & Wildlife National Wetlands Inventory (NWI), the County Soil Surveys, and 30-meter Thematic Mapper (TM) Satellite Imagery.

The NWI was selected because its primary purpose was to map wetlands. Unfortunately, these maps were created with photography from the early 1980s in coastal North Carolina, and many changes have occurred in the landscape. In North Carolina, NWI also omitted many pine-dominated wetland areas. It also tended to exaggerate the boundary of linear wetlands (based on field data collected at random sites with representatives from USFWS, NC Division of Soil and Water Conservation and DCM). DCM wished to improve upon the NWI, and in particular include pine-dominated wetlands, as these areas are important to the ecology of the coastal area.

Detailed soils information from the county soil surveys were also selected for use in DCM's mapping efforts. While soils alone should not be used to identify wetlands, they can be very useful in identifying marginal areas. They are also extremely useful in helping to define the type of wetland one should expect to find in an area. Pocosins, for example, would only be expected to occur on a limited range of organic and certain sandy soil types.

DCM employed Thematic Mapper (TM) Satellite Imagery in the development of a mapping methodology as well. DCM used imagery that had been classified in the late 1980s in much of coastal North Carolina to support the Albemarle-Pamlico Estuarine Study, a National Estuary Program, to identify developed areas, pine monocultures and other habitat types. Because this data layer was not developed as a wetlands inventory, many of the classes were not directly applicable to DCM's approach. However, the imagery was more recent than that from the soil surveys and NWI, and it provided additional habitat data not available in either of the other sources.

DCM chose to incorporate the benefits of each of these data sources into its mapping techniques.

DCM's Wetland Classification

When the wetland mapping project began in the early 1990s, the North Carolina Natural Heritage Program had developed a very detailed classification system of all natural areas in the state. These breakdowns were based on vegetative composition and assumed complete homogeneity at all sites (Schafale and Weakley, 1990). Although the Natural Heritage Program's classification system is very thorough, DCM chose not to use their classification system for two reasons. First, DCM's mapping approach uses remotely sensed data which cannot provide the level of detail necessary to accurately support the Natural Heritage classification system. Second, the Natural Heritage classification system uses numerous habitat types that would result in complex maps. A product of this type would require users to have a strong technical understanding of the classification system, thus limiting the use of the maps to only those with appropriate technical training.

At the same time DCM was developing a wetlands classification scheme, the NC Division of Water Quality (then the Division of Environmental Management and currently the Division of Water Resources) also was developing a comprehensive classification for wetlands statewide. Obviously, a statewide program would encounter wetland types elsewhere that would not apply to the coastal region. DCM staff worked with staff from all of these agencies to develop a classification scheme that met the needs of its clients without introducing conflict into the existing classification schemes.

Each wetland polygon was assigned to one of DCM's classes based on all the attributes it contains from input data sources. Classification of the Cowardin types into DCM wetland types has been reviewed by personnel from the National Wetlands Inventory and the NC Department of Environment and Natural Resources (now Department of Environmental Quality) Division of Soil and Water Conservation (DSWC). Further soils breakdown was reviewed by certified soil scientists at DCM and the DSWC. The classes currently recognized by DCM are salt/brackish marsh, estuarine shrub scrub, estuarine forest, maritime forest, pocosin, bottomland hardwood or riverine swamp forest, depressional swamp forest, headwater swamp, hardwood flat, pine flat and managed pineland. Polygons that do not have criteria designating them as wetlands were considered non-wetlands. On the maps, cleared and or cutover areas were classified, but were not considered wetlands based on DCM's classifications.

The hydrogeomorphology of a wetland is unique in defining the wetland's function (see Brinson 1993). Because these data serve as the base for additional wetland projects, an accurate determination of this characteristic is essential. Immediately following the overlay procedure, technicians add a new item (HGM) to the wetland coverage. DCM uses three hydrogeomorphic (HGM) classifications to describe wetlands in the North Carolina coastal plain. The three HGM classes of wetlands are riverine, headwater and flat/depressional. Because DCM considers both vegetation and landscape position in its classification (discussed later), riverine, headwater and flat/depressional wetland polygons are assigned an HGM class of 'r', 'h' or 'f', respectively. Digital line graphs of hydrography are relied upon in this step of the procedure. All wetlands that are adjacent to streams or rivers are considered to be in the riverine HGM class and are designated as riverine polygons. This class should include all bottomland hardwood swamps and some swamp forests. It rarely includes any of the interfluvial wetland types. On the occasion that it does, it is a small section of a large flat from which a small stream emerges. Only the polygons adjacent to the stream are considered riverine. Headwaters are defined as linear areas adjacent to riverine areas that do not have a stream designated on the hydrography data layer. Since these are unique systems that form the transition between flatwoods and riverine wetlands, they are treated specially. Finally, polygons that exist on interfluvial divides are designated as flat/depressional wetlands. No wetlands along streams should be found in this class, unless field verification showed otherwise.

DCM Field Verification

As methods were being developed, field verification was ongoing to ensure that the classification system reflected reality. DCM visited approximately 400 wetlands in and around Carteret County. The Division randomly selected sites within a stratification of watersheds (14-digit hydrologic units). Within each watershed, DCM classified sites based on landscape position, vegetative cover, and soil and hydrologic characteristics. Ongoing field verification also allowed staff the opportunity to adequately assess the classification assigned by NWI. If a particular Cowardin class was found to be systematically misidentified, the algorithm for automation was updated. While this method does not provide for a usable accuracy assessment, it allowed the most accurate methods to be developed. None of the data collected for this purpose were applied to the final accuracy assessment.

A concurrent accuracy assessment was made possible by a grant from the EPA. The assessment provides details about the likelihood of finding a wetland where DCM indicates one should exist as well as an indication of how likely a user is to find the mapped wetland type in that location.

DCM Final Mapping

DCM mapped more than 2.8 million acres (1,150,000 ha) of wetlands within the 20 coastal counties (Table 5) and more than 1.5 million acres (600,000 hectares) in the 20 Inner Coastal Plain counties. Salt/Brackish marshes, which do enjoy additional state protection under the state Coastal Area Management Act and the Dredge and Fill Act, are only 8% of the wetlands that fall within the jurisdictional area of the North Carolina Coastal Management Program.

To better understand the accuracy of these data, DCM obtained a grant from the EPA. Based on a sample size of at least 50 sites per wetland type (selected in a stratified random sample), data indicate that the overall probability of a mapped wetland being jurisdictional was 89%. This means that if an area is shown as a wetland in DCM data, there is only an 11% possibility that it is not actually a wetland. Conversely, upland areas identified on the map had a 73% probability of actually being an upland. In other words, any upland area on a DCM map has a 27% chance of containing a wetland (Shull III 1999).

It should be noted that not all jurisdictional wetlands were captured in DCM's mapping process. DCM was more successful identifying some classes than others. This is expected because the natural system is a continuum from one community, ecosystem and landscape to another. Placing a wetland area into one of several classes means that there will be cases where there is not a clear fit. The DCM Wetland Type maps are, therefore, more accurate for some community types than for others. For example, as one might expect, there was some difficulty distinguishing headwater swamps from riverine swamp/bottomland hardwood wetlands because these habitat types often grade into one another. Determining a precise boundary between them can be difficult even in the field.

DCM’s GIS wetland data can be viewed on DCM’s online map viewer or downloaded by county on the Division’s website. These data and maps are not designed to replace an on-site jurisdictional evaluation of any wetland. They are intended to be used in a planning context and to help understand the environment in which we live.

National Wetlands Inventory Background

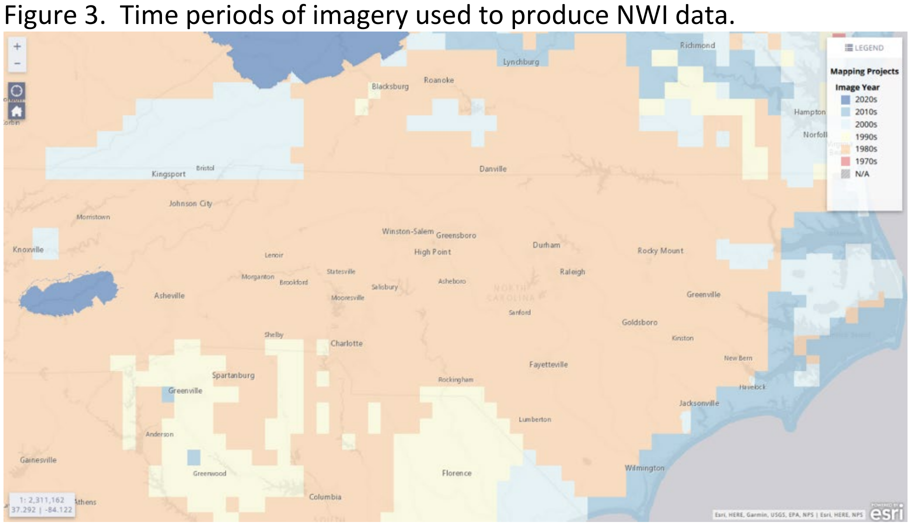
The National Wetlands Inventory (NWI) dataset, first published in 1988, is a national dataset created in response to the Emergency Wetlands Resources Act of 1986 and is maintained by the U.S. Fish and Wildlife Service (FWS). This dataset was developed to support the protection, restoration, and management of wetland resources by providing detailed spatial and thematic information to biologists. The NWI is the wetlands layer for the National Spatial Data Infrastructure (NSDI), and the FWS is the principal federal agency charged with maintaining geospatial wetland data. NWI data conforms to standards set forth by the Federal Geographic Data Committee (FGDC) [Wetlands Mapping Standard](https://www.fgdc.gov).

The NWI dataset categorizes wetlands into several types based on their hydrological, ecological, and vegetative characteristics, and follows the classification standard set forth by the FGDC in the [Classification of Wetlands and Deepwater Habitats of the United States.](https://www.fgdc.gov) The FGDC wetland classification system is based on Cowardin et al. (1979) and employs a system, subsystem, class model. It is important to note that NWI data is not intended to be used to support legal, regulatory, or jurisdictional analysis of wetlands and deepwater habitats, as the scale of the data and methods used to produce the data are insufficient for such applications.

Historically, the NWI dataset covers wetlands of at least 1 acre in size, but 2009 standards specify a target mapping unit of 0.5 acre using 1 meter or better resolution imagery. NWI data across North Carolina varies, with most of the wetland data reflecting imagery from the 1980's. Figure 2 illustrates the time period for the images used to create NWI data. Data production reflects standards in place at the time it was produced, so much of North Carolina's wetland data was produced using lower quality base data and likely had a target mapping unit of greater than 0.5 acres. The NWI is the only spatial data layer that provides statewide coverage in North Carolina, so despite its age and limitations, it serves an important need for statewide analysis.

Updates to the NWI dataset are carried out periodically to reflect changes in wetlands over time due to natural processes or human activities. This ongoing maintenance ensures that the data remains relevant and useful for tracking wetland trends, assessing the impacts of development, and guiding restoration projects. At present, there are no active or recent updates to North Carolina NWI data.

Figure 3. Time periods of imagery used to produce NWI data.



https://fwsprimary.wim.usgs.gov/wetland-projects-v2/

III. Limitations of Existing Data and Landcover Overlay Analyses

National Wetland Inventory Accuracy

Analysis of National Wetland Inventory data across the state indicates high errors of omission (70 to 92%) for smaller wetlands (<1.0 ac), which particularly affects areas of the state where smaller wetlands are common, such as the Piedmont and Mountain ecoregions (Gale 2021a).

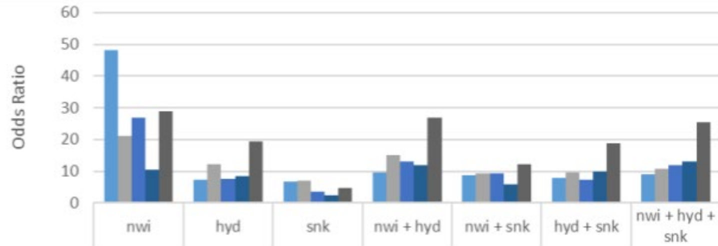
DEQ has conducted two major landcover overlay analyses that evaluate wetland map accuracies. The Division of Water Resources evaluated National Wetland Inventory data and the subsequent accuracy results of overlay analysis. Specifically, DWR assessed the accuracy of using the NWI as a base layer overlaid with hydric soils and/or statewide digital elevation model (DEM) terrain derivatives (hydrologic sinks) Table 5. DWR applied this method in four major ecoregions covering the entire state of North Carolina (Blue Ridge, Piedmont, Southeastern Plains, Middle Atlantic Coastal Plain). Deep water, open water, and lotic systems were removed from the NWI layer prior to overlay.

Table 5. Descriptions of the different overlay models tested. From Gale 2021b.

Model	NWI	Hydric soils	Sink	Wetland indicator
nwi	X			NWI wetland feature present
hyd		X		Soil mapping unit >25% hydric soil components by area
snk			X	Hydrologic sink present
nwi + hyd	X	X		NWI wetland **or** hydric soil presence
nwi + snk	X		X	NWI wetland **or** hydrologic sink presence
hyd + snk		X	X	Hydric soil **or** hydrologic sink presence
nwi + hyd + snk	X	X	X	NWI wetland **or** hydric soil **or** hydrologic sink presence

Overlaying the additional layers of hydric soil and/or hydrologic sinks did not improve the accuracy of NWI alone (Figure 4). Nearly all of the overlay models showed low overall accuracy for the majority of ecoregions and statewide. The odds ratio reflects accuracy of correctly identifying both wetlands and non-wetlands; higher ratios are desirable. A manual review of spatial data for the unexpectedly high odds ratio in the Blue Ridge suggested that NWI captured the largest wetlands in this area and missed the majority of the smaller wetlands (NCDWR 2021). The "nwi" model may also reflect a higher rate of correct identification of non-wetlands, since the odds ratio reflects the accuracy of all classifications. The higher rate of correct identification of non-wetlands may have contributed to the high odds ratio in the Blue Ridge ecoregion. Overall, the "nwi" model had higher odds ratios for individual ecoregions than most of the other models, though the "nwi" model varied widely across ecoregions, suggesting it may have inconsistent reliability statewide. The hydrologic sinks ("snk") provided the lowest overall performance based on odds-ratios, particularly in the eastern portions of the state (Southeastern Plains and Middle Atlantic Coastal Plain). The addition of other model variables to "nwi" did not lead to an increase in the odds ratio for any of the combined models ("nwi + hyd", "nwi + snk", "nwi + hyd + snk").

Figure 4. Odds ratios for overlay models by ecoregion and statewide. From Gale 2021b



	nwi	hyd	snk	nwi + hyd	nwi + snk	hyd + snk	nwi + hyd + snk
Blue Ridge	48	7	7	10	9	8	9
Piedmont	21	12	7	15	9	9	11
Southeastern Plains	27	7	3	13	9	7	12
Middle Atlantic Coastal Plain	10	8	3	12	6	10	13
Statewide	29	19	5	27	12	19	25

Summary of DCM's overlay method and resulting accuracy

DCM used an overlay method applied to the 20 coastal counties; the Division used NWI as the base layer, overlaid with soils and satellite (Landsat) imagery data (Shull III 1999). The presence of hydric soils was required to classify pocosins, hardwood flats, and pine flats as wetlands. DCM used Landsat imagery to detect evergreen vegetation and cleared or otherwise altered wetlands. DCM also used hydrography layer to identify streams and other features.

When compared to field data, the overall accuracy was 81%. Errors of inclusion and exclusion were both generally low (<25%) in determinations of wetland location as well as upland location, however the errors of exclusion were higher than errors of inclusion. Most of these wetlands were small (<1 acre, which were excluded from NWI dataset) or drier-type wetlands. Minimum mapping unit for soils was 1 acre. Accuracy rates were higher for marshes than for woody wetlands. The accuracy of mapped wetlands was 89%. It is important to note that *"DCM's maps are an underestimation of wetlands in the 20 coastal counties under CAMA, and many wetland types are confused."* (Shull III 1999).

IV. Proposed Methodology for Updating NC Wetland Maps

The workgroup determined that the best available wetland mapping currently available is DCM maps for the 40 coastal counties, followed by NCDOT wetland location probability models, followed by National Wetland Inventory data, which is also used as a basis for wetland locations and types in C-CAP landcover mapping. A proposed methodology for generating the most accurate/updated wetland map for the state is as follows:

1. 40 Coastal North Carolina Counties
    a. Start with DCM wetland maps for the 40 coastal counties. Use new C-CAP landcover mapping (canopy/impervious/water) to identify areas of existing DCM wetlands that have been converted to other land cover types. Note: A 2025/2026 initiative will result in C-CAP mapping of high and low marsh areas, and the workgroup recommends that this data may be evaluated as a possible update and/or replacement of the coastal marsh features in DCM wetland maps.
2. Remainder of North Carolina

a. Utilize the NWI data as the base layer for all areas where DCM data is not available. Utilize the new C-CAP canopy/impervious/water data to identify areas of wetland conversion to other land cover types. However, the workgroup recommends that the new 1-meter resolution C-CAP detailed land cover data be used when it becomes available. North Carolina is currently in the process of obtaining the new C-CAP data, and it is expected to be available in 2025.
b. Alternate Method: NCDOT has developed an innovative wetland mapping approach that uses machine learning, artificial intelligence, elevation models, jurisdictional field data and other variables to map wetland location probability. NCDOT has found that these new probability models have much higher accuracy results than historical NWI data, especially in the mountain regions. The workgroup believes the NCDOT machine learning wetland probability models (where available and vetted) are likely to be more accurate than the updated NWI/C-CAP maps and could be used to map the presence and absence of wetlands in the Piedmont and Mountain ecoregions. NCDOT wetland mapping could also be used to identify wetlands not on DCM wetland maps, especially smaller wetlands. [Note: utilizing NCDOT wetland mapping models may take a long time (years) unless funding is made available to NCDOT. As of July 2024, NCDOT has created wetland location probability models for 75 counties and is working to verify the models in 20 to 25 counties. Location prediction is based on detailed elevation data and slope locations to create a flow analysis. Models have also been trained with field wetland delineations. An accuracy assessment in a 28-mile corridor in Kinston, NC showed the model correctly predicted the location of wetland areas 86 to 87% of the time. The wetland location probability maps will be published on NCDOT's ATLAS *webservice.*]

The workgroup recommends the NOAA's C-CAP data layers and land cover classes be utilized to identify areas where wetlands from the base map (the combined DCM wetland data and NWI data with NCDOT supplements) have been converted or altered:

REMOVE from wetland base map where the following C-CAP categories overlap with wetlands:

- Developed, High intensity - DCM mapping considered this as "cleared wetland" if NWI showed wetland
- Developed, Medium intensity - DCM mapping considered this as "cleared wetland" if NWI showed wetland
- Developed, Low intensity - DCM mapping considered this as "cleared wetland" if NWI showed wetland
- Developed, Open space
- Ag. Land, Cultivated - DCM mapping considered this as "cleared wetland" if NWI showed wetland
- Open Water
- Bare Land
- Unconsolidated Shore - DCM mapping identified these as open water (non-wetland)

CLASSIFY on wetland base map the following C-CAP categories as "cleared" and "cutover" (these are unlikely to still be wetlands):

- Ag. Land, Pasture/Hay - DCM mapping considered this as "cleared wetland" if NWI showed as wetland.
- Grassland/Herbaceous - DCM mapping considered this as "cleared wetland" if NWI showed as wetlands.

RETAIN wetlands with the following C-CAP categories. These are areas remain probable wetlands:

- Deciduous Forest
- Evergreen Forest – would include managed pinelands that are wetlands
- Mixed Forest
- Scrub/Shrub
- Palustrine Forested Wetland
- Palustrine Scrub/Shrub Wetland
- Palustrine Emergent Wetland
- Estuarine Forested Wetland
- Estuarine Scrub/Shrub Wetland
- Estuarine Emergent Wetland
- Palustrine Aquatic Bed
- Estuarine Aquatic Bed

A Note on a Machine Learning Method Tested by DWR

Maximum entropy (MaxEnt) is a machine learning method often used in data science and artificial intelligence that automates complex statistical model building. One significant advantage of the MaxEnt approach is that it only requires presence data for model training, whereas almost all other modeling approaches require absence data as well.

Gale (2021b) ran two models using the MaxEnt procedure. Gale ran an initial complete model with input from 22 different statewide variables, which soil attributes (5), terrain derivatives (11), climate (3), vegetation (2), and NWI. Gale then ran a second model ("minimal model") after removal of covarying variables and variables with too many missing values. The final minimal model included hydric soils, vegetation community type, minimum temperature (30-year average; proxy for precipitation), elevation, sink depth, slope, topographic position index, and plan curvature (curvature perpendicular to slope), with the majority of the contributions to the model coming from the first five variables. Gale ran both models in a focus area, the Northern Outer Piedmont ecoregion, because of limitations on time resources available. *Gale (2021a and 2021b) found that both MaxEnt models resulted in very large increases in Producer's Accuracy relative to NWI, suggesting that the MaxEnt models were capturing many more true wetlands in the landscape. General accuracy of all classifications by the minimal model were greater than NWI accuracy in all size classes.*

Results showed that MaxEnt models as well as NWI showed inverse trends depending on the wetland size class, with under-prediction more prevalent in smaller features and over-prediction more prevalent in larger features. Both MaxEnt models, however, outperformed NWI in identifying smaller wetland features (<0.5 ac) based on both Producer's Accuracy and User's Accuracy.

Generating this model for the entire state (especially the Piedmont and Mountains) and verifying its accuracy would require funding and time, but results are promising and should be considered in future wetland mapping updates.

IVB. Alternative Method for Updating NC Wetland Maps

An alternative method for updating NC wetland maps is to contract with the U.S. Fish & Wildlife Service (USFWS) to update the National Wetland Inventory (NWI) for North Carolina. The current NWI maps in North Carolina are mostly based on based on a 1:58,000 scale color infrared photography from the 1980s. USFWS current methodologies follows the FGDC Wetland Mapping Standard, which creates minimum requirements for metadata, projection, spatial resolution of imagery, omission errors, horizontal accuracy with a 95% confidence level of 5-meters for wetlands and 15-meters for estuarine and deepwater habitats, and feature and attribute accuracy. The targeted mapping unit (TMU) has been enhanced from 1.0 acres to 0.5 acres. Current USFWS methods capture wetland features larger than 0.5 acres and 1 acre of estuarine and lacustrine habitats. Narrow features with discernible interior area are visible at 1:12,000. Features as small as 0.01 acres will be accepted into the dataset. Overall, the improved accuracy using new NWI standards would result in a significant improvement in wetland mapping for the piedmont and mountain regions of North Carolina. An updated NWI data set could also be utilized to update or augment the DCM wetland mapping in the coastal plain.

USFWS also produces an NWI+ dataset. The NWI+ dataset is not a standard product of NWI and are only created as a special product when external users or partners provide the funding. The goal of NWI+ was to integrate the concept of HGM classifications into the NWI mapping dataset (similar to how DCM integrated HGM into the DCM wetland type datasets.) The value of these enhancements would allow the user to better predict wetland functions at the landscape level. In the NWI+ dataset, descriptors for landscape position, landform, water flow path, and waterbody type are added to the NWI dataset (a.k.a., "LLWW Descriptors"). These enhancements would more accurately evaluate the potential effect of the USSC Sackett decision. The NWI+ LLWW data can also be used to assess carbon sequestration, bank and shoreline stabilization, streamflow maintenance, sediment and other particulate retention, and surface water detention.

Five landscape positions for wetlands are recognized: marine (ocean intertidal shores), estuarine (estuarine intertidal shores), lentic (lake or reservoir shores), lotic (river, stream shores, floodplains), and terrene (isolated or not subject to overflow). Landforms include basins, flats, floodplains, fringes, and slopes. Several water flow paths can be defined: inflow, outflow, throughflow, bidirectional-tidal, bidirectional-nontidal, and isolated (geographically) (Cowardin et al. 2023). These resources can be valuable in protecting wetlands due to wetlands' flood storage and flood resiliency functions.

The wetlands workgroup highly recommends that North Carolina funds the development of updated NWI+ data sets for the state. The estimated cost to conduct this work is 0.12 cents per acre. North Carolina currently has 34.4 million acres of land. The total cost of the project would be around $4.1 million for USFWS to create the state's map.

V. Approaches to Determining the Effect of Sackett v. EPA on Protection of North Carolina Wetlands

Purpose

The Supreme Court's decision in Sackett vs. EPA notes that the Clean Water Act refers only to streams, oceans, rivers, and lakes and to "adjacent wetlands that are 'indistinguishable' from those bodies of water due to a continuous surface connection." They require that a jurisdictional wetland "has a continuous surface connection with that water, making it difficult to determine where the 'water' ends, and the 'wetland' begins." The workgroup identified three separate approaches that can be used to estimate the probability that the wetland may be negatively affected by the Sackett decision.

Approach I. Wetland Type

Wetland types differ based on water source, geomorphology, soil, vegetation, landscape position, and numerous other environmental factors. The water source can be precipitation, groundwater, or surface flow, which is especially important for this analysis. Below Table 6 categorizes wetlands into low risk, moderate risk, and high risk. Wetlands labeled as high risk do not have predominant surface flow inputs and can be geographically isolated. They are seasonally saturated, therefore dry for part of the year, and occur in generally flat or nearly flat areas. Descriptions of the individual wetland types can be found here.

DCM wetland data published in the late 1990s/early 2000s represents forty coastal counties that contain 85% of all of NC's wetlands. The wetland data was derived from 1:24,000 scale National Wetlands Inventory data, 1:24,000 scale county detailed soils data, and Landsat Thematic Mapper 30-meter resolution satellite imagery. This is the only dataset for North Carolina wetlands that provides wetland type information. To assess the risk to wetlands, the sum of acreage for each wetland type can be calculated using ArcGIS Pro software. Those sums can then be added up based upon the table below to understand the number of acres at high risk, moderate risk, or low risk due to the Sacketts Appeal.

Table 6: Risk effects by wetland type.

Metric	Low Risk	Moderate Risk	High Risk
Wetland Type	Salt/Brackish Marsh Estuarine Shrub Scrub Estuarine Forest Bottomland Hardwood Riverine Swamp Forest	Headwater Swamp Freshwater Marsh Depressional Swamp Forest	Hardwood Flat Pine Flat Pocosin Managed Pineland Human Impacted Area Maritime Swamp Forest

Approach II. Hydrogeomorphic Classification

Similar to the wetland type approach, the same dataset mentioned above includes data on each wetland's hydrogeomorphic classification: Estuarine, Riverine, Headwater, or Flat/Depressional. Vegetation, landscape position, and hydrology are used to identify these classifications. Riverine classified wetlands are wetlands that are adjacent to perennial streams and rivers, estuarine wetlands are found near estuaries/sounds, headwater wetlands are found at the uppermost reaches of watersheds, and lastly, flat/depressional wetlands generally are not hydrologically connected to surface water, are geographically isolated, and their water input comes from primarily precipitation, runoff, and groundwater.

To assess the risk of wetlands to the Sacketts Appeal, the sum of acreage for each hydrogeomorphic classification can be calculated using ArcGIS Pro. The acreage result of each risk category can then be compared to the results of Approach I.

Table 7: Risk effects by HGM classification.

Metric	Low Risk	Moderate Risk	High Risk
HGM Classification	Estuarine (e) Riverine (r)	Headwater (h)	Flat/depressional (f)

<u>Approach lll. Hydrological Connectivity</u>

The Supreme Court's decision in Sackett vs. EPA notes that the Clean Water Act refers only to streams, oceans, rivers, and lakes and to "adjacent wetlands that are 'indistinguishable' from those bodies of water due to a continuous surface connection". They require that a jurisdictional wetland "has a continuous surface connection with that water, making it difficult to determine where the 'water' ends, and the 'wetland' begins." Therefore, analysis of hydrologic connections of streams to existing wetlands is needed.

<u>Mapped streamflow duration</u>

- NC NCDOT's Hydro-ATLAS has the most up-to-date maps of perennial and intermittent streams, but these two stream types may be combined into "perennial/intermittent".

- NHDPlus HR (high resolution) (2018 latest version) has NHD Flowlines coded as Perennial or Intermittent (and others like ditch, connector, pipeline, artificial path, etc.). The end of the "perennial" segment may be used to differentiate between perennial and intermittent in the ATLAS layer, if there is no differentiation in the ATLAS information.

<u>Ponds/Waterbodies</u>

ATLAS is missing approximately 70% of the ponds that NHD has due to a difference in minimum collection size (2 acres for ATLAS vs 0.25 acre for NHD). NHD is recommended for including ponds and smaller waterbodies. However, for future plans, note that NC Hydro-ATLAS is currently the best NC specific data, but it will be evolving into "NC Hydro", which will have the ponds to a minimum size of 0.25 acre and also double line streams added into it.

<u>Proposed Methodology</u>

There could be different outcomes depending on how regulators apply the Sackett decision. In determining which wetland features would be included in the federal jurisdiction definition, several different scenarios should be considered. Hydrologic (stream/river) features would be considered connected/touching if the wetland boundary is within 100 feet. This considers the fact that NWI polygon boundaries have a 40-foot error in any direction plus additional spatial error in remote mapping of hydrologic features. The hydro lines represent the approximate center of a given stream, and those stream widths can be up to 50 feet (or 100 feet total). NHD specifications capture large rivers as waterbodies, with a minimum of 50-foot width to be displayed as a waterbody instead of a line. ATLAS has a minimum of 100 feet width for a feature to be captured as a waterbody. A 100-foot buffer on a wetland feature is expected to capture the margin of error on both the stream and wetland side.
Wetland polygons of different wetland types would be merged for the purposes of this assessment; wetlands of different types adjacent to each other would be considered one larger wetland.
Scenarios:

- Type of stream:
  - Include wetland if it connects to intermittent or perennial stream

    - Include wetlands if it connects to perennial stream only
- Floodplain criterion:
    - Include wetland if it is within 50-year floodplain mapped area
    - Include wetland if it is within 100-year floodplain mapped area
- Ditches (Ditches may or may not be considered a surface connection.):
    - Include wetland if it connects to WOTUS with a ditch
    - Exclude wetland that connect to WOTUS with a ditch

Alternate Hydrological Connection Method

The Environmental Defense Fund completed a study of potential Sackett effects using NWI Cowardin classifications and stream connectivity to estimate jurisdictional risk. They used 3 models combining NWI classifications to (updated with developed lands from NCLD removed from NWI) and NHDPlus HR for streams and waterbodies:

- Perennial streams
- Perennial streams + intermittent
- Perennial streams + intermittent + canals/ditches

DEQ's and EDF's preliminary analyses had similar results (50 to 70% wetland area not federally protected after Sackett, and up to 90% depending on how federal regulators interpret and apply the phrase from Sackett, "indistinguishable from Waters of the U.S.").

VI. Estimated Resources Needed

Estimated Resources Needed for Updating NC Wetland Maps

The estimated resources needed to facilitate the methodology detailed in Section IV (DCM) include:

- 2 Full Time Employee (FTE) GIS Specialist I for 1 year if performed in-house
- Estimated $400,000 if contracted out (the actual amount will vary based on the contractor.
- Recommended: A pilot project can provide more accurate estimates of personnel and processing time requirements.

Alternative Method for Updating NC Wetland Maps (NWI Updated Statewide)

The estimated cost to conduct this work is 0.12 cents per acre. North Carolina currently has 34.4 million acres of land. The total cost of the project would include

- $4.1 million for USFWS to create the state's updated NWI map. Estimated time to complete 2.5 years.
- Additional resources necessary to complete would include:
- 1/2 FTE for 2.5 years as project manager at GIS specialist (II) level or above

Approaches to Determining the Effect of Sackett v EPA on Protection of North Carolina Wetlands

- Assuming the NC Wetland Maps have been updated, the time and effort to complete the three Sackett Analyses are modest:
    - Wetland Type Assessment – 14 Days FTE GIS specialist (II) level or above
    - HGM Assessment – 14 Days FTE GIS specialist (II) level or above
    - Hydrological Connectivity – 90 days FTE GIS specialist (II) level or above
- If substantive mapping enhancements are needed or included in the Sackett Analyses, the timeline is much longer. For reference, these are the CGIA estimates to Facilitate the Statewide Additions of CGIA and HWG Recommendations to the NCDOT ATLAS Hydrography Dataset.
    - Waterbody additions
        - Capture small waterbodies (1D and 2D) - 1,700 person days of ATLAS Hydrography Team
        - Addition of 2D stream/river polygons. - 272 person-days of effort and processing
    - Feature attributes and connectivity 272 person-days of effort and processing
    - Z-enabled features – 314 person-days of effort and processing
    - Water Boundary Dataset 156 person-days of effort and processing
    - Polyline Issues - 5 person-days annually

Literature Cited

Brinson, M.M. 1993. A Hydrogeomorphic Classification for Wetlands. Wetlands Research Program Technical Report WRP-DE-3, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service Report. FWS/OSB-79/31. 131 p.

Cowardin, L. M., Carter, V., Golet, F. C., LaRoe, E. T., U.S. Fish and Wildlife Service, Brinson, M. M., & Tiner, R. W. (2023). Wetland classification systems for mapping. In *A Fact Sheet for Tribal Wetland Programs* [Report].
https://www.nawm.org/pdf_lib/tribal_wp/fact_sheet_wetland_classification_systems_for_mapping.pdf
Environmental Laboratory. 1987. Corps of Engineers Wetland Delineation Manual. Technical Report Y-87-1. U.S. Army Engineers Waterways Experiment Station. Vicksburg, MS.

Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. Cooperative Technical Publication. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service. Washington, DC.

Florida Senate. (n.d.). *CS/CS/HB 1379: Environmental Protection*.
https://flsenate.gov/Session/Bill/2023/1379

Gale, S. 2021a. National Wetlands Inventory (NWI) accuracy in North Carolina. Published by the NC Division of Water Resources, NC Department of Environmental Quality. Completed as partial fulfillment of U.S. EPA Multipurpose Grant AA-01D03020. 28pp.

Gale, S. 2021b. Automated identification of wetlands using GIS in North Carolina. Published by the NC Division of Water Resources, NC Department of Environmental Quality. Completed as partial fulfillment of U.S. EPA Multipurpose Grant AA-01D03020. 33pp.

Hefner, J.M. and J.D. Brown. 1985. Wetland trends in the southeastern United States. Wetlands. 4:112.

McElfish, J. 2022. STATE PROTECTION OF NONFEDERAL WATERS: TURBIDITY CONTINUES. Environmental Law Institute. https://www.eli.org/sites/default/files/files-pdf/52.10679.pdf

McElfish, J. 2023. What Comes Next for Clean Water? Six Consequences of Sackett v. EPA. https://www.eli.org/vibrant-environment-blog/what-comes-next-clean-water-six-consequences-sackett-v-epa

Mississippi Legislature. (n.d.). *Senate Bill 2647*.
https://billstatus.ls.state.ms.us/documents/2024/html/SB/2600-2699/SB2647IN.htm#:~:text=AN%20ACT%20ENTITLED%20THE%20%22MISSISSIPPI,STORM%20PROTECTION%2C%20HABITAT%20CONSTRUCTION%20AND

Mitsch, W.J. and J.G. Gosselink. 1986. Wetlands. Van Nostrand Reinhold, publishers, New York.

National Water Summary on Wetland Resources *United States Geological Survey Water Supply Paper 2425* https://pubs.usgs.gov/publication/wsp2425

NCSL. 2024. *NCSL Environmental and Natural Resources Legislation Database* (Version 2023-present) [Computer software]. National Conference of State Legislatures. https://www.ncsl.org/environment-and-natural-resources/environment-and-natural-resources-legislation-database

NCDWR. 2021. National Wetlands Inventory (NWI) Accuracy in North Carolina. NC Dept. of Environmental Quality, Raleigh, NC: NC Division of Water Resources.

New Mexico Wetlands Program. (2024). https://www.env.nm.gov/surface-water-quality/wetlands/

North Carolina Department of Environmental Quality. 2024. *Executive Order 305: An order to protect and restore NC's critical natural and working lands* [Slide show; Presentation].

Schafale and Weakley. 1990. Classification of the Natural Communities of North Carolina, Third Approximation, North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment and Natural Resources, Raleigh, NC.

Shull III, L. 1999. An accuracy assessment of GIS wetland mapping in the coastal counties of North Carolina: A report of the Strategic Plan for improving coastal management in North Carolina. Published by the Division of Coastal Management, NC Department of Environment, Health, and Natural Resources. Completed in fulfillment of U.S. EPA grant CD994678-95. 56pp.

Supreme Court of the United States. 2023. *Supreme Court of the United States Syllabus*. https://www.supremecourt.gov/opinions/22pdf/21-454_4g15.pdf

Sutter, L. & North Carolina Division of Coastal Management. (1999). *DCM Wetland mapping in coastal North Carolina*.

Tennessee General Assembly. (n.d.). *SB 0629*. https://wapp.capitol.tn.gov/apps/BillInfo/Default.aspx?BillNumber=SB0629&ga=113

U.S. Department of the Interior. 2024. Biden-Harris Administration Announces $25 Million from Investing in America Agenda to Protect Wetlands in Arizona. *U.S. Department of the Interior*. https://www.doi.gov/pressreleases/biden-harris-administration-announces-25-million-investing-america-agenda-protect

Wilson, K.A. 1962. North Carolina Wetlands: Their Distribution and Management. North Carolina Wildlife Resources Commission. Raleigh, NC 167pp.