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Connecticut Wetlands: Characterization and Landscape-level Functional Assessment

March 2013

Cover: A headwater wetland in northwest Connecticut. (Ralph Tiner photo)

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Note: The findings and conclusions in the report are those of the authors and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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INTRODUCTION

The U.S. Fish and Wildlife Service (FWS) recently updated its National Wetlands Inventory (NWI) data for Connecticut with support from the Connecticut Department of Energy and Environmental Protection (CT DEEP). The results of this update are summarized in "*Wetlands and Deepwater Habitats of Connecticut: 2010 Status*" (Tiner 2013a). The CT DEEP project involved more than a simple update of the wetlands data as it also included, among other things, construction of a more comprehensive wetland database (NWI+ database) and use of this information to predict wetland functions at the landscape-level across the state.

During the past decade, the Northeast Region of the U.S. Fish and Wildlife Service developed techniques for using NWI data to better characterize wetlands and predict wetland functions at the watershed scale or landscape level. The techniques involve adding hydrogeomorphic-type descriptors to standard NWI data to create what is now called an "NWI+ database" (Tiner 2010, 2011a). This expanded database has more attributes assigned to mapped wetlands to describe wetlands beyond what was possible through conventional NWI classification. The Cowardin et al. system (1979) used for standard NWI mapping emphasizes ecological system, water depth, vegetation life-form, the frequency and duration of inundation or soil saturation, and some other features. This classification was designed in the 1970s for producing wetland maps – a time when geospatial information and geographic information systems (GIS) were just evolving. The NWI maps were used to get an idea of whether wetland was present or not on a particular parcel and if so, what type of wetland it was. Since the 1970s, mapping technologies have advanced to where the NWI no longer produces a pre-printed set of maps (Tiner 2009). Instead we use desktop mapping tools to produce "geospatial data" that can be viewed on a computer. Today the basic NWI data are posted online and anyone can use, create, and print custom wetland maps for her or his area of interest using an online mapping tool. With advancement of GIS technology, we also have the ability to analyze map data for large geographical areas. We are no longer simply looking at a map or putting overlays of thematic data on a hardcopy map. Instead we analyze the data contained in a geospatial database and can link to other digital data sources for more complex analyses.

Since a major objective of the Connecticut wetlands inventory was to predict wetland functions statewide, we needed to add hydrogeomorphic-type characteristics to the wetlands database to create a NWI+ database. These properties include what are now called "LLWW descriptors" (LLWW represents the first letter of each feature: landscape position, landform, water flow path, and waterbody type). This information when combined with the basic wetland features from the Cowardin et al. classification (system, class, subclass, water regime, and special modifiers) greatly expands the functionality of the Connecticut wetlands database. By reviewing the literature and working with wetland specialists across the Region and beyond, a set of correlations linking the attributes in the NWI+ database to numerous wetland functions have been established (Tiner 2003, 2011b). An overview of this process and applications can be found in "NWIPlus: Geospatial Data for Watershed-level Functional Assessment" (Tiner 2010).

NWI+ data were produced for Connecticut as part of the agreement with CT DEEP and the data were used to produce a more comprehensive characterization of the state's wetlands and a landscape-level assessment of wetland functions. This report briefly describes the methodology employed and presents a summary of the results for the entire state and its eight major and minor watersheds. The geospatial data showing the location of wetlands by different types and wetlands of functional significance can be viewed through an online mapper (see Results). Although waterbodies were also classified by this project, the emphasis of this report will be on wetlands with only some reference to waterbody classification.

Study Area

According to the Connecticut Department of Economic and Community Development, Connecticut encompasses about 4,845 square miles of land plus numerous waterbodies including rivers, streams, lakes, ponds, and some parts of coastal embayments along the shores of Long Island Sound. Three rivers and their watersheds dominate the state: the Thames River in the east, the Housatonic in the west and the Connecticut River in between (Figure 1; Table 1). Connecticut contains six major watershed basins: the Thames, Connecticut, Housatonic, Southwest Coast, South Central Coast, and Southeast Coast and two minor watersheds – a portion of the Pawtucket (Rhode Island) and the Hudson (New York). Some portions of the state do not fall in any of these watersheds, e.g., coastal islands such as the Thimbles (Branford), Kelsey Island (East Haven), Watts Island (Niantic), and Mason Island (Mystic).

Figure 1. Major and minor watersheds of Connecticut.

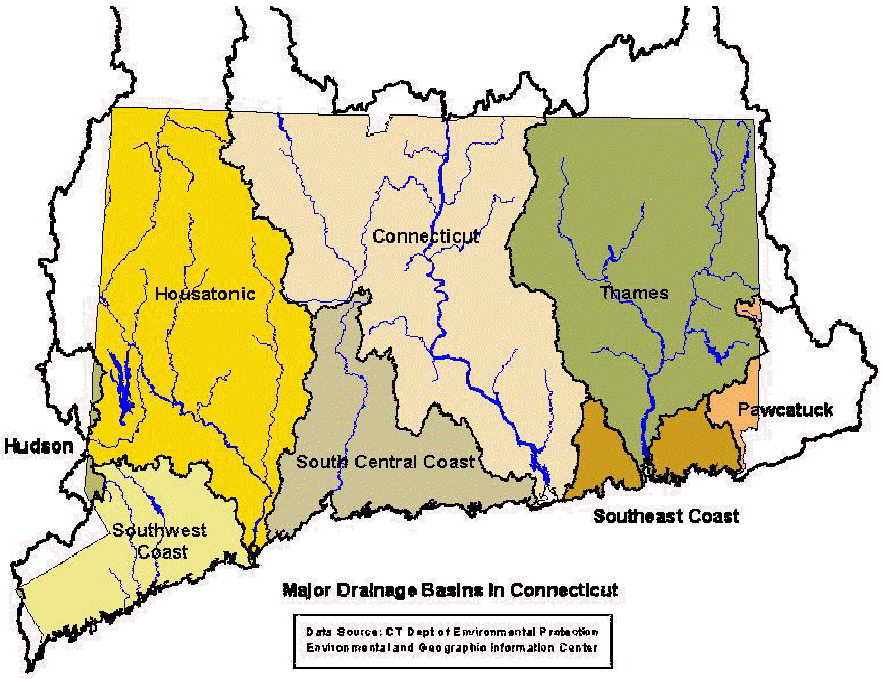


Table 1. Area of major watersheds and percent of state. *Note*: The total area is higher than the state's land area due to the inclusion of waterbodies, except Long Island Sound and its coastal embayments.

Watershed	**Land and Water Area (sq. mi.)**	**Percent of State**
Connecticut	1,436.3	28.8
Housatonic	1,235.2	24.8
Hudson	22.3	0.54
Pawcatuck	56.7	1.11
South Central Coast	512.3	10.33
Southeast Coast-East	87.2	1.8
Southeast Coast-West	76.2	1.5
Southwest Coast	391.9	7.97.9
Thames	1,161.9	23.3
State Total	4,980.0	

METHODS

Creating the NWI+ Database

The updated Connecticut wetlands inventory based on 2010 imagery served as the foundation for this characterization and functional assessment (Tiner 2013a). To be able to use the updated database for landscape-level functional assessment, additional properties of mapped wetlands needed to be added to the basic inventory data, thereby creating a "NWI+ database." These features included landscape position, landform, and water flow path following Tiner (2011a). Deepwater habitats and ponds were further classified by waterbody type and water flow path. Collectively these descriptors are called "LLWW descriptors" (using the first letter of each descriptor).

To expand the wetland classification, the mapped wetlands were re-examined using digital geospatial data for streams (National Hydrography Data, NHD), topography (Digital Raster Graphics, DRGs), elevation (Digital Elevation Models, DEMs), and digital imagery from the summer of 2010 (Table 2). Adding hydrogeomorphic-type descriptors to existing wetland inventory data created an "NWI+ database" that could be further expanded to include other geospatial data such as wetlands of significance for a variety of functions and potential wetland restoration sites.

Table 2. Data sources used in the inventory.

Data Type and Source

Digital Imagery: 2010 4-Band Infrared NAIP
http://www.ctecoapp3.uconn.edu/ArcGIS/Services/images/Ortho_2010_4Band_NAIP/ImageServer
Digital Imagery: 2004 Black & White
http://www.ctecoapp3.uconn.edu/ArcGIS/Services/images/Ortho_2004/ImageServer
Digital Imagery: 1990 Black & White
http://www.ctecoapp3.uconn.edu/ArcGIS/Services/images/Ortho_1990/ImageServer
Raster Data: Digital Raster Graphics (DRG)
http://isse.cr.usgs.gov/ArcGIS/services/DRG/TNM_Digital_Raster_Graphics
Raster Data: Digital Elevation Model (DEM) (3-meter)
http://datagateway.nrcs.usda.gov/
Vector Data: Contour Lines (2-10 ft)
http://www.ctecoapp2.uconn.edu/arcgis/services/maps/Elevation_Bathymetry
Vector Data: SSURGO Hydric Soil Data
http://soildatamart.nrcs.usda.gov/Survey.aspx?State=CT
Vector Data: National Hydrography Dataset (NHD)
http://datagateway.nrcs.usda.gov/
Vector Data: 1980/81 National Wetlands Inventory Data
http://www.fws.gov/wetlands/Data/State-Downloads.html

Expanded Wetland Classification

The LLWW classification contains four major elements to describe wetlands beyond the Cowardin et al. (1979) classification: 1) landscape position, 2) landform, 3) water flow path, and 4) waterbody type (Tiner 2011a). These hydrogeomorphic-type descriptors focus on abiotic properties that are vital to predicting wetland functions.

Five landscape positions describe the location of a wetland relative to a waterbody if present: 1) *marine* (along the ocean), 2) *estuarine* (along tidal brackish waters), 3) *lotic* (along rivers and streams and subject to overflow), 4) *lentic* (in basins of lakes and reservoirs), and 5) *terrene* (sources of streams or isolated – completely surrounded by upland, or not affected by the aforementioned waters). Since Long Island Sound is an estuary, there are no marine wetlands in Connecticut.

Landform describes the physical shape of the wetland. Several types are recognized: *basin* (depressional wetland), *flat* (wetland on a nearly level plain), *floodplain* (overflow land along rivers subject to periodic inundation), *fringe* (wetland in water, within the banks of a river, or on an estuarine intertidal plain), *island* (wetland completely surrounded by water), and *slope* (wetland on a hillside).

Water flow path defines the direction of flow of water associated with the wetlands (Table 3). If the wetland is a source of a stream or a seep, it is an *outflow* wetland. River and streamside wetlands are *throughflow* wetlands with water running through them (both into and out of) during high water periods. Wetlands that only receive water from channelized flow without any outflow are considered *inflow* wetlands. Some wetlands have no channelized inflow or outflow – they are *isolated*, essentially with no water flow path, although water undoubtedly can enter via runoff from the land and exit via groundwater. Wetlands along lakes and reservoirs have water levels that rise and fall with lake levels - *bidirectional-nontidal*; lakeshore wetlands associated with streams were classified as *throughflow*. Tidal wetlands experience *bidirectional-tidal* flow with ebb and flood tides. Figure 2 shows the classification of different types of nontidal wetlands across the landscape.

The characteristics of all mapped wetlands and waterbodies were expanded by adding the above attributes plus waterbody type and some other descriptors (e.g., headwater) (see Table 4 for outline of steps). This NWI+ database would be used to describe wetlands in more detail than provided by Cowardin et al. (1979) and to predict wetland functions for Connecticut wetlands at the state and watershed levels.

Table 3. Brief definitions of water flow paths used in this study.

Water Flow Path (map code)	**Definition**
Bidirectional-nontidal outflow (BO)	Water levels rise and fall with water in an outflow lake
Bidirectional-nontidal throughflow (TB)	Water levels rise and fall with water in a throughflow lake
Bidirectional-tidal (BT)	Water ebbs and flows largely in response to tides
Inflow (IN)	Water flows into an area with no surface flow outlet (a closed system); collected water is lost through evaporation, transpiration and possibly groundwater recharge
Outflow-artificial (OA)	Water flows out of the system through a ditch or manmade channel; no direct surface water inflow
Outflow-intermittent (OI)	Water flows out of the system periodically usually during the wet season or during and shortly after heavy rains; no direct surface water inflow; typically associated with intermittent streams and groundwater discharge; may be the source of a stream
Outflow-perennial (OU)	Water flows out of the system year-round; no direct surface water inflow; typically associated with perennial streams, rivers and groundwater discharge; often the source of a stream
Throughflow-artificial (TA)	Water enters from a water source above and flows out of the system via a ditch or manmade channel or canal
Throughflow-intermittent (TI)	Water enters from a water source above and flows out of the system via an intermittent stream; flow usually occurs during the wet season or during and shortly after heavy rains
Throughflow-perennial (TH)	Water flows through the system more or less year-round via a perennial stream; wetlands subject to seasonal overflow

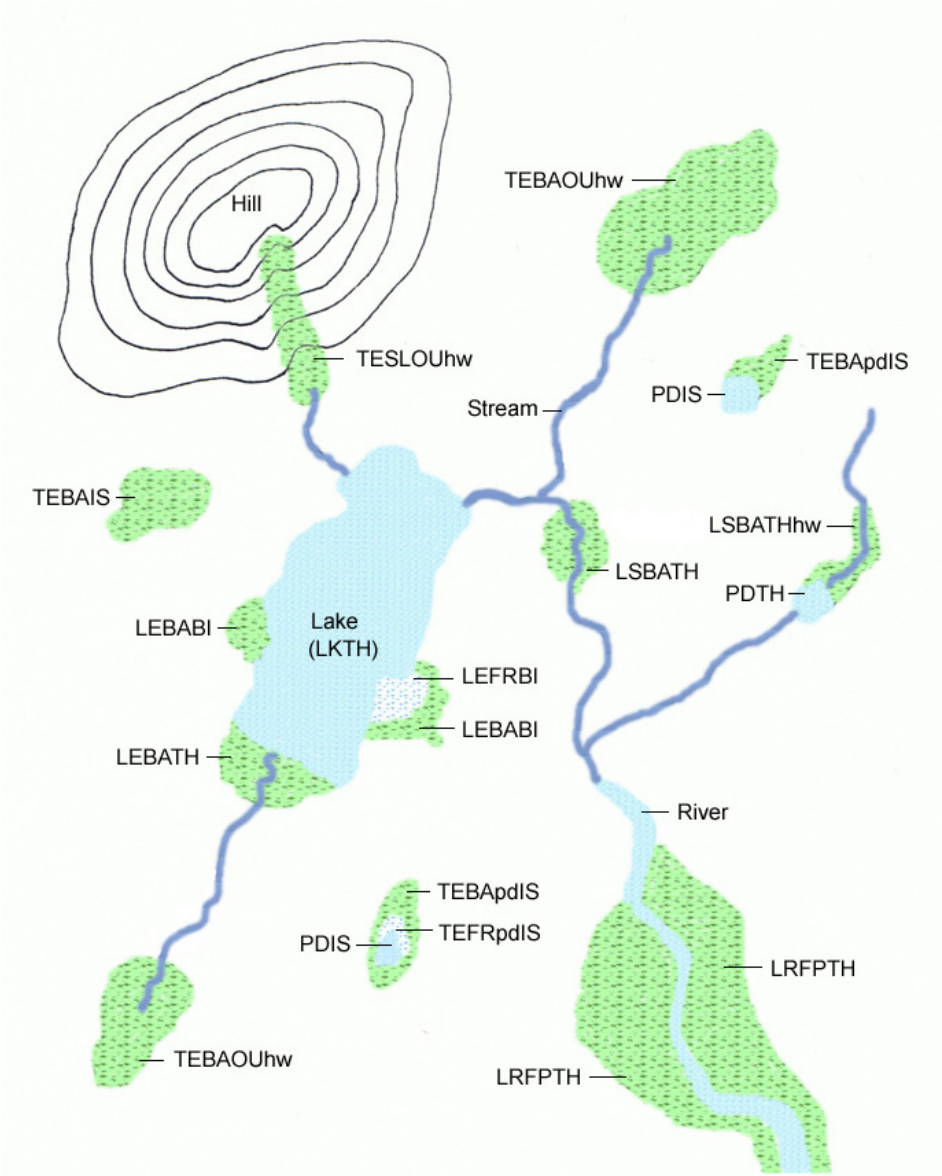


Figure 2. Nontidal wetlands classified by abiotic features: landscape position – TE (terrene), LE (lentic), LR (lotic river), LS (lotic stream); landform – BA (basin), FP (floodplain), FR (fringe), SL (slope) [FL – flat not shown]; water flow path – IS (isolated), TH (throughflow), OU (outflow), BI (bidirectional-nontidal); waterbody type – PD (pond), LK (lake); other modifiers: hw (headwater), pd (pond-associated wetland). To interpret code: TEBAIS = terrene basin isolated and LSBATH = lotic stream basin throughflow.

Table 4. Expanding wetland classification involves both automated and manual routines.

Step 1. Automation

a. Parse the Cowardin field.

b. Run Cowardin to LLWW tool that only populates known values, mostly marine and estuarine types.

Step 2. Manual Interpretation with some Automation

a. Intersect wetlands with the National Hydrography Data (NHD) layer using the FCODE 46003 for intermittent and 46006 for perennial throughflow. This will give a foundation to build off of and greatly increases speed of visual interpretation.

b. Intersect the wetlands with the NHD layer using all linears, and then select all adjacent polygons to these selected wetlands until no new selections are made. The remaining polygons are seeded with the isolated water flow path. Further inspection will require some to be changed to outflows based of the more accurate DRG layer.

Step 3. Manual Review

a. Visual inspection using the Digital Raster Graphic (DRG) and already populated polygons to finish populating the water flow path.

b. Visual inspection of all lake basins is done to determine the proper flow for lentic wetlands.

c. Once everything has a correct flow using established relationships based on said flow, landscape and then landform are determined. Regional exceptions to these relationships are then applied as necessary.

d. Other modifiers such as tidal restriction and estuary discharge are done visually.

e. Outflows are generally considered headwater and visual interpretation along with the NHD layer (which is used to display NHD headwaters) is used to determine other headwaters.

f. Error checking and consistency steps including later review during analyses.

Data Analysis and Summaries

The NWI+ database was used to generate acreage summaries of wetlands and deepwater habitats grouped by the Cowardin et al. types and LLWW types (landscape position, landform, and water flow path) and to predict wetland functions for each of Connecticut's major watershed basins. To do the latter, relationships between properties in the NWI+ database and a variety of wetland functions had to be established. From previous studies, a table listing each of 11 functions and the relevant wetland properties was used to identify wetlands with potential to perform each function at high or moderate levels (Appendix A). The 11 functions were: 1) surface water detention (for nontidal wetlands only), 2) streamflow maintenance, 3) coastal storm surge detention, 4) nutrient transformation, 5) sediment and other particulate retention, 6) carbon sequestration, 7) bank and shoreline stabilization, 8) provision of fish and aquatic invertebrate habitat, 9) provision of waterfowl and waterbird habitat, 10) provision of habitat for other wildlife, and 11) provision of habitat for unique, uncommon, or highly diverse wetland plant communities. The foundation for the functional assessment was an earlier report relating specific wetland types to functional performance (Tiner 2003, slightly revised based on more recent applications, e.g., Tiner 2011b).

Geospatial Data and Online Map Production

The NWI+ database was used to construct an online mapping tool – NWI+ Web Mapper – using ESRI's ArcGIS online mapping service (Appendix B). Data layers included classifications of wetlands by NWI types (Cowardin et al. 1979), landscape position, landform, water flow path, and by their predicted potential to provide each of 11 different functions mentioned above.[1] Using the online mapper allows users to zoom into specific areas of interest and thereby see more detail than could be provided by producing maps for an 8.5" x 11.0" format (typical report page). Moreover, the tool permits the user to display the data on aerial imagery or topographic or planimetric maps and to produce custom maps for use in reports or for other purposes. The online mapper can be accessed through a website called "Wetlands One-Stop Mapping" (http://aswm.org/wetland-science/wetlands-one-stop-mapping). The geospatial data produced for this project allows for other geographic analyses (e.g., smaller watersheds, counties, towns, and other areas of special interest). Data will be available from CTDEEP.

[1] The online mapper also includes other data layers such as "areas that may support wetlands based on soil mapping" and potential wetlands restoration sites but these layers are not pertinent to the findings of this report.

LIMITATIONS OF LANDSCAPE-LEVEL FUNCTIONAL ASSESSMENT

Source data are a primary limiting factor for landscape-level functional assessment. Updated Connecticut wetlands inventory data (expanded to include hydrogeomorphic properties, e.g., landscape position, landform, water flow path, and waterbody type) and existing stream data (e.g., NHD and DRGs) were used as the foundation for this assessment. All wetland and stream mapping have limitations due to scale, photo quality, date of the survey, and the difficulty of photointerpreting certain wetland types (especially evergreen forested wetlands and drier-end wetlands; see Tiner 1990, 1999 for details) and narrow or intermittent streams especially those flowing through dense evergreen forests and beneath built-up lands. Consequently many small streams were not identifiable on the imagery used for the inventory. This would affect their LLWW classification. Also joining different geospatial data sources is challenging and often times inexact since they were interpreted from different imagery and aligned to different products (i.e., aerial imagery or maps).

Since wetland classification drives a wetland's designation as high, moderate, or not significant for a given function (see Appendix A), any misclassification would affect such designation. For example, wetlands identified as isolated may be connected to other wetlands and waters by a small stream that was not identified during this inventory. Where this is the case, the wetland is actually an outflow wetland and should be significant for streamflow maintenance with possible differences in other functions as well. When interested in an isolated wetland, the user is encouraged to view the wetland on imagery (provided via the NWI+ web mapper) and zoom in to see if there is a small stream present.[2] If a stream is observed, then reclassify the wetland and use the correlation table (Appendix A) to determine the appropriate levels of functions for this wetland. Another situation where misclassification may be an issue is where wetlands along major rivers occurred above a distinct topographic break (visible on a USGS topographic map). These wetlands were classified as terrene wetlands (e.g., outflow where a stream was present). Some of these wetlands may occur on the river's active floodplain depending on the height of the topographic break relative to the river flood stage elevation. The terrene outflow wetland would have been designated as moderate for surface water detention, whereas if classified as a lotic river floodplain wetland, it would be rated as high for that function. A similar issue may arise along streams where wetlands were classified with a seasonally or temporarily flooded water regime. Streamside wetlands with these water regimes were routinely classified as lotic stream wetlands. If, however, they are not subject to annual overbank flooding because they are located on a terrace, they should be classified as terrene wetlands as such wetlands would be groundwater types and not overflow wetlands. This classification difference could influence a number of functions.

Recognizing source data limitations, it is equally important to understand that this type of functional assessment is a preliminary one based on wetland characteristics interpreted through remote sensing and using the best professional judgment of various specialists to develop relationships between wetland characteristics in the database and wetland functions. This type

[2] This imagery is different than that used for this survey and may therefore show a stream; also zooming in allows viewing at a larger scale than used for the inventory which also facilitates identification of small streams and other features.

of functional analysis is designed to produce landscape- or watershed-level assessments covering large geographic areas. The wetland classification employed, although expanded from the traditional NWI, does not account for all elements of variability in wetlands such as chemical variation in surface waters that are strongly influenced by underlying geology, especially in relatively undisturbed watersheds (Azzolina et al. 2007).

Wetlands are rated based on their biotic or abiotic characteristics as having high or moderate potential for supporting each of eleven wetland functions: surface water detention (nontidal wetlands), coastal storm surge detention (tidal wetlands and contiguous nontidal wetlands), streamflow maintenance (headwater wetlands), sediment and other particulate retention, nutrient transformation, carbon sequestration, bank and shoreline stabilization (wetlands along waterbodies), and provision of habitat for: a) fish and aquatic invertebrates, b) waterfowl and waterbirds, c) other wildlife, and d) unique, uncommon, and highly diverse wetland plant communities. Wetlands not assigned a rating are assumed to have little or no potential for providing such function at a significant level, with one exception for unique, uncommon, and highly diverse wetland plant communities which is by design a very conservative assessment. The ratings are based on a review of the literature and best professional judgment of numerous wetland scientists from public agencies, private non-government organizations, and academia. Also, no attempt is made to produce a more qualitative ranking for each function (e.g., comparison to a “reference” type representing a wetland of the type in the “best” condition, or considering the degree to which it actually performs a function given opportunity and adjacent land uses) or for each wetland based on multiple functions. To do that would require more input from others and more data, well beyond the scope of this type of broad-scale evaluation. For detailed reviews of wetland functions, see Mitsch and Gosselink (2007) and Tiner (2013b) and for a broad overview, see Tiner (2005).

Functional assessment of wetlands can involve many parameters. Typically such assessments have been done in the field on a case-by-case basis, considering observed features relative to those required to perform certain functions or by actual measurement of performance. The preliminary assessments based on remote-sensing information do not seek to replace the need for field evaluations since they represent the ultimate assessment of the functions for individual wetlands. Yet, for a watershed analysis, basin-wide field-derived assessments are not practical, cost-effective, or even possible given access considerations. For watershed planning, a more generalized assessment (level 1 assessment) is worthwhile for targeting wetlands that may provide certain functions, especially for those functions dependent on landscape position, landform, hydrologic processes, and vegetative life form (Brooks et al. 2004). Later these results can be field-verified when it comes to actually evaluating particular wetlands for acquisition purposes (e.g., for conserving biodiversity or for preserving flood storage capacity) or for project impact assessment. Current aerial photography may also be examined to aid in further evaluations (e.g., condition of wetland/stream buffers or adjacent land use) that can supplement the preliminary assessment.

The landscape-level functional assessment approach -"Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF) - applies general knowledge about wetlands and their functions to develop a watershed overview that highlights possible wetlands of significance in terms of performance of various functions. To accomplish this objective, the

relationships between wetlands and various functions are simplified into a set of practical criteria or observable characteristics based on the classification features in the expanded wetland database (i.e., NWI+ database). Such assessments may be further expanded (with additional effort) to consider the condition of the associated waterbody and the neighboring upland or to evaluate the opportunity a wetland has to perform a particular function or service to society, for example.

W-PAWF does not account for the opportunity that a wetland has to provide a function resulting from a certain land-use practice upstream or the presence of certain structures or land-uses downstream. For example, two wetlands of equal size and like vegetation may be in the appropriate landscape position to retain sediments. One, however, may be downstream of a land-clearing operation that has generated considerable suspended sediments in the water column, while the other is downstream from an undisturbed forest. The former should be actively performing sediment trapping in a major way, whereas the latter may not. Yet if land-clearing takes place in the latter area, the second wetland will likely trap additional sediments as well as the first wetland. The entire analysis typically tends to ignore opportunity since such opportunity may have occurred in the past or may occur in the future but the important point is that the wetland is there to perform this service at higher levels when necessary.

W-PAWF also does not consider the condition of the adjacent upland (e.g., level of disturbance or stress) or the actual water quality of the associated waterbody that may be regarded as important metrics for assessing the health of individual wetlands. Collection and analysis of these data may be done as a follow-up investigation, where desired, for so-called "condition assessments."

The predictions for the function – unique, uncommon, or highly diverse wetland plant communities is a conservative assessment based on the Cowardin et al. and the LLWW classifications. It may include some plant communities that are common but uncommon in that they occur in a particular landscape (e.g., a marsh along a river versus one in a depression). A more comprehensive listing would be to combine the results of this analysis with data on critical habitats from CTDEEP or other organizations.

It is important to re-emphasize that the preliminary assessment does not obviate the need for more detailed assessments of the various functions and assessment of wetland condition and opportunities to provide more benefits given the state of the contributing watershed and adjacent land use activities. This preliminary assessment should be viewed as a starting point for more rigorous assessments, since it attempts to cull out wetlands that may likely provide significant functions based on generally accepted principles and the source information used for this analysis. This assessment is most useful for regional or watershed planning purposes, for a cursory screening of sites for acquisition, and to aid in developing landscape-level wetland conservation and protection strategies. The approach can also be used to evaluate cumulative impacts of various alterations and changes in wetlands on key functions as was done for the Nanticoke River watershed on the Delmarva Peninsula (Tiner 2005b) or to consider the national and regional-scale impacts of policy changes on certain wetland types (e.g., geographically isolated wetlands or headwater wetlands, or determining significant nexus to waters of the United States). For site-specific evaluations, additional work will be required,

especially field verification and collection of site-specific data for potential functions (e.g., following the hydrogeomorphic assessment approach as described by Brinson 1993 or other onsite evaluation procedures, e.g., rapid field assessment). This is particularly true for assessments of fish and wildlife habitats. Other sources of data may exist to help refine some of the findings of this report (e.g., state natural heritage data). CTDEEP has produced geospatial data on “critical habitats” that is much more extensive than the conservative listing of wetlands identified as “Unique, Uncommon, or Highly Diverse Wetland Plant Communities” in this report. Additional modeling could be done, for example, to identify habitats of likely significance to individual species of animals based on their specific life history requirements (see U.S. Fish and Wildlife Service 2003 for Gulf of Maine habitat analysis).

Also note that the criteria used for the relationships were based on current applications of the Service's wetland classification (Cowardin et al. 1979) and on professional judgment of many experienced wetland scientists in the eastern region. Through this analysis, numerous wetlands are predicted to perform a given function at a significant level presumably important to a watershed's ability to provide that function. "Significance" is a relative term and is used in this analysis to identify wetlands that are likely to perform a given function at a high or moderate level. Wetlands not highlighted may perform the function at a low level or may not perform the function at all. It is also emphasized that the assessment is limited to wetlands (i.e., areas classified as wetlands according to the Cowardin et al. classification system). Deepwater habitats and streams were not included in the assessment, although their inherent value to wetlands and many wetland-dependent organisms is apparent and widely recognized.

RESULTS

Geospatial Data and Online Mapper

Geospatial data for Connecticut's wetlands and deepwater habitats are available online via the NWI+ Web Mapper at http://aswm.org/wetland-science/wetlands-one-stop-mapping/2836-nwi (see Appendix A for an introduction to this tool). As mentioned earlier, custom maps for specific areas can be made using the online mapping tool with data displayed on a variety of basemaps (including aerial imagery). While the website displays numerous data layers, the ones of interest for functional assessment are LLWW types and wetlands of significance for various functions (Table 5). To view the location of wetlands by the classifications of this assessment, readers must access the NWI+ web mapper.

Table 5. List of data layers included on the NWI+ web mapper that are particularly relevant to this report.

"NWI+ Footprints" – shows project areas where NWI+ data are available.

"Wetland Codes" – places dots on the wetlands so that user can click on the dot to get the wetland classification by NWI type and by LLWW type.

"NWI Types" – shows mapped wetlands and deepwater habitats by Cowardin et al. types (color-coded types – legend can be viewed by clicking on "NWI Types" then on "Legend").

"NWI+ Landscape" – shows mapped wetlands classified by landscape position (color-coded types – view legend as described above)

"NWI+ Landform" – shows mapped wetlands classified by landform (color-coded types – view legend as described above)

"NWI+ WaterFlowPath" - shows mapped wetlands classified by water flow path (color-coded types – view legend as described above)

"_____ Function" shows wetlands predicted to perform specific functions at significant levels (e.g., high or moderate): "BSS" (bank and shoreline stabilization, "CAR" (carbon sequestration, "CSS" (coastal storm surge detention), "FAIH" (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI codes only), and WBIRD (waterfowl and waterbird habitat).

Statewide Findings

The classification and acreage of Connecticut's wetlands by NWI type (Cowardin et al. types) have been reported in a companion report (Tiner 2013a) and key findings will be repeated here for a more complete characterization of the state's wetlands. Also a 1992 report described in considerable detail the diversity of Connecticut's wetland plant communities; consult Chapter 6 in "Wetlands of Connecticut" (Metzler and Tiner 1992; available online at: http://www.fws.gov/northeast/EcologicalServices/pdf/WetlandsofConnecticut.pdf). For the current report, the statewide findings will be presented first, then followed by the watershed results. The state summary will describe the characterization of wetlands and waters based on the Cowardin et al. (1979) and Tiner (2011a) classifications and then present the preliminary assessment of wetland functions for the state. The next section will summarize the wetland characterization findings for watersheds, with results for individual watersheds presented in Appendix C as a series of tables and figures.

Characterization of Wetlands and Waters

Wetlands Classified by Cowardin et al. Types

Nearly 220,000 acres of wetlands were inventoried (Table 6), covering about seven percent of the state's land area or six percent of the state's land-water area. Palustrine wetlands are the predominant type as they are the "inland wetlands" - composed of forested wetlands, shrub swamps, wet meadows, marshes, bogs, and ponds. They make up 91 percent of the state's wetlands (Figure 3). Forested wetlands are the major palustrine type, comprising almost two-thirds (62%) of these freshwater wetlands (Figure 4). Emergent types (marshes and wet meadows) are next in abundance followed by scrub-shrub wetlands, ponds, and aquatic beds rounding out the palustrine types. Estuarine wetlands represent nearly 8 percent of the state's wetlands. The emergent type (salt and brackish marshes) dominates these wetlands which comprise almost three-quarters (73%) of the estuarine wetlands (Figure 5). Unconsolidated shores (beaches and tidal flats) account for most of the rest of the estuarine wetlands (25% of them). Lacustrine wetlands, mostly shallow bottoms of lakes and reservoirs and associated aquatic beds, account for 1 percent of the state's wetlands. The latter were detected by this survey due to the use of leaf-on imagery as one of the datasets for interpretation. Only 187 acres of riverine wetlands were inventoried. They are aquatic beds and exposed shores, while the permanently flooded riverine areas were treated as deepwater habitats.

From a hydrologic standpoint, estuarine wetlands were mostly irregularly flooded (inundated by the tides less than daily), while most of the freshwater wetlands were seasonally flooded types. About 90 percent of the estuarine wetlands represented the former, whereas the remaining ones were flooded daily by the tides (regularly flooded). Of the state's palustrine wetlands, 83 percent were seasonally flooded with most of these being seasonally flooded/saturated types, 11 percent were permanently flooded (ponds), and only three percent were temporarily flooded.

Humans and beavers had an impact on the state's wetlands. Forty-seven percent of the state's estuarine wetlands and only 2 percent of palustrine wetlands were partly drained by ditching.

Almost 10 percent of the palustrine wetlands were impounded and nearly 5 percent were excavated. Less than 1 percent of the estuarine wetlands were impounded. Beaver activity was detected in about 1 percent of the state's palustrine wetlands. Only 54 acres were farmed.

Table 6. Acreage of Connecticut's wetlands based on 2010 imagery and classified according to Cowardin et al. (1979). *Note: Palustrine wetlands were further separated into tidal and nontidal "subsystem."* Although such subsystems are not recognized by Cowardin et al., they are important ecological distinctions.

System	**Subsystem**	**Class**	**Acreage**
Estuarine	Intertidal	Aquatic Bed	91.7
		Emergent	12,417.3
		Scrub-Shrub	214.8
		(Vegetated Total)	*(12,723.8)*
		Unconsolidated Shore	4,177.2
		Rocky Shore	80.6
		(Nonvegetated Total)	*(4,257.8)*
	Total Estuarine		***16,981.6***
Palustrine	Tidal	Aquatic Bed	5.0
		Emergent	1,296.7
		Forested	487.3
		Scrub-Shrub	487.1
		(Vegetated Total)	*(2,276.1)*
		Unconsolidated Bottom	37.4
		Unconsolidated Shore	7.7
		(Nonvegetated Total)	*(45.1)*
		Total Palustrine Tidal	*2,321.2*
	Nontidal	Aquatic Bed	8,016.1
		Emergent	27,339.0
		Forested	122,942.8
		Scrub-Shrub	25,474.9
		Farmed	53.8
		(Vegetated Total)	*(183,826.6)*
		Unconsolidated Bottom	14,015.9
		Unconsolidated Shore	34.3
		(Nonvegetated Total)	*(14,050.2)*
		Total Palustrine Nontidal	*197,876.8*
	Total Palustrine		***200,198.0***

Lacustrine	Littoral	Aquatic Bed	1,007.8
		Emergent	157.0
		(Vegetated Total)	*(1,164.8)*
		Unconsolidated Bottom	360.2
		Unconsolidated Shore	665.3 (4.3 = tidal)
		(Nonvegetated Total)	*(1,025.5)*
	Total Lacustrine		***2,190.3***
Riverine	Tidal	Aquatic Bed	13.0
		Unconsolidated Shore	37.5
		Total Tidal	*50.5*
	Nontidal	Aquatic Bed	120.3
		Unconsolidated Shore	14.5
		Rocky Shore	1.2
		Total Nontidal	*136.0*
	Total Riverine		***186.5***
TOTAL MAPPED			**219,556.4**

Figure 3. Wetlands classified by ecological system.

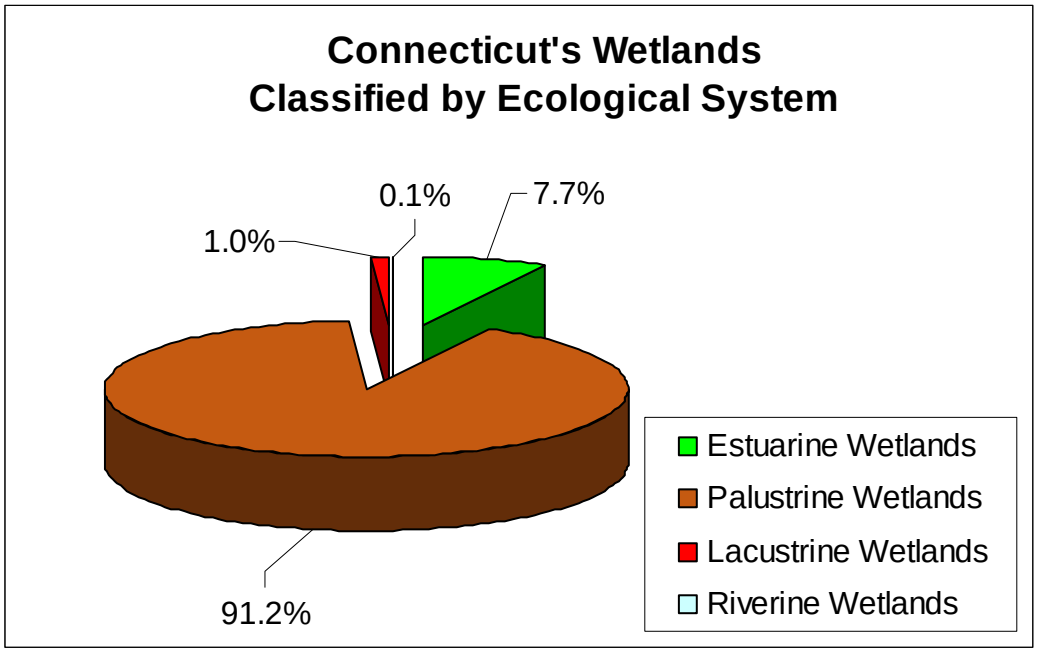


Figure 4. Distribution of palustrine wetlands by wetland class. “Nonvegetated” type includes mostly ponds (unconsolidated bottoms), but also unconsolidated shores and farmed wetlands.

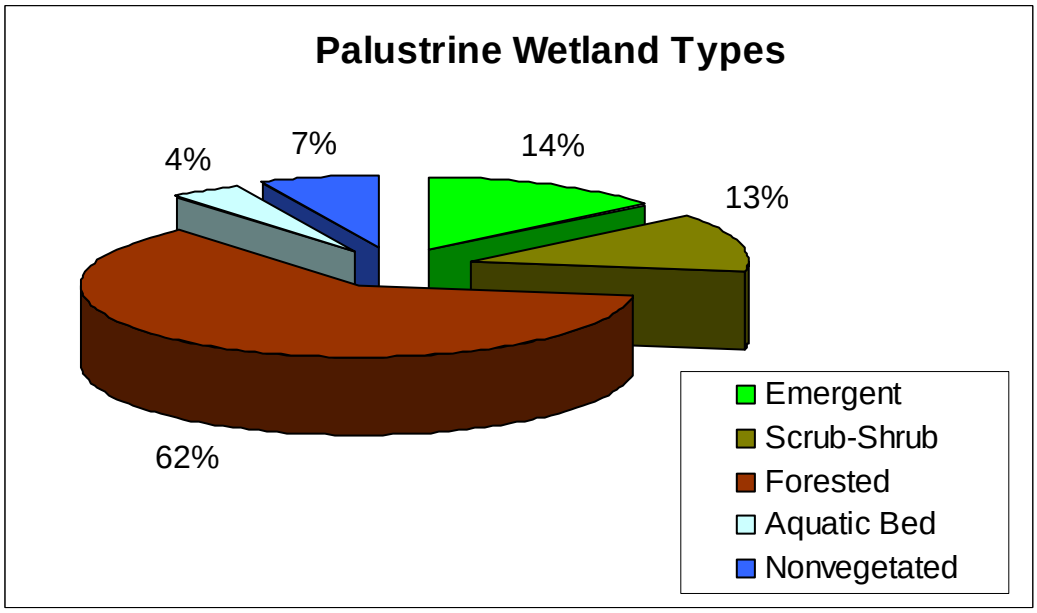
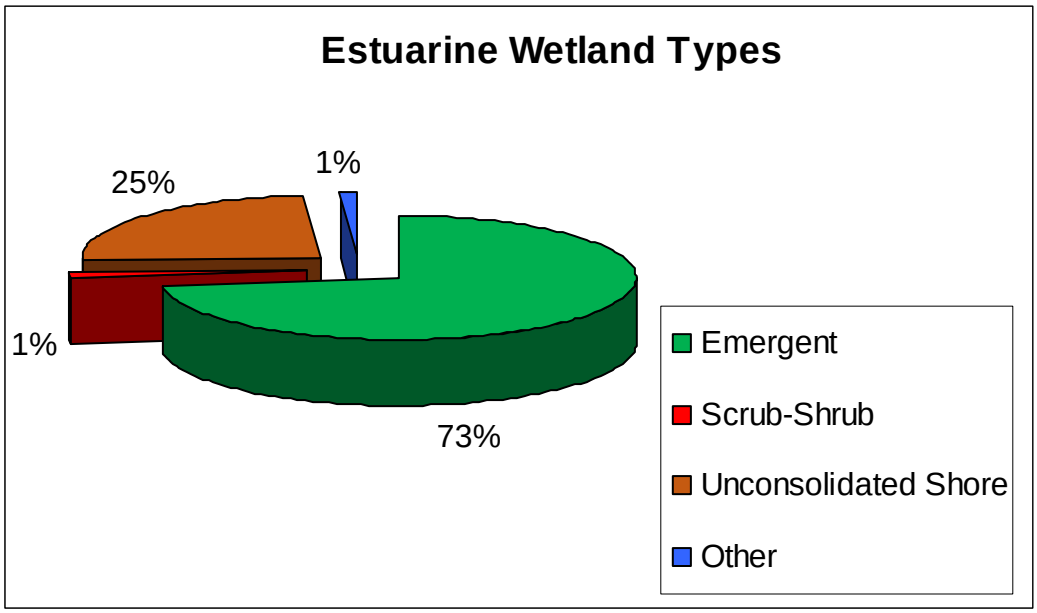


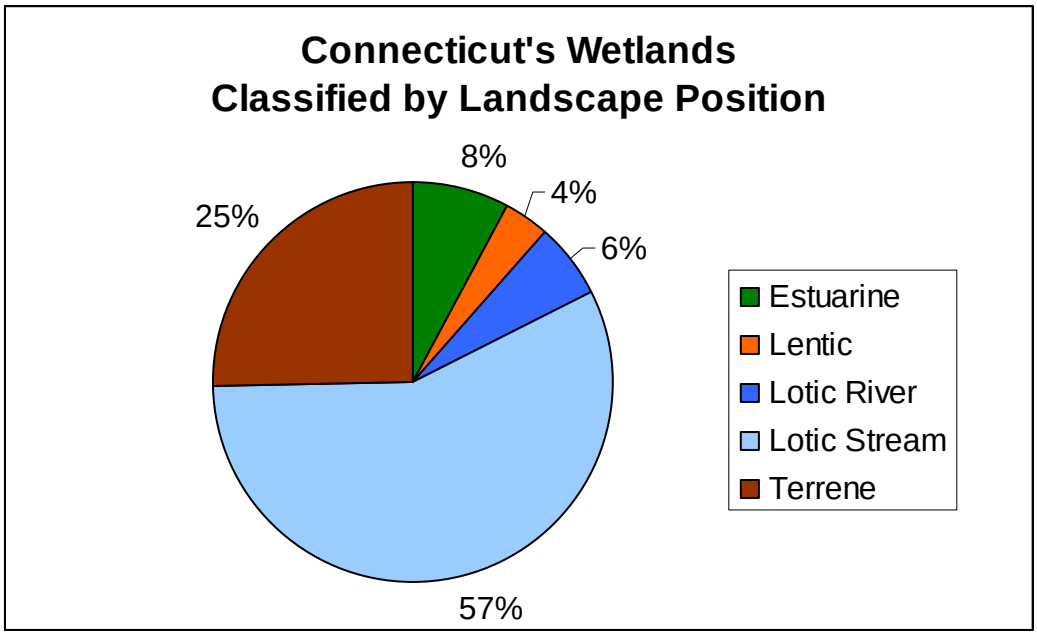
Figure 5. Distribution of estuarine wetlands by wetland class. “Other” type is represented by aquatic beds and rocky shores.



Wetlands Classified by LLWW Types

Sixty-two percent of the state's wetlands were associated with rivers and streams (lotic wetlands and in-stream ponds), while 25 percent were represented by terrene wetlands that were mostly sources of streams and isolated wetlands (Figure 6; Table 7). Estuarine wetlands accounted for 8 percent of Connecticut's wetlands. The remaining wetlands (4%) occurred along lake shores (lentic wetlands).

Figure 6. Distribution of wetlands by landscape position according to Tiner (2011a). (Note: Ponds were not classified by landscape position; throughflow and bidirectional-tidal ponds were considered to be in-stream ponds, therefore in the lotic stream landscape, while inflow, isolated, and outflow ponds were considered to be in terrene landscape position for this chart.)



From the landform perspective, 84 percent of the state's wetlands were formed in depressions including ponds, seasonally flooded streamside wetlands and isolated depressional wetlands or were tidal wetlands behind causeways, embankments, or other restrictive structures (basins and ponds; Figure 7). Eight percent of the state's wetlands were fringe types that were mostly semipermanently flooded wetlands along the shores of fresh waterbodies (lakes, ponds, and rivers) and estuarine wetlands with unrestricted access to Long Island Sound, its embayments, and coastal rivers. Floodplain wetlands along major rivers accounted for 6 percent of the state's wetlands, while 2 percent were flats (including temporarily flooded and saturated wetlands).

Most (63%) of Connecticut's wetlands are throughflow types associated with rivers and streams and subject to periodic overflow (Figure 8). Many outflow types are also linked to lotic waters as they are the sources of streams. Together these types represented roughly three-quarters of the state's wetlands. Tidal wetlands (bidirectional-tidal types) also occur along the

tidal reach of coastal rivers as well as around estuarine embayments. They accounted for 9 percent of the state's wetlands as they include both estuarine and freshwater tidal types.

Table 7. Wetlands of Connecticut (excluding ponds) classified by LLWW descriptors according to Tiner (2011a). (Note: Difference in sums is due to round-off procedures.)

Landscape Position	**Landform**	**Acreage**	**Water Flow Path**	**Acreage**
Estuarine	Basin	4,080.4	Bidirectional-tidal	16,981.5
	Fringe	12,870.8		
	Island	30.2		
	Total	*16,981.4*		
Lentic	Basin	5,841.0	Bidirectional-outflow	49.3
	Flat	66.5	Bidirectional-throughflow	7,175.8
	Fringe	1,906.4	Bidirectional-tidal	10.2
	Island	8.9	Outflow-perennial	58.6
	Total	*7,822.8*	Throughflow-perennial	528.8
			Total	*7,822.7*
Lotic River	Floodplain	13,268.5	Bidirectional-tidal	2,191.1
	Fringe	304.6	Throughflow-perennial	11,382.0
	Total	*13,573.1*	*Total*	*13,573.1*
Lotic Stream	Basin	104,581.7	Bidirectional-tidal	69.6
	Flat	4,243.6		
	Fringe	2,655.1	Throughflow-artificial	55.5
	Island	5.0	Throughflow-perennial	117,187.7
	Pond	14,414.0	Throughflow-intermittent	8,586.6
	Total	*125,899.4*	*Total*	*125,899.4*
Terrene	Basin	45,934.8	Inflow	6.0
	Flat	816.6	Isolated	26,556.3
	Fringe	119.7	Outflow-artificial	2,820.2
	Slope	647.6	Outflow-intermittent	5,091.3
	Pond	7,748.1	Outflow-perennial	20,758.1
	Total	*55,266.8*	Throughflow-artificial	35.0
			Total	*55,266.9*

Figure 7. Distribution of wetlands by landform. “0%” means less than 1%; the “Other” category includes slopes and islands represented less than 0.3% of the state’s wetlands.

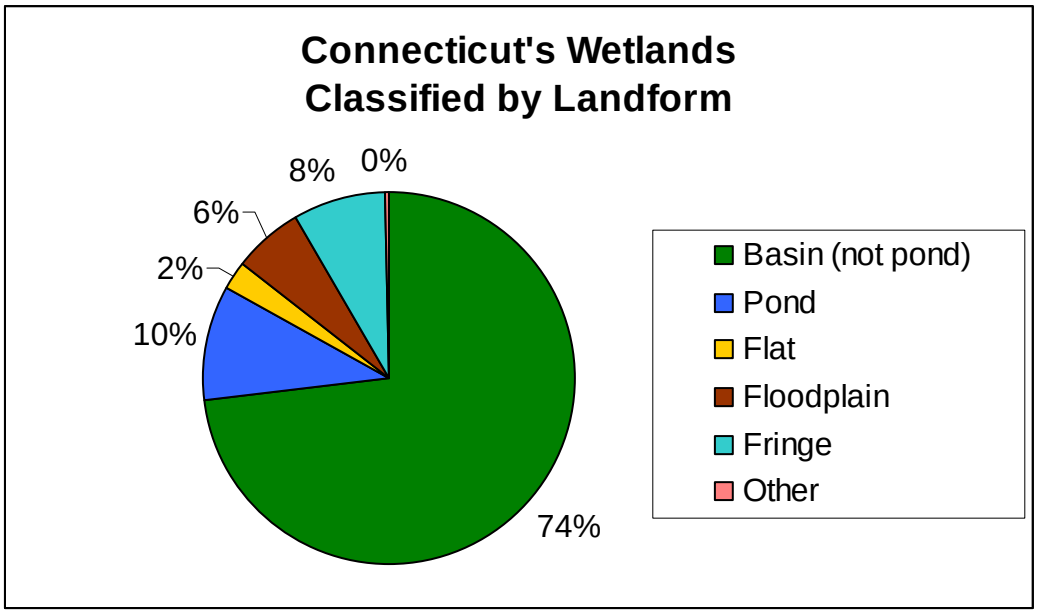
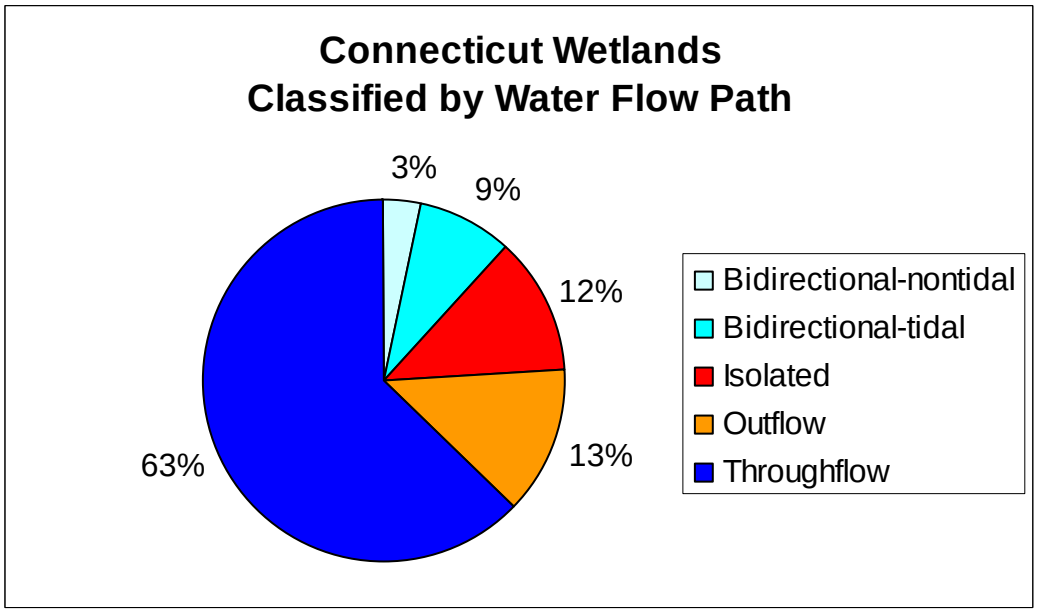


Figure 8. Distribution of wetlands by water flow path.



Isolated wetlands lacking a detectable inflow or outflow channel comprised 12 percent of the state’s wetlands, while the remainder were wetlands in coves or embayments of lakes where their water level were strongly influenced by lake levels (bidirectional-nontidal).

Waters Classified by LLWW Types

Over 476,000 acres of waters were mapped in Connecticut. It was no surprise that the overwhelming majority (80%) was estuarine since the state occupies a large section of Long Island Sound (Table 8; Figure 9). Lakes were the second-ranked waterbody type accounting for 10 percent of the waterbodies and most of them (95%) were dammed (e.g., reservoirs). Rivers and ponds each comprised 5 percent of the state's waterbodies. (*Note that the river total does not include most streams as they were too narrow to map.*) A wide variety of ponds occurred in the state and the majority were created or altered (50% impounded and 41% excavated), with only 7 percent natural and nearly 2 percent beaver-influenced (Table 8). Additional characteristics of natural ponds are given in Table 9, while Tables 10 and 11 present further classification of dammed/impounded and excavated ponds, respectively.

Table 8. Connecticut waters classified by waterbody type and water flow path according to Tiner (2011). (Note: Difference in sums is due to round-off procedures.)

Waterbody		**Acreage**	**Water Flow Path**	**Acreage**
Estuary	LI Sound	374,559.6	Bidirectional-tidal	388,895.4
	Watersheds	14,335.8		
	Total	*388,895.4*		
Lakes	Natural	1,946.5	Bidirectional-tidal	247.2
	Dammed	48,230.1	Isolated	213.1
	Excavated	486.4	Outflow-artificial	422.0
	Total	*50,663.0*	Outflow-perennial	1,544.8
			Throughflow-interm.	53.7
			Throughflow-peren.	48,182.3
			Total	*50,663.1*
River	Low Gradient	5,451.2	Bidirectional-tidal	7,291.8
	High Gradient	1,658.1	Throughflow	7,109.3
	Tidal Gradient	7,291.8	*Total*	*14,401.1*
	Total	*14,401.1*		
Pond	Natural	1,522.3	Bidirectional-tidal	42.4
	Dammed/Impounded	11,074.9	Inflow	1.6
	Excavated	9,155.5	Isolated	4,301.2
	Beaver	409.4	Outflow-artificial	1,198.7
	Total	*22,162.1*	Outflow-intermittent	449.9
			Outflow-perennial	1,796.7
			Throughflow-artificial	55.5
			Throughflow-interm.	603.2
			Throughflow-peren.	13,712.9
			Total	*22,162.1*

Figure 9. Distribution of open waterbodies by type. These numbers do not include wetlands associated with the deepwater habitats, but focus on the open water portion of them; for ponds, aquatic beds and unconsolidated shores are also included, but not contiguous vegetated wetlands.

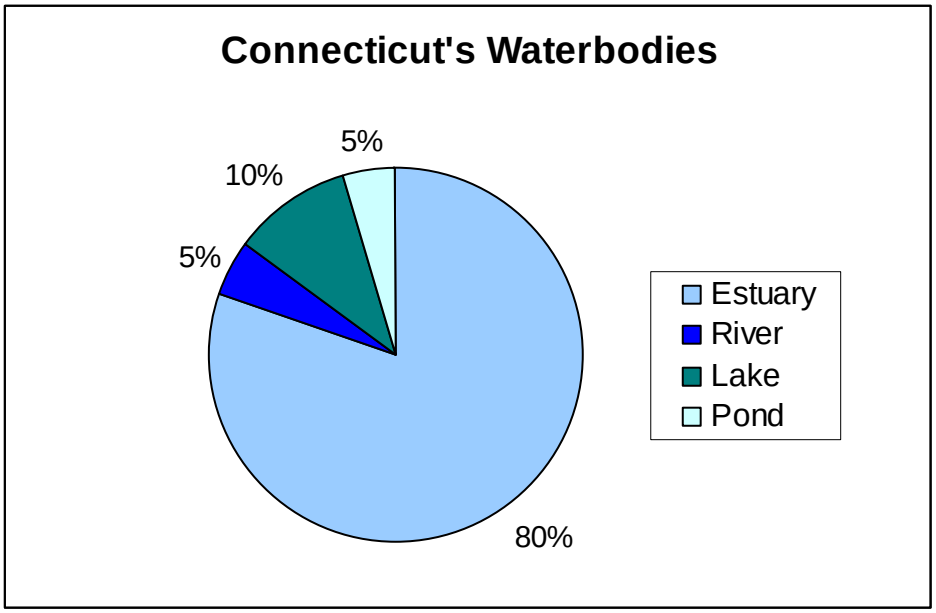


Table 9. Extent and characteristics of beaver and other natural ponds. (Note: Difference in sums is due to round-off procedures.)

Pond Type (code)	**Acreage**	**Water Flow Path**	**Acreage**
Bog (PD1a)	67.1	Bidirectional-tidal	0.4
Woodland-wetland (PD1b)	1,175.5	Isolated	182.5
Woodland-dryland (PD1c)	124.0	Outflow-artificial	18.9
Prairie-dryland (PD1e)	110.4	Outflow-intermittent	37.5
Interdunal (PD1o)	5.1	Outflow-perennial	225.4
Floodplain (PDq)	2.9	Throughflow-perennial	1,018.6
Other (PDr)	35.2	Throughflow-intermittent	36.8
Total	*1,520.2*	*Total*	*1,520.1*
Beaver	407.3	Isolated	7.8
		Outflow-artificial	41.4
		Outflow-perennial	35.5
		Throughflow-perennial	324.7
		Total	*409.4*

Table 10. Extent and characteristics of dammed/impounded ponds. (Note: Difference in sums is due to round-off procedures.)

Pond Type (code)	**Acreage**	**Water Flow Path**	**Acreage**
Agriculture (PD2a)	1,110.9	Bidirectional-tidal	10.4
Cropland (PD2a1)	186.9	Inflow	0.8
Livestock (PD2a2)	36.8	Isolated	1,181.6
Aquaculture (PD2b)	1.5	Outflow-artificial	404.8
Commercial (PD2c)	595.4	Outflow-intermittent	184.2
Comm-Stormwater (PD2c1)	5.0	Outflow-perennial	901.3
Industrial (PD2d)	103.7	Throughflow-artificial	4.9
Residential (PD2e)	3,991.6	Throughflow-intermittent	302.4
Resid-Stormwater (PD2e1)	2.3	Throughflow-perennial	8,084.7
Sewage Treatment (PD2f)	6.6	*Total*	*11,075.1*
Golf (PD2g)	71.4		
Other Recreational (PD2i)	402.5		
Mining (PD2j)	24.2		
Sand/gravel (PD2j1)	47.5		
Other (PD2o)	4,488.6		
Total	*11,074.9*		

Table 11. Extent and characteristics of excavated ponds. (Note: Difference in sums is due to round-off procedures.)

Pond Type (code)	**Acreage**	**Water Flow Path**	**Acreage**
Agriculture (PD3a)	1,135.0	Bidirectional-tidal	31.6
Cropland (PD3a1)	318.2	Inflow	0.8
Livestock (PD3a2)	53.8	Isolated	2,929.3
Aquaculture (PD3b)	1.9	Outflow-artificial	733.6
Commercial (PD3c)	664.2	Outflow-intermittent	228.2
Comm-Stormwater (PD3c1)	5.8	Outflow-perennial	634.5
Industrial (PD3d)	156.9	Throughflow-artificial	50.7
Indust-Stormwater (PD3d1)	5.9	Throughflow-intermittent	263.9
Indust-Wastewater (PD3d2)	6.2	Throughflow-perennial	4,284.9
Residential (PD3e)	3,866.3	*Total*	*9,157.5*
Sewage Treatment (PD3f)	21.5		
Golf (PD3g)	431.7		
Wildlife Management (PD3h)	7.2		
Other Recreational (PD3i)	224.6		
Mining (PD3j)	115.8		
Sand/gravel (PD3j1)	192.8		
Other (PD3o)	1,947.8		
Total	*9,157.7*		

Preliminary Landscape-level Functional Assessment

Wetlands are recognized as vital natural resources for the multitude of functions they perform (Table 12). It was not surprising that 90 percent or more of the state's wetlands were predicted to perform a number of functions at significant levels (Table 13; Figures 10 and 11). These functions include surface water detention (important for flood protection), sediment and other particulate retention (important for water quality renovation), nutrient transformation (important for productivity), carbon sequestration (important for mitigating climate change), and provision of habitat for "other wildlife" (not waterfowl, waterbirds, fish, or aquatic invertebrates). Other functions performed by most wetlands included maintenance of stream flow (vital for aquatic life), bank and shoreline stabilization (important for reducing erosion, sedimentation of waterbodies, maintaining water quality, and protecting private property), and provision of habitat for waterfowl and waterbirds. Wooded wetlands along streams contributed to the high rating for the latter function because they provide habitat for wood ducks. They were also recognized as important for fish and aquatic invertebrates since they provide shade that moderates water temperature vital to aquatic life. Less than half of the state's wetlands were rated as significant for fish and aquatic invertebrates as many wetlands are simply not wet long enough to support these species. Less than 10 percent of the state's wetlands provided space for temporary water storage from coastal storms (storm surge). These wetlands include tidal wetlands and low-lying nontidal wetlands that may be subject to infrequent flooding by storm tides. Given rising sea-level, coastal storm surge detention is a crucial function of high importance to coastal property owners. Also the nontidal wetlands rated as significant for this function will likely become tidal wetlands in the future. Only 7 percent of the state's wetlands were identified as unique, uncommon, or highly diverse wetland plant communities. This percentage is a very conservative estimate as the methods employed by this survey were not refined enough to do a comprehensive analysis. Moreover, if the state's field-verified data on critical habitats were included, the acreage of wetlands in this category would be higher. However integrating such data into the assessment was beyond the scope of this preliminary functional assessment.

Table 12. General relationships between wetlands and eleven functions. Predicted level of performance is also given for each function. (See Appendix A for more detailed correlation.)

Function	**Wetlands Predicted to Perform This Function**
Surface Water Detention	
High	Wetlands along rivers, streams, and lakes and subject to flooding for more than 2 weeks; throughflow ponds; stormwater treatment ponds
Moderate	Wetlands in same locations subject to brief flooding; other ponds (except some types, e.g., isolated impoundments)
Coastal Storm Surge Detention	
High	Tidal wetlands (excluding diked types)
Moderate	Diked tidal wetlands and freshwater wetlands along tidal wetlands
Streamflow Maintenance	
High	Headwater wetlands (except partly drained, impounded, and excavated types)
Moderate	Altered headwater wetlands; seasonally flooded wetlands along rivers and streams
Nutrient Transformation	
High	Seasonally flooded or wetter vegetated wetlands; vegetated tidal wetlands, intertidal reefs; nutrient-rich wetlands (e.g., fens)
Moderate	Temporarily flooded or seasonally saturated wetlands; ponds with mixtures of open water and vegetation
Carbon Sequestration	
High	Seasonally flooded or wetter vegetated wetlands; vegetated tidal wetlands (except vegetated rocky shores);wetlands on organic soil (bogs); aquatic beds
Moderate	Temporarily flooded or seasonally saturated wetlands; tidal mudflats; ponds (excluding some types, e.g., isolated impoundments)
Sediment/Particulate Retention	
High	Vegetated wetlands (excluding seasonally saturated types); throughflow ponds and associated vegetated wetlands; stormwater treatment ponds
Moderate	Nonvegetated wetlands (excluding seasonally saturated types); other ponds (with some exceptions, e.g., isolated impoundments)
Bank and Shoreline Stabilization	
High	Vegetated wetlands along river, streams, and estuaries (excluding island wetlands); rocky shores
Moderate	Nonvegetated intertidal wetlands (including reefs) in similar positions; vegetated wetlands along ponds

Fish/Aquatic Invertebrate Habitat

High	Marine intertidal wetlands (excluding irregularly flooded types); estuarine wetlands (except *Phragmites*-dominated); freshwater tidal marshes and flats; aquatic beds; semipermanently flooded wetlands along lakes, rivers, streams, and ponds; shallow water zone of lakes; mixed open water/vegetated wetlands; ponds associated with semipermanently or permanently flooded vegetated wetlands
Moderate	Seasonally flooded marshes along rivers, lakes, and streams; semipermanently flooded *Phragmites* marshes adjacent to open water; estuarine wetlands dominated by *Phragmites* but mixed with other species; regularly flooded Phragmites marshes; seasonally flooded-tidal forested and shrub wetlands mixed with emergent species; certain types of ponds (typically $\geq$ 1acre)

Waterfowl and Waterbird Habitat

High	Marine and estuarine wetlands (except *Phragmites*-dominated irregularly flooded marshes and artificial rocky shores); freshwater tidal marshes and flats; semipermanently flooded vegetated wetlands; aquatic beds; lacustrine flats and shallow water; seasonally flooded marshes; waterfowl impoundments
Moderate	*Phragmites* marshes contiguous to open water; estuarine shrub wetlands mixed with emergents; aquatic beds and ponds (>1 acre; excluding some types); seasonally flooded marshes (>1 acre) along intermittent streams and in depressions
Wood Duck	Seasonally flooded or wetter forested and shrub swamps (not shrub bogs) along rivers and streams

Other Wildlife Habitat

High	Vegetated wetlands >20 acres; wetlands 10-20 acres in size with 2 or more vegetated classes (except *Phragmites*); natural ponds
Moderate	Other vegetated wetlands

Unique, Uncommon or Highly
Diverse Wetland Plant Communities

Significant	Regularly flooded estuarine vegetated wetlands (low marsh), estuarine intertidal aquatic beds (not algae); oligohaline vegetated wetlands; riverine tidal marshes and flats; freshwater tidal marshes (including shrub swamps); river floodplain wetlands (including those in the freshwater tidal zone); acidic wetlands on organic soils (bogs and possibly Atlantic white cedar swamps); nutrient-rich fens; lotic fringe wetlands (excluding those dominated by dead woody plants) *(Note: This function is intended to identify wetlands that may be different from the majority of the state's wetlands and focuses on vegetation, landscape position, salinity, and special modifiers applied in the classification process. It excludes any ditched, excavated, or impounded wetland and those with Phragmites as dominant or co-dominant.)*

Table 13. Wetlands of potential significance for various functions for Connecticut. Note: Any difference in sums is due to round-off procedures.

Function	Significance	Acreage	% of All Wetlands
Surface Water Detention	High	138,423	63
	Moderate	59,889	27
	Total	**198,312**	**90**
Coastal Storm Surge Detention	High	16,886	8
	Moderate	2,887	1
	Total	**19,773**	**9**
Streamflow Maintenance	High	84,732	39
	Moderate	59,144	27
	Total	**143,876**	**66**
Nutrient Transformation	High	192,532	88
	Moderate	7,167	3
	Total	**199,699**	**91**
Sediment and Other Particulate Retention	High	154,471	70
	Moderate	54,739	25
	Total	**209,210**	**95**
Carbon Sequestration	High	193,036	88
	Moderate	21,800	10
	Total	**214,836**	**98**
Bank and Shoreline Stabilization	High	145,630	66
	Moderate	24,738	11
	Total	**170,368**	**78**
Fish and Aquatic Invertebrate Habitat	High	17,678	8
	Moderate	18,154	8
	(Subtotal)	(35,832)	(16)
	Shading	63,994	29
	Total	**99,826**	**45**

Table 13 (cont'd).

Function	Significance	Acreage	% of All Wetlands
Waterfowl and Waterbird Habitat	High	50,909	23
	Moderate	8,527	4
	Wood Duck	89,468	41
	Total	**148,904**	**68**
Other Wildlife Habitat	High	62,836	29
	Moderate	137,866	63
	Total	**200,702**	**91**
Unique, Uncommon or Highly Diverse Plant Communities*			
	Low Salt/Brackish Marsh	704	
	Oligohaline Marsh	18	
	Tidal Fresh Marsh	1,085	
	Tidal Fresh Shrub Swamp	480	
	Acidic Wetland (bog - "a")	500	
	Circumneutral Emergent Wetland	126	
	Circumneutral Forested Wetland	1,140	
	Circumneutral Shrub Swamp	160	
	Beaver-influenced wetlands ("b")	213	
	Semipermanently Flooded EM	1,810	
	Semipermanently Flooded FO	19	
	Semipermanently Flooded SS	159	
	Lotic River Floodplain	8,400	
	Riverine Tidal Flat	35	
	Riverine Nontidal Aquatic Bed	55	
	Total	**14,664.1****	**7**

*This listing is very conservative as the inventory was not intended to fully address this function; the state has more extensive and field-verified information on this type of function listed as "Critical Habitats" – see CTDEEP's GIS data on "Critical Habitats" (access data at: http://www.**ct**.gov/deep/gis).
**Actual sum of the above numbers is greater than this number since some wetlands were classified in two categories (e.g., beaver/semipermanently flooded, circumneutral/beaver, and circumneutral/semipermanently flooded).

Figure 10. Percent of state's wetlands predicted to perform various functions at significant levels. Note: Findings for "Uncommon Plant Communities" are very conservative.

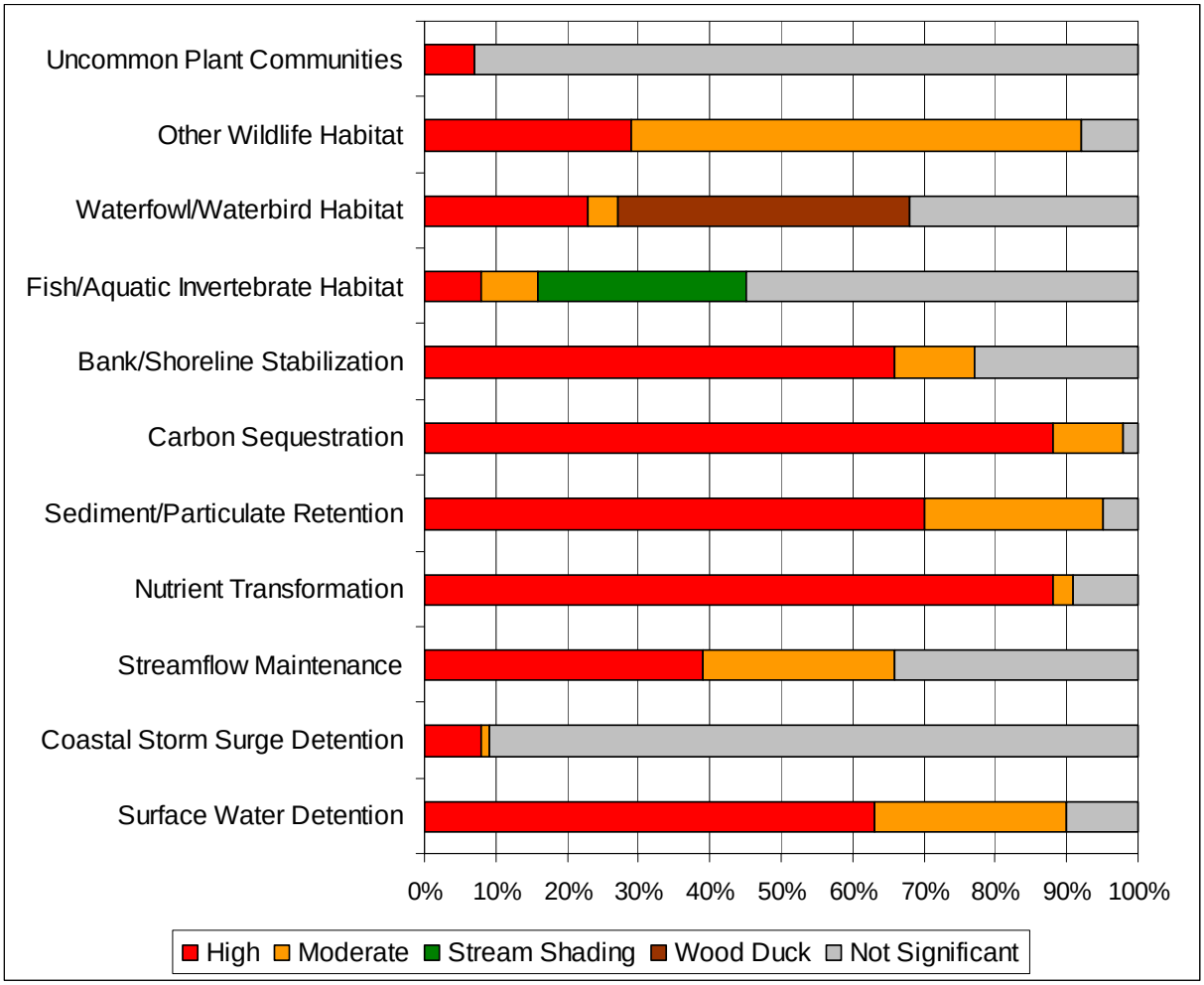
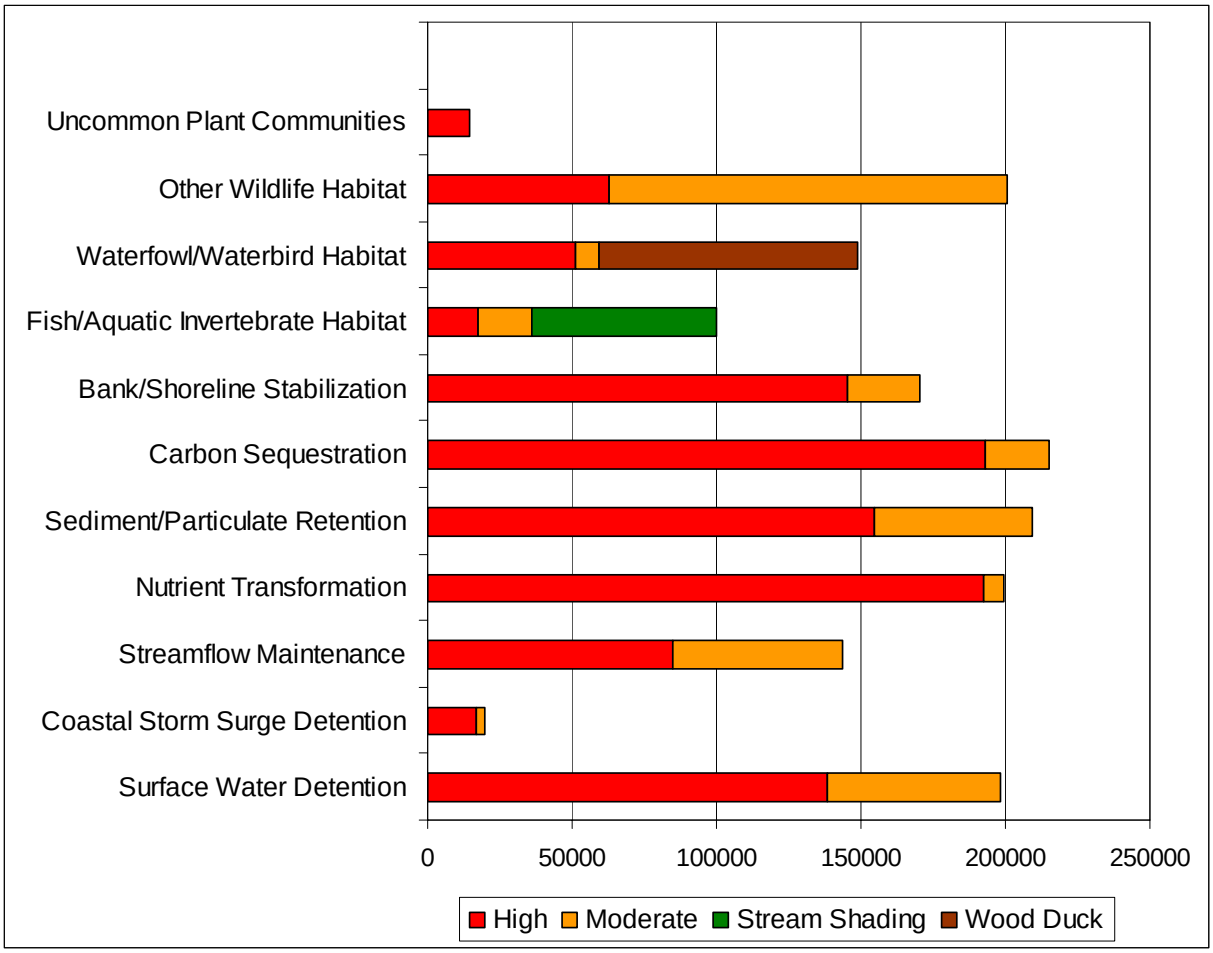


Figure 11. Statewide preliminary landscape-level assessment of wetlands: acreage of wetlands predicted to perform various functions at significant levels. Note: Findings for "Uncommon Plant Communities" are very conservative.



Watershed Findings

The results of this inventory and analysis for Connecticut's wetlands are generally summarized below. This section focuses on characterization, with more detailed characterizations plus the findings of the landscape-level functional assessment for each watershed presented in Appendix C.

Characterization of Wetlands

Wetlands Classified by Cowardin et al. Types

Three of the state's watersheds accounted for nearly three-quarters of the state's wetlands: the Connecticut, Thames, and Housatonic watersheds (Figure 12; Table 14). In large part the size of these watersheds affected these results as these three watersheds comprised over 75 percent of the state. Palustrine vegetated wetlands (forested, scrub-shrub, emergent, and aquatic beds) were the most abundant type in every watershed (Figure 13; Table 14). Estuarine wetlands were most extensive in the South Central Coast watershed which possessed more than half of the state's salt and brackish tidal wetlands (Figure 14). It had more than twice the acreage of the next ranked watershed – the Connecticut River watershed (Table 14; Figure 15).

Figure 12. Distribution of state's wetlands by watershed.

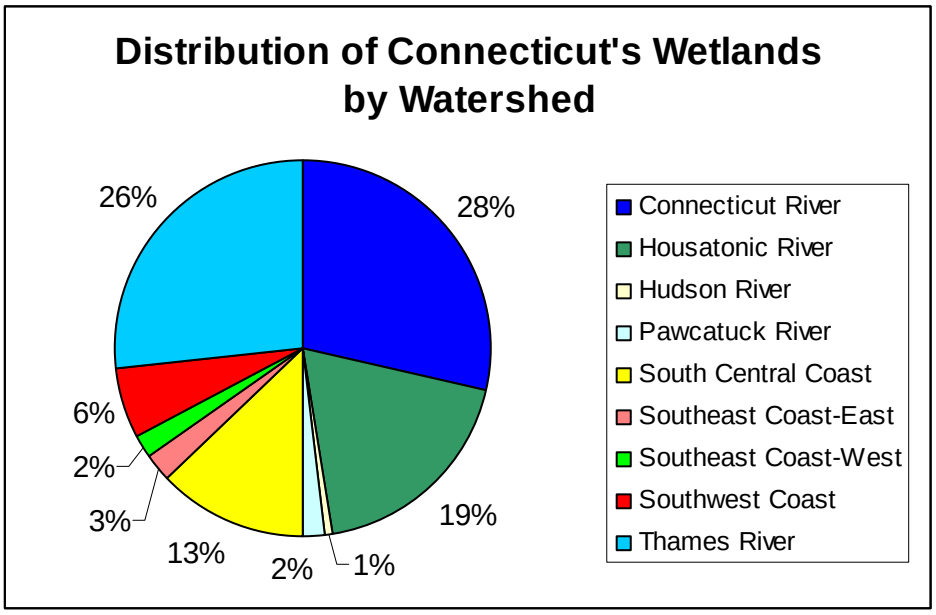


Table 14. Wetland acreage by watershed. The Southeast Coast watershed has been separated into subwatersheds since they occur on opposite sides of the Thames River.
Coding: E = estuarine; P = palustrine; Veg = vegetated; NVeg = nonvegetated; LW = lacustrine wetland; RW = riverine wetland; T = freshwater tidal wetland; f = farmed wetland.
Note: 4,040 acres of wetlands were not in any of the defined watersheds; they included 3,936 acres of estuarine wetlands and104 acres of palustrine wetlands.

Watershed	**EVeg**	**ENVeg**	**PVeg**	**PNVeg**	**LW**	**RW**	**Total (% of state's wetlands)**
Connecticut	2,604	183	1,893 T 52,376	24 T 29f 3,587	4 T 290	50 T 27	***61,067 (27.8)***
Housatonic	503	121	44 T 35,205	3,448	713	25	***40,059 (18.2)***
Hudson	--	--	1,020	81	--	--	***1,101 (0.5)***
Pawtucket	42	--	3,630	93 T	--	8	***3,773 (1.7)***
South Central Coast	5,886	594	148 T 18,574	7 T 2f 1,576	490	--	***27,277 (12.4)***
Southeast Coast (east)	910	30	119 T 4,468	3 T 194	6	--	***5,730 (2.6)***
Southeast Coast (west)	406	135	26 T 2,869	184	13	--	***3,633 (1.7)***
Southwest Coast	1,150	424	25 T 9,636	19 T 1,750	247	--	***13,251 (6.0)***
Thames	36	20	12 T 55,912	3,118 23f	427	76	***59,624 (27.2)***

Figure 13. Distribution and acreage of Connecticut's wetlands by watershed and classified by ecological system and vegetated/nonvegetated.

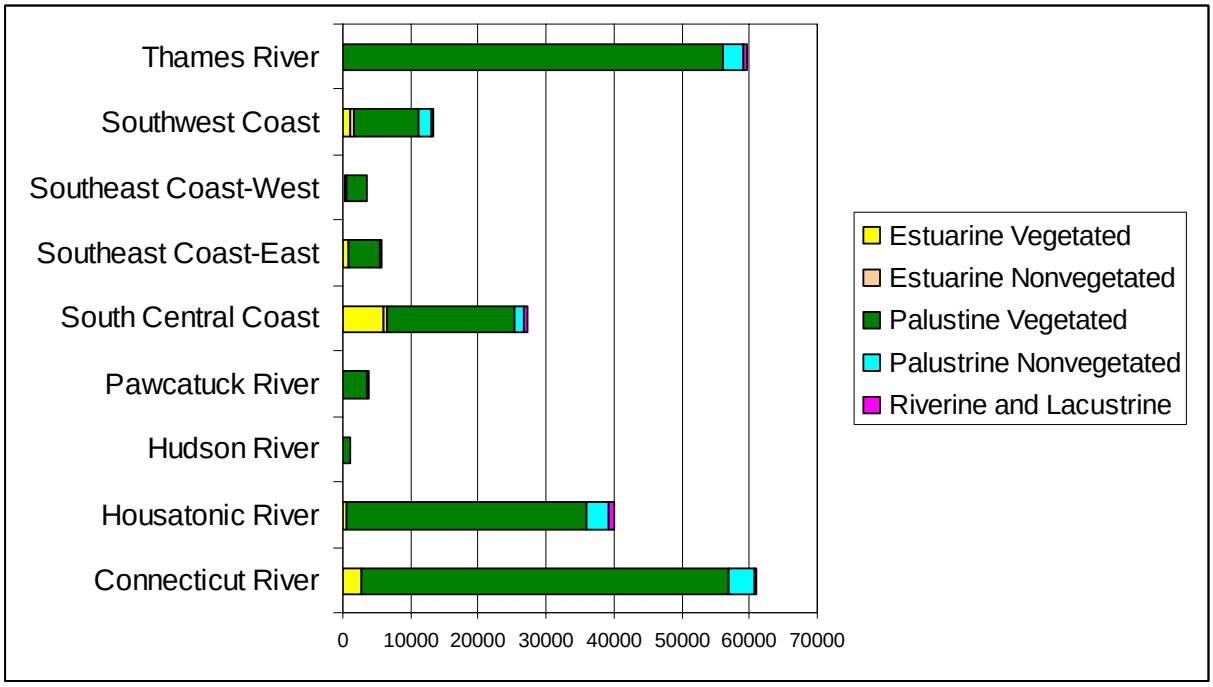


Figure 14. Percent of state's estuarine wetlands in each watershed. "0%" means less than 1%.

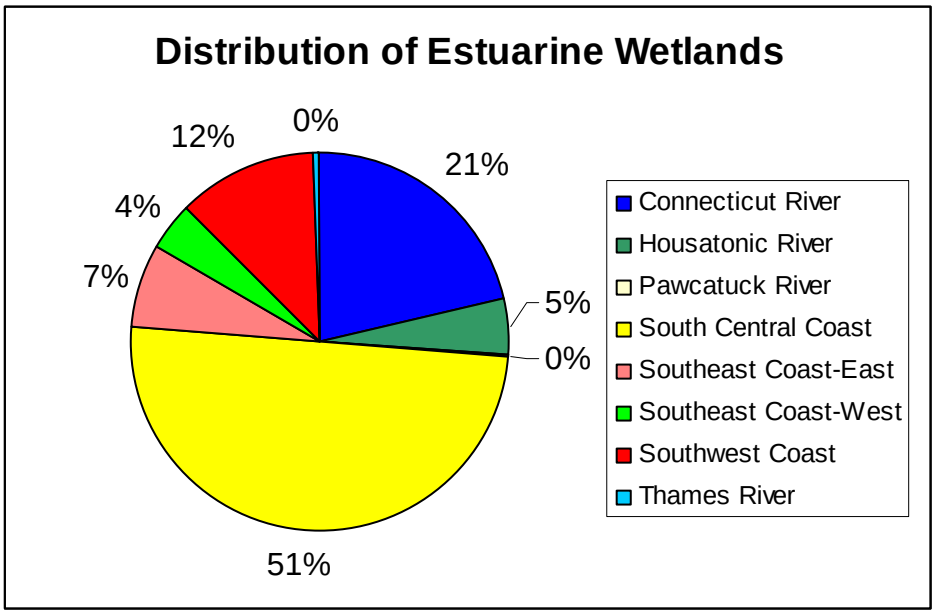
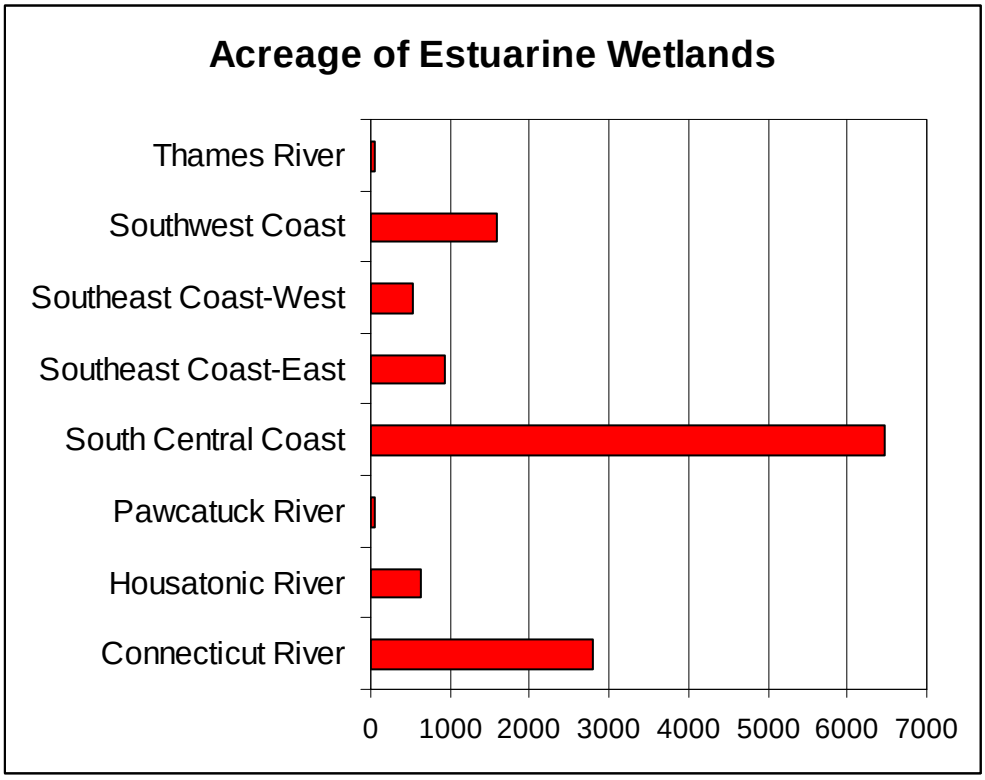


Figure 15. Acreage of estuarine wetlands in each watershed.



Wetlands Classified by LLWW Types

In all watersheds, wetlands occurred mostly along rivers and streams (lotic types) while terrene types (wetlands serving as sources of streams and isolated types) were second-ranked in abundance from the landscape perspective (Table 15; Figures 16 and 17). Lotic wetlands were most extensive in both the Thames and Connecticut watersheds with each possessing over 36,000 acres (Table 15; Figure 18). These two watersheds also accounted for more than half of the state's terrene wetlands (Figure 19). Lentic wetlands were most abundant in the Thames and Housatonic watersheds (Figure 20), while estuarine wetlands were most common in the South Central Coast watershed (Figures 14 and 15). Three-quarters of the state's ponds were found in the state's three largest watersheds – Connecticut, Housatonic, and Thames (Figure 21).

Table 15. Wetland extent classified by landscape position for each watershed. Note: Differences between these totals and those in Table 13 are due to round-off procedures.

Watershed	**Estuarine**	**Lentic**	**Lotic**	**Terrene**	**Pond**	**Total**
Connecticut	2,787	1,139	36,910	14,282	5,938	***61,056***
Housatonic	624	2,485	23,531	8,381	5,040	***40,061***
Hudson	--	--	812	179	111	***1,102***
Pawcatuck	42	262	2,451	786	232	***3,773***
South Central Coast	6,481	892	10,782	6,893	2,230	***27,278***
Southeast Coast-East	940	27	3,090	1,289	384	***5,730***
Southeast Coast-West	541	43	1,978	742	330	***3,634***
Southwest Coast	1,574	312	6,496	2,642	2,226	***13,250***
Thames	57	2,664	38,930	12,312	5,661	***56,624***

Figure 16. Extent of wetlands in each watershed classified by landscape position.

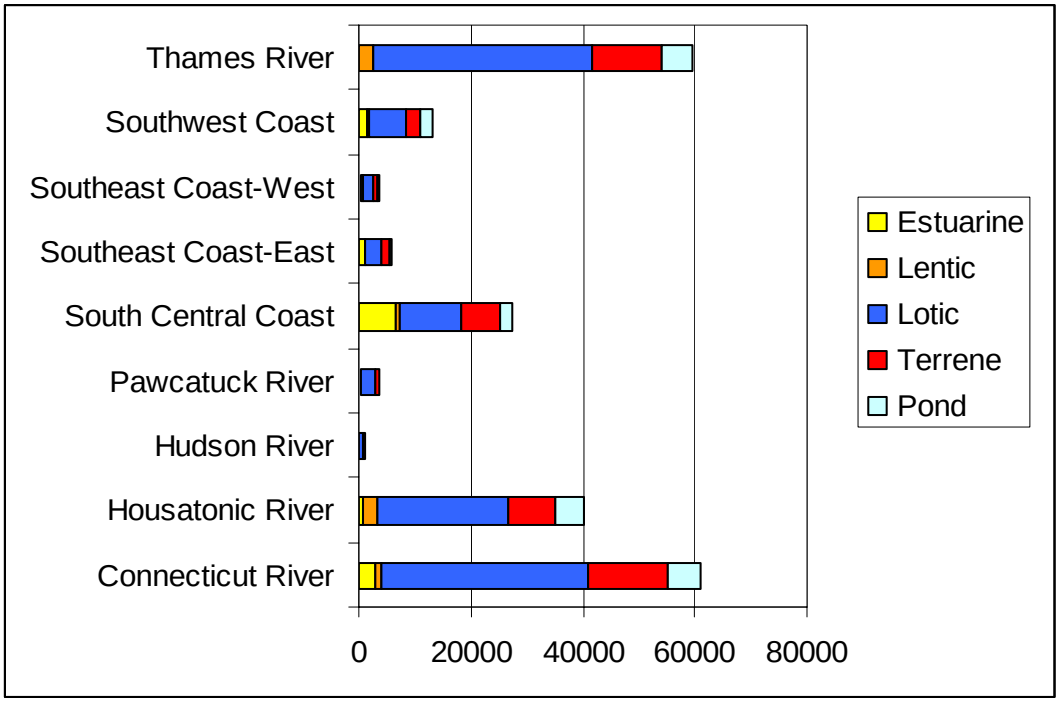


Figure 17. Percent of wetland types within each watershed.

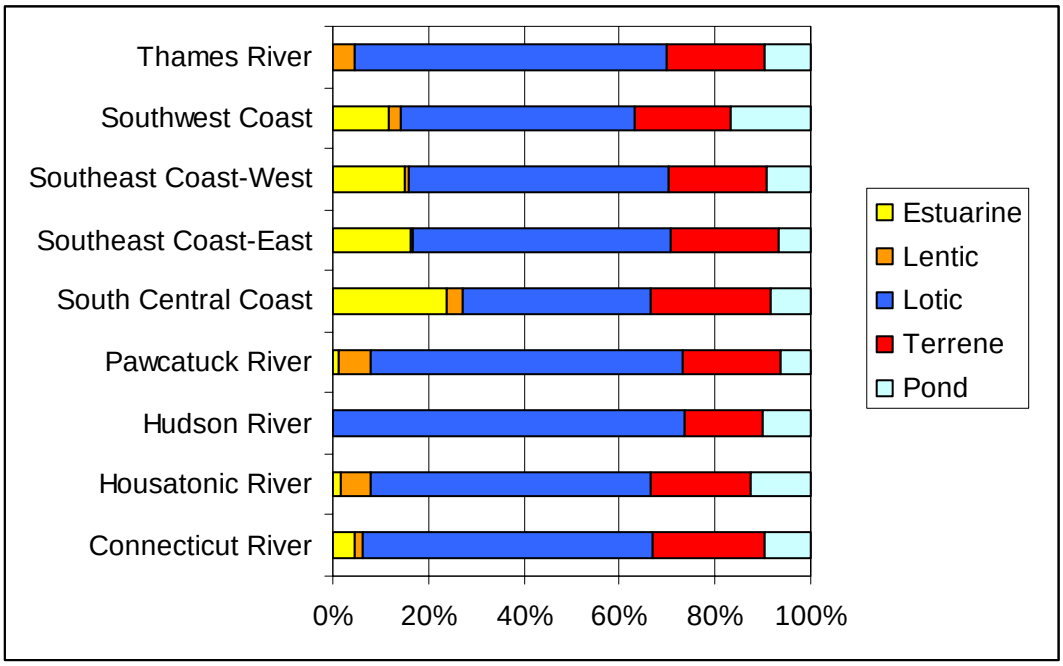


Figure 18. Percent of state's lotic wetlands in each watershed.

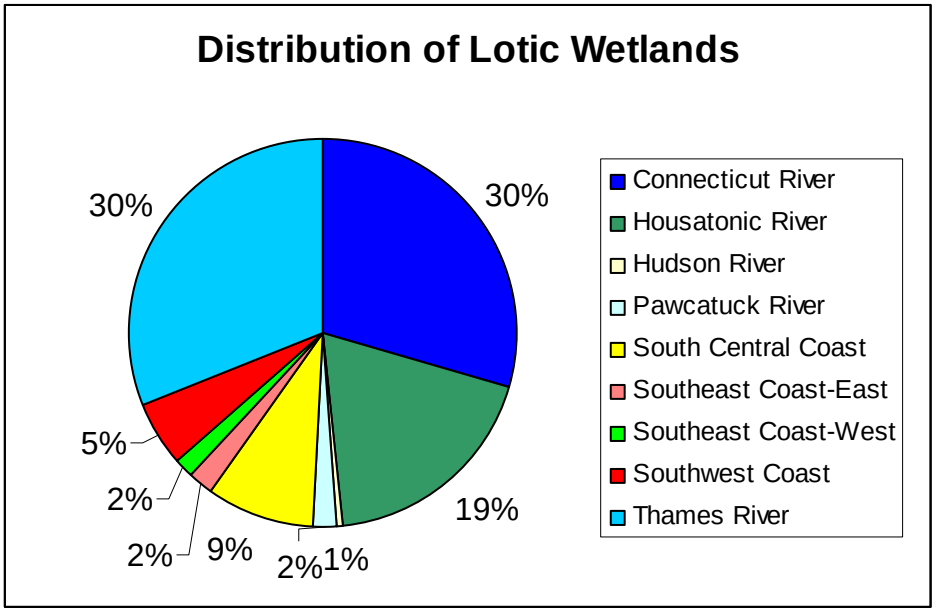


Figure 19. Percent of state's terrene wetlands in each watershed.

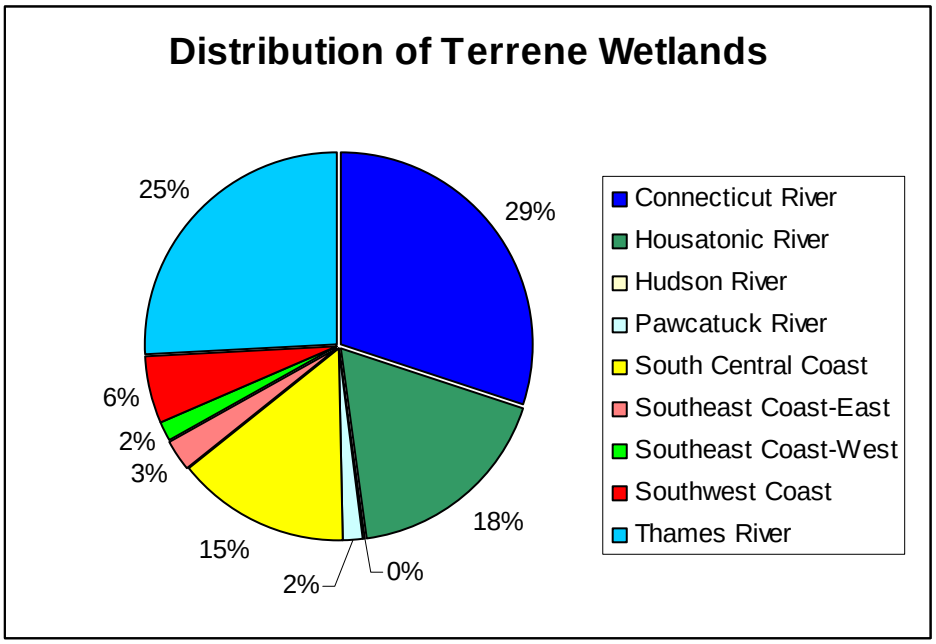


Figure 20. Percent of state's lentic wetlands in each watershed.

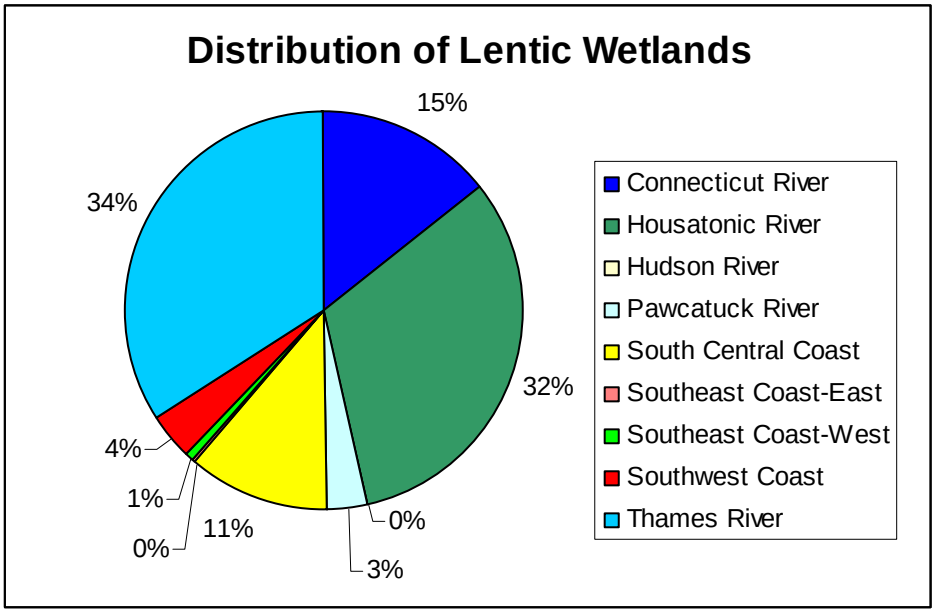
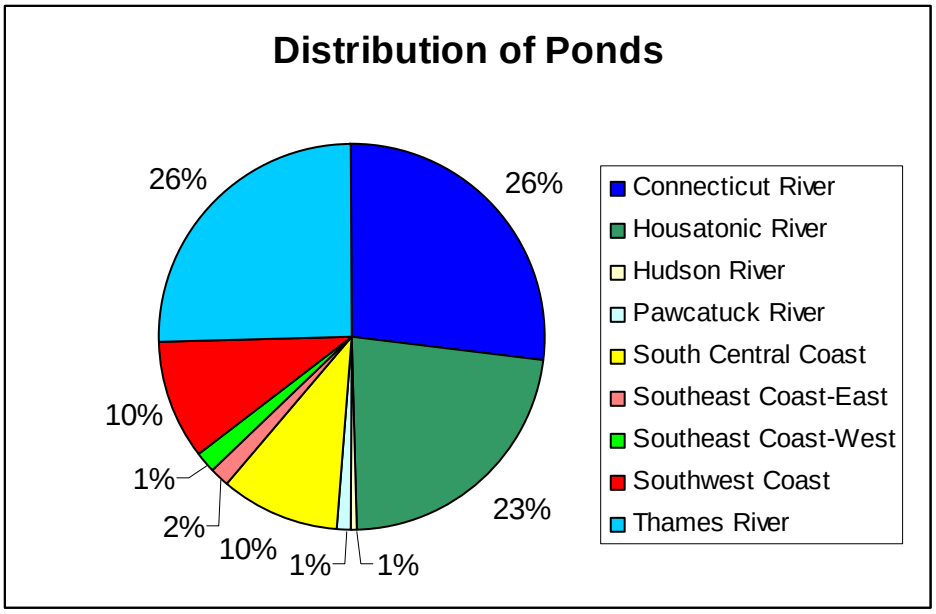


Figure 21. Percent of state's ponds in each watershed.



SUMMARY

Connecticut contains a wealth of diverse wetland types. Nearly 220,000 acres of wetlands occupy the state, accounting for roughly seven percent of the state's land mass. Most (91%) of the wetlands are freshwater types including wooded swamps (palustrine forested wetlands), shrub swamps (palustrine scrub-shrub wetlands), marshes and wet meadows (palustrine emergent wetlands), ponds (palustrine unconsolidated shores), and the shallow water zone of lakes and rivers. Tidal wetlands are mostly salt and brackish types (estuarine wetlands: 16,982 acres) but also include 2,371 acres of freshwater tidal types.

Nearly two-thirds of the state's wetlands occurred along rivers and streams (lotic landscape position), with most of them associated with streams. Terrene wetlands (outflow and isolated types) represented one-quarter of Connecticut's wetlands, while estuarine and lentic wetlands (along the shores of estuaries and lakes/reservoirs, respectively) made up the remainder. Eighty-four percent of the state's wetlands are basin types – either formed in depressions (natural or artificial, e.g., ponds) or behind roads, railroad embankments, or other development that restrict tidal flow to some extent. Estuarine wetlands with open access to Long Island Sound, its embayments, and coastal rivers make up most of the state's fringe wetlands. Floodplain wetlands subject to annual flooding along major rivers accounted for 6 percent of the wetlands. From the water flow path perspective, 63 percent or nearly two-thirds of the wetlands were throughflow types, while outflow and isolated types comprised most of the remaining wetland acreage (13% and 12%, respectively).

Since wetlands are recognized as vital natural resources for the multitude of functions they perform, it was not surprising that more than 90 percent of the state's wetlands were predicted to perform a number of functions at significant levels. These functions include surface water detention (important for flood protection), sediment and other particulate retention (important for water quality renovation), nutrient transformation (important for productivity), carbon sequestration (important for mitigating climate change), and provision of habitat for "other wildlife" (e.g., more terrestrial species).

Three of the state's watersheds accounted for nearly three-quarters of the state's wetlands: the Connecticut, Thames, and Housatonic watersheds. Palustrine vegetated wetlands (forested, scrub-shrub, emergent, and aquatic beds) were the most abundant type in every watershed. Estuarine wetlands were most extensive in the South Central Coast watershed which possessed more than half of the state's salt and brackish tidal wetlands. In all watersheds, wetlands occurred mostly along rivers and streams (lotic types) while terrene types (wetlands serving as sources of streams and isolated types) were second-ranked from the landscape perspective. Lotic and terrene wetlands were most extensive in both the Thames and Connecticut watersheds. Lentic wetlands were most abundant in the Thames and Housatonic watersheds. Three-quarters of the state's ponds were found in the state's three largest watersheds – Connecticut, Housatonic, and Thames.

The findings presented in this report are particularly noteworthy in that they are the first statewide landscape-level wetland functional assessment done for Connecticut. This

preliminary assessment is a starting point for more rigorous assessments. It attempted to identify wetlands that may likely provide significant functions based on generally accepted principles and the source information used for this analysis. This assessment is most useful for regional or watershed planning purposes, for a cursory screening of sites for acquisition, and to aid in developing landscape-level wetland conservation and protection strategies. The approach can also be used to evaluate cumulative impacts on wetlands on key functions and to predict the expected benefits of restoring wetlands at numerous sites.

ACKNOWLEDGMENTS

Numerous individuals contributed to the mapping of Connecticut's wetlands. Wetland photointerpretation was performed by the Conservation Management Institute (CMI) at Virginia Tech University. CMI did wetland interpretation, quality control, database construction, and GIS analysis of the data for this project, with major contributions from Kevin McGuckin, Nicole Fuhrman, Brian Diggs, and Dave Orndorff. Scott Klopfer, Executive Director of CMI was instrumental in developing the agreement and creating the team to do this work. Ralph Tiner (Regional NWI Coordinator) designed the project, coordinated the inventory, performed quality assurance review of the geospatial data, and prepared the report. Kevin McGuckin was the project coordinator for CMI. Tim Fannin, Jo Ann Mills, and Bill Wilen of the U.S. Fish and Wildlife Service and Bob Gilmore (CTDEEP) provided peer review for this report.

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APPENDICES

APPENDIX A: Correlation table showing wetlands of significance for each of eleven functions

Note: For a key to the codes that appear on the following list, see "Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors: Version 2.0." (Tiner 2011) http://digitalmedia.fws.gov/cdm/ref/collection/document/id/1324)

CORRELATION BETWEEN FUNCTIONS AND WETLAND TYPES:
CONNECTICUT FUNCTIONAL ASSESSMENT

Function (code)	Level of Function	Wetland Types
Surface Water Detention (SWD)	High	LEBA (excluding LE5 and LE6 wetlands and wetlands with "K" water regime unless in a reservoir or dammed lake), LEFR (excluding LE5 and LE6 wetlands and wetlands with "K" water regime unless in a reservoir or dammed lake), LEFL (only in reservoir or dammed lake: LE2FL and LE3FL; not in impoundments), LEIL (not "A", "B" or "K" water regime), LSBA, LRFPba, LSFR (not "A" water regime), LRFR (not "A" water regime), LRIL (not "A" water regime), PDTH, TEFRpdTH, TEBApdTH, TEBATH, TEBATI, PD2c1, PD2d1, PD2e1, PD3c1, PD3d1, PD3e1
	(Note: The high level should not include any wetlands with "A" or "B" water regimes with one exception for LEFL in reservoirs or dammed lakes. Retained floating mat bogs such as LEFR because their area will store surface water when lake levels rise. Does not include areas now classified as LK that were mapped as PUB_ by NWI following NWI mapping conventions. Also should not include any LE wetland associated with an artificial freshwater impoundment completely surrounded by estuarine wetland or water, or any isolated impounded ponds and associated wetlands.)	
	Moderate	LRFPfl, LRFR (other than above), LSFL, LE1FL, LEIL (other than above, excluding LE5 and LE6 wetlands), LSFR (other than above), TEBA (other than above; excluding isolated impounded), PD (other except PD2f , PD3f, and isolated impounded ponds), TE__pd (other, excluding slope wetlands TESLpd__), TEFP__, TEFL__
	(Note: This function should not include any tidal wetlands – E2___, R1US, R1EM, and P___N, R, S, T and V - as they are covered under the Coastal Storm Surge function.)	

Coastal Storm Surge Detention (CSS)	High	ESBA, ESFR, ESIL, LR5FR, LR5FP, LR5IL, LS5BA, LS5FL, LS5FR, MAFR, MAIL, LE__BT (should exclude diked wetlands and tidal ponds that are impounded and associated tidal wetlands in these categories since the dike prevents storm flowage except during extremes such as hurricanes)
	Moderate	Other tidal wetlands not include above (which includes diked tidal wetlands) and any TE wetland (except SL - slope) or LS1 wetland contiguous with an estuarine wetland (usually marked by “ed” – these are bordering nontidal wetlands subject to infrequent or occasional tidal flooding during storms), TE wetland (except SL – slope) contiguous with marine waters or wetlands (should be marked with “md” or “ow”), TE__tr, TE__td, LS1_td, LS1_tr
	(Note: Taking a conservative approach by focusing on lowland wetlands along the estuary and not including similar wetlands in the tidal freshwater reach.)	
Streamflow Maintenance (SM)		
	High	"hw" wetlands (unaltered - excluding "d", "h", and "x" types)
	Moderate	altered "hw" wetlands (excluding "h" types), LR1FPba (excluding “h” or “d” types), LS__BA (excluding "h" and not LS5), TEBAOUds (excluding “h” or “d” types)
	(Note: While acreage of headwater wetlands may increase due to building ponds in headwater seeps (point features not polygons) and blocking drainageways, these wetlands do not increase streamflow and are not included in this function. However, when headwater vegetated wetlands are excavated to create ponds, the streamflow maintenance function is lowered from high (natural headwater wetland) to moderate as the wetland still provides for flow at high water periods and some flow at other times as well.)	

Nutrient Transformation (NT)	High	P__(AB, EM, SS, FO and mixes)C, P__(AB, EM, SS, FO and mixes)E, P__(AB, EM, SS, FO and mixes including __/UB and UB/__, etc.)F, P__(AB, EM, SS, FO and mixes)R, P__(AB, EM, SS, FO and mixes)T, P__(AB, EM, SS, FO and mixes)N, P__(AB, EM, SS, FO and mixes)H, P__(AB, EM, SS, FO and mixes)L or V, E2AB, E2EM (and mixes), E2SS (and mixes), E2FO (and mixes), E2RF, M2AB, P__(AB, EM, SS, FO and mixes)Bt (fen) , L2_(AB, EM and mixes)C, L2_(AB, EM, and mixes)E, L2_(AB, EM, and mixes)F, L2_(AB, EM, and mixes)H, L2_(AB,EM, and mixes)N, L2_(AB,EM, and mixes)R, L2_(AB,EM, and mixes)T, L2_(AB, EM, and mixes)V
	(Note: In relevant regions, try to separate fens from bogs as the former are nutrient-rich sites while the latter are nutrient-poor sites: use circumneutral modifier "t" to identify fens EM1_t, SS__t, FO__t from bogs PSS__Ba, PFO__Ba, for example GA coast – Include PFO3B, PSS3B and mixes of the two since they are permanently saturated; but not mixes with other types of "B" wetlands (FO1, FO4, EM, etc.).. Exclude PFO5 and PSS5 from high.)	
	Moderate	P__(AB, EM, SS, FO and mixes)B (not "t" fen), P__(AB, EM, SS, FO)A, P__(AB, EM, SS, FO and mixes)S, L2EM_A, PUS/__(mixed with vegetation classes excluding FO5 and SS5), PUB/__(mixed with vegetation classes)H, L2EM_S, PFO5/other vegetated, PSS5/other vegetated
	(<u>Note</u>: Commercial cranberry bogs – PSSf – are not rated as significant for this function, nor are other farmed wetlands - Pf.)	

Carbon Sequestration (CAR)	High	P__ (AB,EM, SS, FO, and mixes)E, P__ (AB,EM, SS, FO, and mixes)F, P__ (AB,EM, SS, FO, and mixes)C, P__ (AB,EM, SS, FO, and mixes)T, P__ (AB,EM, SS, FO, and mixes)R, P___Ba (and mixes), P____g (=wetlands on organic soils), E2EM (and mixes), E2SS (and mixes), E2FO (and mixes), R1EM, R_EMC, R_EME, R_EMF, L2EM_F, L2EM_E, L2EM_C, L2AB_F, L2AB_H, P__B (permanently saturated types; bogs noted with "a"), L2AB_G, L2AB_V, R_AB_F, R_AB_G, R_AB_V, R_AB_H, PAB_V, PAB_G, PAB_H
	(Note: Bogs and other permanently saturated wetlands and wetlands with organic soils should be rated as high for this function. Exclude AB1, PFO5 and PSS5 from 'High'. GA coast – Include PFO3B, PSS3B and mixes of the two since they are permanently saturated; but not mixes with other types (FO1, FO4, EM, etc.).)	
	Moderate	P__ (AB,EM, SS, FO, and mixes)A, P__ (AB,EM, SS, FO, and mixes)B (seasonally saturated types; permanently saturated types should be rated as High), P__ (AB,EM, SS, FO, and mixes)S, E2AB, R_EMA, L2EM_A, E2US (including mixes dominated by nonvegetated class; focus on mudflats and organic flats for purely nonvegetated types and exclude sand flats/beaches and other substrates; not E2US_P), R1US (and mixes dominated by nonvegetated class; focus on mudflats and organic flats for purely nonvegetated types and exclude sand flats/beaches and other substrates), PUB (and mixes; and not PD2 b,c,d,e1,and f or PD3 b,c,d,e1, f and j1; also exclude isolated impounded ponds), PUS/vegetated, and L2US/vegetated, L2UB/vegetated, PFO5 (excluding isolated and impounded), PSS5 (excluding isolated and impounded)
	(Note: Mixes for vegetated wetlands are those where vegetation is the dominant class, while mixes for nonvegetated wetlands are those where the substrate is the dominant class. Commercial cranberry bogs – PSSf – and other farmed wetlands P__f are not included; also "mixes" should include nonvegetated wetlands where vegetated types predominate and vegetated wetlands where nonvegetated types predominate. If mapping includes any H, G or V wetlands that are vegetated by vascular plants other than aquatic bed species – not dead trees, they too should be rated as high for this function. Also exclude M2AB1__ and E2AB1__ as these types are typically associated with rocky shores as mapped.)	

Sediment and Other Particulate Retention (SR)	High	ES__(vegetated and mixes), LEBA, LEFR (vegetated and mixes, not “fm”-floating mat), LEIL(veg and mixes, not “fm”), M2AB3__, LSBA, LRBA, LSFP, LRFP, LRFR (veg, not “fm”), LSFR(veg, not “fm”), LRIL (veg, not “fm”), PDTH, TE__pdTH (including __pq), PDBT, TE__pdBT, TEBATH, TEBATI, TEIFbaTH, TEIFbaTI, TEFRpdTH, PD2c1, PD2d1, PD2e1, PD3c1, PD3d1, PD3e1
	Moderate	E2__(US, SB, RF, excluding RS), LEFR (nonveg), LEFL (veg), LSFL (not P___B_), LRIL (nonveg), LRFR (nonveg), LSFR (nonveg), M2US, M2RF, Other TEBA (not P__B_), PD1, PD2 and PD3 (not c, d, e, f, g, j types), PD4, TEFLpd (not P__B_), TEFP__ (not P_B_), TEFL__ (P__A, not P__B_), TE__pdOU, TE__pdIN, Other TEFRpd__
	(Note: No “B” wetlands should be identified as significant for this function; only flooded types: A, C, E, F, H, R, S, T, R, N, M, and L should be rated. This will exclude bogs.)	
Bank and Shoreline Stabilization (BSS)	High	E2__(AB, EM, SS, FO and mixes; not IL), E2RS (not ESIL), E2US_P (not ESIL), M2RS(not MAIL), M2AB1N (not IL), LR_(AB, EM, SS, FO and mixes; not LRIL and not “fm”), LS_(AB, EM, SS, FO and mixes and not “fm” ”), LE__(AB, EM, SS, FO and mixes; not LEIL and not “fm” ”), R_RS, L2RS
	Moderate	E2US_N or M (not IL), M2US (not IL), TE__pd (AB, EM, SS, FO and mixes), TE__OUhw (AB, EM, SS, FO and mixes), E2RF (when occur along a shoreline), M2RF (when occur along a shoreline)
	(Note: Exclude IL wetlands from this function since they are not shoreline features.)	

Fish and Aquatic
Invertebrate Habitat (FAIH)

High	E2EM (including mixes with other types where EM1 or EM2 predominates; excluding E2EM5P__ and mixes where EM5 predominates and mixed communities dominated by E2FO or E2SS), E2US_M, E2US_N, E2RF, E2AB, E2RS/AB, L2_F, L2_H or G, L2AB, L2UB/__(AB, EM, SS, FO), LE__ (vegetated; AB, EM, SS, FO) and NWI water regime = H (permanently flooded), M2AB, M2RS/AB, M2US_M, M2US_N, M2RF; P__F and adjacent to PD (PD1, PD2 a3,b,and h, PD3b and h, and PD4 only), LK, RV (all except LR4), or ST (all except LS4) waters; P__F and __FRsl or __BAsl (slough), PAB (not excavated or impounded), PUB/__(AB, EM, SS, FO), P__(EM, SS, FO)H, PEM__(N,R,T, or L, except EM5), PSS_T, PFO_T, PD (PD1, PD2 a3,b,and h, PD3b and h , and PD4 only) associated with P__(AB, EM, SS, FO)F, R1EM, R1AB, R1US(except S), R2AB, R2EM, PD (PD1, PD2a3, 2b, 2h, PD3b, and 3h, and PD4) associated with P__(AB, EM, SS, FO)H

(Note: M1AB3L = submerged eelgrass – important habitat but is not wetland so it is not included above; reports will note this. L2__K wetlands were not rated due to unknown management.)

Moderate	LE__ and PEM1E (and mixes and contiguous with waterbody), LR__ and PEM1E (and mixes and contiguous with waterbody), LS__ and PEM1E (and mixes and contiguous with waterbody), PEM5F and adjacent to LK, RV (except LR4), or ST(except LS4) waters, E2EM5N (and mixes), PEM5N (and mixes), E2EM5/1P, E2EM5P__ and adjacent to the estuary (and mixes, but not "interior" E2EM5P_), E2FO/EM__ (not EM5), E2SS/EM__ (not EM5), LR5__ and PFO/EM_R or T (not EM5), LS5__ and PFO/EM_R or T (not EM5), LS5__ and PSS/EM_R or T (not EM5), PD (≥ 1 acre in size and PD1, PD2 a, b, h, PD3 a3, b, h, or PD4), TEFRpd (along these ponds), PAB (impounded or excavated and ≥1 acre and not associated with PD2 c,d,e,f,and g or PD3 c,d,e,f, and g), LR_FPba

		(Note: Ponds one acre or greater and certain types were selected as moderate. Residential ponds 5 acres or greater were also identified as moderate for CT assessment; larger size was used to exclude ponds in dense urban/suburban areas.)
	Stream Shading (Shade)	LS (not LS4 or not LS__pd) and PFO, LS (not LS4 or not LS_pd) and PSS (not PSS_Ba or not PSSf); excluding FO5 and SS5
	(Note: Shrub bogs should be excluded from all the above, e.g., PSS3Ba and commercial bogs = PSSf)	
Waterfowl and Waterbird Habitat (WBIRD)	High	E2EM1 or E2EM2 (includes mixes where they predominate), E2EM5N, E2US__ M, N, P, and T water regimes (not S water regime), E2RF, E2AB, E2RS, L2_F (vegetated, AB, EM, SS, FO and mixes with nonvegetated), L2AB (and mixes with nonvegetated), L2US_(F,E, C, R, or T), L2UB_F, L2_H (vegetated, AB, EM, SS, FO and mixes with nonvegetated), M2AB, M2RS (excluding jetties and groins – M2RSPr), M2US, M2RF, P__F and adjacent to PD (PD1, PD2a3, 2h, PD3h, and PD4 only), LK, RV(not LR4) or ST (not LS4) waters or along a slough ("sl" modifier); PAB (not excavated or impounded, except those associated with wildlife impoundment – "wi"), P__T, P__H (vegetated, EM, SS, FO including mixes with UB), PEM1Eh, PEM1Eb; PUS_F, PUS_E, LS__ and PEM1E (including mixes; not LS4), LR__ and PEM1E (including mixes; not LR4), TE__ hw and PEM1E (including mixes); LE__ and PEM1E (including mixes); PEM_N (and mixes), PEM__R, (includes mixes, but excludes Phragmites-dominated EM5), P__/EM_N, and P__/EM_R (not EM5), PD2h, PD3h, PD4, PD1 associated with P__(AB, EM, SS, FO)F, PD associated with P___T, PD1 associated with P__(AB, EM, SS, FO)H, PUB__b, R1EM, R_EMF, R1US (except S water regime), TE_pd and PEM1E (including mixes)

Moderate	E2EM5P (and mixes) and contiguous with open water (not "interior" marshes), E2SS1/EM1P6, E2SS1/EM1Ph, E2EM5/1P, PEM5__E,F, R, or T and adjacent to PD, LK, RV(not LR4), or ST(not LS4), other L2UB (not listed as high), Other PD (≥ 1 acre in size and PD1, PD2 a, h, PD3 a, h, or PD4), Other P__F (vegetated wetlands), PAB (impounded or excavated and >1 acre), LS4 and PEM1E (> 1 acre in size), TEBA and PEM1E (> 1 acre in size)
Wood Duck	LS(1,2, or 5)BA and P__ (FO or SS and mixes; not PSS3Ba or PSSf – commercial cranberry bog), LS(1,2, or 5)FR and P__ (FO or SS and mixes; not PSS3Ba or PSSf), LR(1,2, or 5)FPba and P__(FO or SS and mixes; not PSS3Ba or PSSf), LRFPba and PUB/FO; PFO_R, T, or L (and mixes) and contiguous with open water, PSS_R, T, or L (and mixes) and contiguous with open water

(Note: All waterfowl impoundments and associated wetlands that should be marked with "wi" should be rated as high for this function. Ponds used for aquaculture (2b, 3b) are excluded since management will likely deter use of these ponds; associated wetlands should also be excluded as should wastewater treatment, industrial, and commercial ponds and lakes and associated wetlands. Shrub bogs, e.g., PSS3Ba, commercial bogs = PSSf , and farmed wetlands: P__f should be excluded in Northeast, but check use of farmed wetlands in Prairie Pothole and elsewhere. Comment: PEM1C wetlands along waterbodies may also be important for this function in some regions, but in the Northeast these may be wet meadows rather than marshes; these wetlands are recognized as important for "Other Wildlife.")

Other Wildlife Habitat (OWH)	High	Any vegetated wetland complex ≥ 20 acres, wetlands 10-20 acres with 2 or more vegetated classes (excluding EM5), certain ponds (PD1a, b, c, d, e, f, h, i, j, k, l, m, n, o, p, q1, q2, q3, q4) , freshwater wetlands (P___ or L2____) on undeveloped portions of barrier islands or beaches, small permanently flooded or semipermanently flooded wetlands (including PUBH and PUBF) within a forested wetland or upland forest (can use specific PD types to identify these), other forested or scrub-shrub wetlands within 100m of these permanently flooded or semipermanently flooded wetlands
	Moderate	Other vegetated wetlands
	(Note: Vegetated wetlands should focus on EM, SS, and FO; exclude AB from the size determination of a vegetated wetland complex, but include AB mixes with EM, SS, and FO (e.g., AB/FO, EM/AB) except FO5 and SS5.)	
Unique, Uncommon, or Highly Diverse Wetland Plant Communities (UWPC)	Regionally significant	E2EM1N, E2EM1P6, R1EM, R1US (only where vegetated in summer), PEM1N, PEM1R, PEM2N, PEM2R, PSS_R, PSS_T, PFO4__g and PSS4__g (Atlantic white cedar; including mixtures), P___t (fens – EM, SS, FO), E2AB__ (eelgrass and SAV beds-not algae), LS__FR (excluding PFO5 and SS5), LR__FR excluding PFO5), *PD1m (woodland vernal pool), E2EM1N6, PEM1T
	(Note: Exclude any altered wetland – x, h, td, and tr – plus any "d" wetland that is channelized or extensively ditched; also exclude any EM5 wetland or wetland mixed with EM5 unless it is native Phragmites. R1US wetlands only where mapped on leaf-off imagery and no summer image was available; otherwise should be mapped as R1EM2 where vegetated in summer with emergents.)	

APPENDIX B. Introduction to the NWI+ Web Mapper

Introduction to the NWI+ Web Mapper

The NWI+ Web Mapper is an online mapping tool based on ESRI's ArcGIS online mapping platform that allows users to view special project data prepared by the U.S. Fish and Wildlife Service (FWS) but not available through the FWS's "Wetlands Mapper." The data were prepared for special projects and are not a standard NWI product. In addition to viewing NWI types for these areas, a number of other data layers are available. These layers may show wetlands classified by hydrogeomorphic properties (landscape position, landform, and water flow path = LLWW descriptors), areas that may support wetlands based on soil mapping (hydric soils lacking a recognizable wetland photo-signature = P-wet areas), wetlands that have been predicted to be important for providing numerous functions, and potential wetland restoration sites. These layers are briefly described below. Once you have opened the mapper, you'll see icons on the tool bar above the map plus a list of five topics: "Intro to the Mapper" (a must-read description of mapper contents and operation), "Wetlands One-Stop" (takes you to the page where other sources of wetland information can be accessed), "NWI" (takes you to the FWS's official NWI website), "Northeast NWI" (takes you to the home page of the Northeast Region's NWI Program), and "CMI" (takes you to the home page of Virginia Tech's Conservation Management Institute). For additional information on this tool and related topics, visit the Association of State Wetland Managers' "Wetlands One-Stop" website at http://aswm.org/wetland-science/wetlands-one-stop-mapping. (*Note: The mapper will likely be upgraded periodically so the actual procedures may vary slightly but using the guidance below should prepare users for future versions.*)

NWI+ Data Layers

Several data layers may be available for each project area: NWI Types, LLWW Types (NWI+ Landscape, NWI+ Landform, and NWI+ WaterFlowPath), eleven Functions, Restoration Types (NWI+ Restoration Type1, NWI+ Restoration Type2), NWI+ P-WetAreas, and layers for accessing more information (e.g., Wetland Codes). These layers are described below. For questions, contact Ralph Tiner, Regional Wetland Coordinator, U.S. Fish and Wildlife Service (FWS) at: ralph_tiner@fws.gov.

NWI Types (*NWI-Common Types*) – this layer displays wetlands and deepwater habitats mapped by the U.S. Fish and Wildlife Service's National Wetlands Inventory Program and classified by the FWS's official wetland classification system (Cowardin et al.1979). (Note: Any differences between NWI+ data and NWI online data can be viewed by adding NWI data from the official NWI website as a separate layer.) For display purposes wetlands have been separated into a number of groups typically by ecological system (Marine, Estuarine, Palustrine, Lacustrine, and Riverine) and/or vegetation type (aquatic bed, marsh, shrub swamp, forest, etc.; some of these terms are common names and not the official Cowardin designation). To view the legend for these types click on "Legend" icon on the tool bar at the top of the mapper, then locate the legend for the layer of interest. For specific NWI nomenclature, simply click on the "Wetland Codes" box and a series of dots (points) will appear on the wetlands. Click on a dot and a search box will appear showing the applicable NWI and LLWW codes for that area and the acreage of the polygon. The Cowardin et al. document can be accessed through the FWS Conservation Library Wetland Publications page (http://library.fws.gov/FWS-OBS/79_31.pdf).

LLWW Types – these layers ("NWI+ Landscape", "NWI+ Landform", and "NWI+ WaterFlowPath") display NWI wetlands and deepwater habitats by hydrogeomorphic-types according to Tiner (2003, 2011, or more recent versions): landscape position, landform, and water flow path (see "LLWW" page for a description of these types and to access the classification document – dichotomous keys and mapping codes, go to: http://digitalmedia.fws.gov/cdm/ref/collection/document/id/1324). For this classification, ponds have been separated from other wetlands for more detailed classification. Like was done for NWI Types, to view the LLWW code for a wetland and waterbody check the box "Wetland Codes" and dots will appear on the wetlands. Click on a dot and a search box will appear displaying the NWI code, LLWW Code, and acreage of the polygon (see the dichotomous keys/mapping codes document for a key to coding and the actual project report for additional information on the application of the classification for the specific project area). Some of the more frequently used codes are: for wetland landscape position = ES – Estuarine, MA – Marine, LS – Lotic Stream, LR – Lotic River, LE – Lentic, and TE – Terrene; for landform = BA – Basin, FL - Flat, FP - Floodplain, FR - Fringe, IS – Island, and SL – Slope; for water flow path = TH – Throughflow, OU – Outflow, IS – Isolated, IN – Inflow, and BI – Bidirectional-nontidal, and BT – Bidirectional-tidal. To view the legend, use the "Legend" tool.

_____ *Function* – these layers display wetlands identified as potentially significant for each of eleven functions: surface water detention (SWD), streamflow maintenance (SM), coastal storm surge detention (CSS), nutrient transformation (NT), sediment and other particulate retention (SR), carbon sequestration (CAR), bank and shoreline stabilization (BSS), provision of fish and aquatic invertebrate habitat (FAIH), provision of waterfowl and waterbird habitat (WBIRD), provision of other wildlife habitat (OWH), and provision of habitat for unique, uncommon, or highly diverse plant communities (UWPC). Descriptions of these functions and the wetlands that provide those functions are found in a 2003 correlation report and tables that update the relationships; a link to these documents can be found on the LLWW page. To view the functions for a particular wetland of interest just check the applicable function box. You can only view one function at a time. If interested in the NWI or LLWW classification for the wetlands simply check the "Wetland Codes" box. As with the other layers, if you want to see the legend, use the "Legend" tool.

NWI+ Restoration Type1 – this layer identifies former wetlands (now nonwetlands) that are in a land use where wetland restoration may be possible. Type 1 restoration sites should be former wetlands that were converted to either "developable land" by drainage and/or filling or deepwater habitats by impoundment (diking) or excavation (dredging). Most of the former sites should be agricultural land that involved wetland drainage or barren land that may represent drained wetlands or filled wetlands. The latter sites are deepwater habitats created from wetlands by impoundment (e.g., L1UBHh in NWI code) or by dredging (e.g., E1UBLx in NWI code). All of the designated sites were mostly likely wetlands based on soil mapping; these sites should not include deepwater habitats created by flooding dryland in river valleys. The referenced sites should have potential for restoration. Whether or not they are viable sites depends on site-specific characteristics, landowner interest, agency funding/priorities, and other factors. For the name of the soil type mapped at a particular site, click the "NWI+ Rest Type 1 Soil Codes." If the site is agricultural land or barren land, restoration will typically require action to bring back the hydrology and may involve removal of fill. For an inundated sites (now deepwater habitats), full or partial removal of the dike or dam would be

needed to restore more natural hydrologic regimes, while excavated sites would require restoration of wetland elevations by bringing in suitable fill material.

NWI+ Restoration Type2 – this layer shows existing wetlands that have been impaired to a degree that affects their ability to function like an undisturbed natural wetland. Click on the "Wetland Codes" box for access to NWI and LLWW codes as described above. In the coastal zone, most of these type 2 restoration sites are either partly drained wetlands (with "d" modifier in the NWI code) or tidally restricted wetlands. The former are extensively ditched (e.g., E2EM1Pd in NWI code) while the latter are separated by other tidal wetlands by roads and/or railroads (look for "td" – tidally restricted/road, "tr" – tidally restricted/railroad, or "to" – tidally restricted/other in the LLWW code). For inland wetlands, type 2 restoration sites include partly drained wetlands ("d" modifier), impounded wetlands ("h" modifier; often ponds – PUBHh – built on hydric soils), excavated wetlands ("x" modifier, typically ponds – PUBHx – dug out from a wetland), and farmed wetlands (NWI code = Pf or PSSf). Sites designated have impairments that may be restorable through various means such as plugging drainage ditches, destroying tile drains, removing tide gates, installing self-regulating tide gates, increasing culvert sizes, breaching impoundments, for example.

NWI+ P-WetAreas – this layer identifies "areas that may support wetlands based on soil mapping." These are areas that did not exhibit a recognizable wetland photo-signature on the aerial imagery used for NWI mapping, but were mapped as hydric soils by USDA soil surveys. They are portions of hydric soil map units from the USDA Natural Resources Conservation Service (NRCS) soil survey geographic database (SSURGO database) that were not farmland, roads, residential houses and lawns, or commercial, industrial or "other" development on the imagery used for NWI mapping (see applicable report). Since they were designated as hydric soil map units, they have a high probability of containing at least some wetland despite not possessing a readily identifiable wetland signature on the aerial imagery used by the NWI. It is a well-known fact that NWI methods cannot detect all wetlands (especially drier-end wetlands – seasonally saturated types) due to limitations of remote sensing techniques and the difficulty of identifying some types even in the field. Many of these hydric soil areas are adjacent to mapped wetlands and may therefore represent the drier portion or upper limit of the wetland while other areas may be upland inclusions within a hydric soil mapping unit. When you click on "NWI+ P-WetArea Codes" box a series of dots (or points) will appear on the polygons, click on these dots to see the hydric soil type ("MUSYM" – the soil map unit symbol used by NRCS, and "muname" – soil map unit name - predominant soil series). Inclusion of these data makes the NWI+ database more complete in terms of locating areas of photointerpretable wetlands and other areas with a high probability for wetland occurrence based on soil mapping.

Appendix C. Watershed summary tables and figures:
characterizations and functional analyses for individual watersheds (listed alphabetically). Three tables and one figure per watershed.

Table CR-1. Wetlands of the Connecticut River watershed (excluding ponds). Mapping codes are provided.

Landscape Position (code)	**Acres**
Estuarine (ES)	2,787.1
Lentic (LE)	1,138.6
Lotic River (LR)	7,209.4
Lotic Stream (LS)	29,700.2
Terrene (TE)	14,281.5
Total	**55,116.8**

Landform	**Acres**
Basin (BA)	42,401.8
Flat (FL)	2,158.0
Floodplain (FP)	7,107.0
Fringe (FR)	3,280.1
Island (IL)	4.9
Slope (SL)	165.0
Total	**55,116.8**

Water Flow Path	**Acres**
Bidirectional-nontidal Outflow (BO)	10.5
Bidirectional-nontidal Throughflow (TB)	1,104.2
Bidirectional-tidal (BT)	4,701.8
Inflow (IN)	4.4
Isolated (IS)	7,198.0
Outflow-artificial (OA)	688.7
Outflow-intermittent (OI)	598.0
Outflow-perennial (OU)	5,774.0
Throughflow-artificial (TA)	18.4
Throughflow-intermittent (TI)	1,185.0
Throughflow-perennial (TH)	33,833.8
Total	**55,116.8**

Table CR-2. Water area in the Connecticut River watershed. Mapping codes are provided. See accompanying wetland table for water flow path types as only mapping codes are given here.

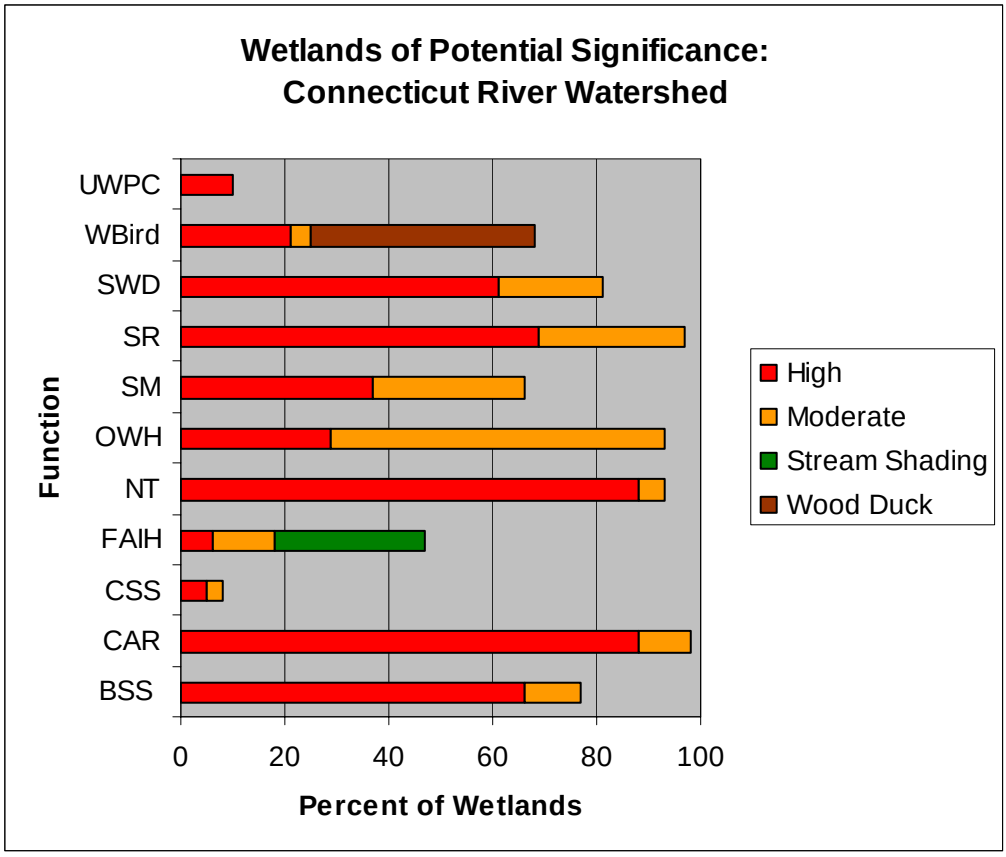
Waterbody Type (code)	**Acres**
Pond (PD)	5,937.8
Lake (LK)	12,257.7
River (RV)	9,329.0
Total Freshwater	**27,524.5**
Estuary (EY)	5,536.4
Total Saltwater	**5,536.4**
Grand Total	**33,060.9**

Water Flow Path	**Acres**			
	Estuary	Lake	Pond	River
BT	5,536.4	227.1	24.9	6,960.5
IN			0.8	
IS		97.6	1,294.8	
OA		62.6	242.3	
OI			38.6	
OU		628.5	618.5	
TA			24.9	
TH		11,214.3	3,553.6	2,368.5
TI		27.6	139.4	
Total	***5,536.4***	***12,257.7***	***5,937.8***	***9,329.0***

Table CR-3. Extent of wetlands predicted to perform certain functions at high and moderate levels for the Connecticut River watershed. For waterfowl/waterbird habitat and, fish/aquatic invertebrate habitat, other wetlands of significance have also been identified: important for wood duck in the former and for stream shading to moderate water temperatures for the latter organisms. Percent of area's wetlands designated as significant is also given. *Coding for functions: BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = unique, uncommon, or highly diverse wetland plant communities.*

Function Code	**Acres High**	**Acres Moderate**	**Acres Other Signif**	**Total Acres**	**% of Area's Wetlands**
BSS	40,353	6,836	-	47,189	77
CAR	54,025	6,041	-	60,066	98
CSS	2,834	1,970	-	4,804	8
FAIH	3,529	7,490	17,811	28,830	47
NT	53,913	2,928	-	56,841	93
OWH	17,730	39,297	-	57,027	93
SM	22,467	17,782	-	40,249	66
SR	42,303	16,811	-	59,114	97
SWD	37,194	18,545	-	55,739	91
WBIRD	12,883	2,595	26,192	41,670	68
UWPC	5,896	-	-	5,896	10

Figure CR-1. Wetlands of potential significance for eleven functions in the Connecticut River watershed.



Key to Function Codes: BSS (bank and shoreline stabilization), CAR (carbon sequestration), CSS (coastal storm surge detention), FAIH (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI and LLWW codes only), and WBIRD (waterfowl and waterbird habitat).

Table HoR-1. Wetlands of the Housatonic River watershed (excluding ponds). Mapping codes are provided.

Landscape Position (code)	**Acres**
Estuarine (ES)	624.3
Lentic (LE)	2,484.5
Lotic River (LR)	1,516.4
Lotic Stream (LS)	22,014.1
Terrene (TE)	8,380.5
Total	**35,019.8**

Landform	**Acres**
Basin (BA)	30,361.1
Flat (FL)	645.0
Floodplain (FP)	1,483.9
Fringe (FR)	2,475.7
Island (IL)	2.8
Slope (SL)	51.3
Total	**35,019.8**

Water Flow Path	**Acres**
Bidirectional-nontidal Outflow (BO)	0.2
Bidirectional-nontidal Throughflow (TB)	2,139.9
Bidirectional-tidal (BT)	667.8
Isolated (IS)	3,078.6
Outflow-artificial (OA)	623.6
Outflow-intermittent (OI)	46.1
Outflow-perennial (OU)	4,632.2
Throughflow-intermittent (TI)	66.0
Throughflow-perennial (TH)	23,765.4
Total	**35,019.8**

Table HoR-2. Water area in the Housatonic River watershed. Mapping codes are provided. See accompanying wetland table for water flow path types as only mapping codes are given here. Any difference in sums is due to round-off procedures.

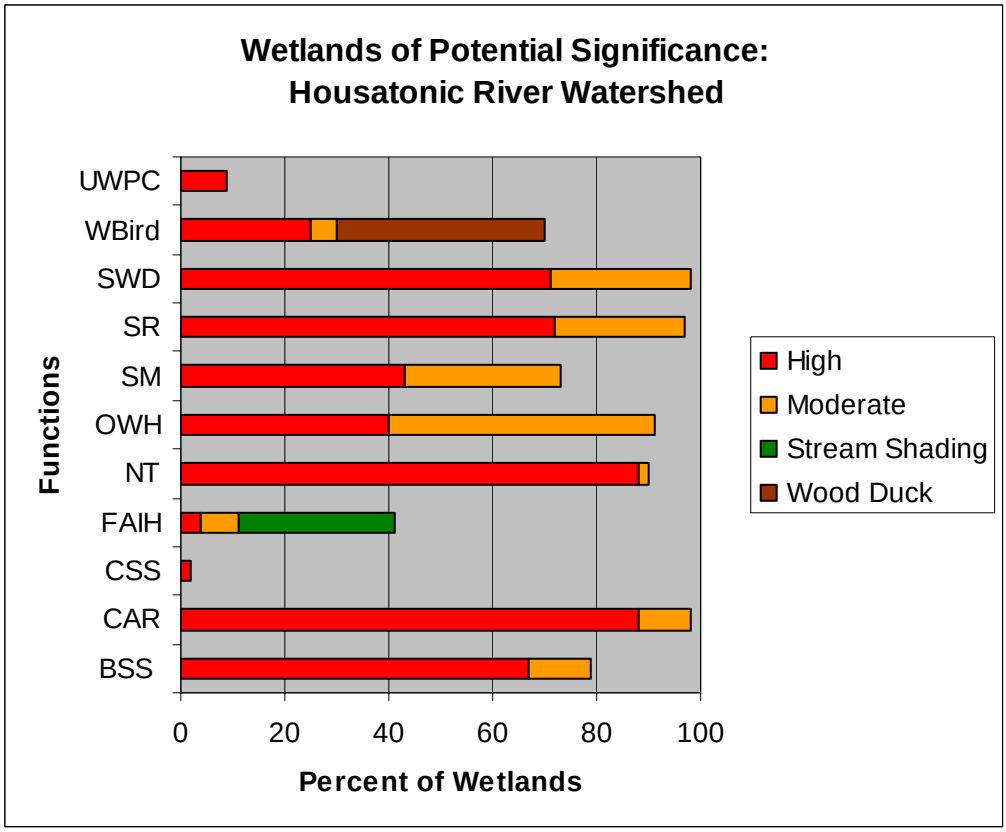
Waterbody Type	**Acres**
Pond (PD)	5,039.7
Lake (LK)	18,378.6
River (RV)	2,686.9
Total Freshwater	**26,105.2**
Estuary (EY)	901.2
Total Saltwater	**901.2**
Grand Total	**27,006.4**

Water Flow Path	**Acres**			
	Estuary	Lake	Pond	River
BT	901.2	20.1		261.0
IN			0.8	
IS		45.4	1,002.2	
OA		212.4	598.9	
OI			2.1	
OU		330.0	314.6	
TA				
TH		17,770.7	3,112.9	2,425.8
TI			8.2	
Total	***901.2***	***18,378.6***	***5,039.7***	***2,686.8***

Table HoR-3. Extent of wetlands predicted to perform certain functions at high and moderate levels for the Housatonic River watershed. For waterfowl/waterbird habitat and, fish/aquatic invertebrate habitat, other wetlands of significance have also been identified: important for wood duck in the former and for stream shading to moderate water temperatures for the latter organisms. Percent of area's wetlands designated as significant is also given. *Coding for functions: BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = unique, uncommon, or highly diverse wetland plant communities.*

Function Code	**Acres High**	**Acres Moderate**	**Acres Other Signif**	**Total Acres**	**% of Area's Wetlands**
BSS	26,262	5,405	-	31,667	79
CAR	35,294	4,039	-	39,333	98
CSS	624	49	-	673	2
FAIH	1,710	2,743	12,027	16,480	41
NT	35,156	1,003	-	36,159	90
OWH	16,120	20,392	-	36,512	91
SM	17,324	12,499	-	29,823	74
SR	28,758	10,021	-	38,779	97
SWD	28,291	10,876	-	39,167	98
WBIRD	10,033	2,077	16,190	28,300	71
UWPC	3,596	-	-	3,596	9

Figure HoR-1. Wetlands of potential significance for eleven functions in the Housatonic River watershed.



Key to Function Codes: BSS (bank and shoreline stabilization), CAR (carbon sequestration), CSS (coastal storm surge detention), FAIH (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI and LLWW codes only), and WBIRD (waterfowl and waterbird habitat).

Table HuR-1. Wetlands of the Hudson River watershed (excluding ponds). Mapping codes are provided. Any difference in sums is due to round-off procedures.

Landscape Position (code)	**Acres**
Lotic Stream (LS)	812.4
Terrene (TE)	178.8
Total	**991.2**

Landform	**Acres**
Basin (BA)	983.0
Flat (FL)	6.7
Fringe (FR)	1.6
Total	**991.3**

Water Flow Path	**Acres**
Isolated (IS)	99.5
Outflow-artificial (OA)	5.5
Outflow-perennial (OU)	73.8
Throughflow-perennial (TH)	812.4
Total	**991.2**

Table HuR-2. Water area in the Hudson River watershed. Mapping codes are provided. See accompanying wetland table for water flow path types as only mapping codes are given here. Any difference in sums is due to round-off procedures.

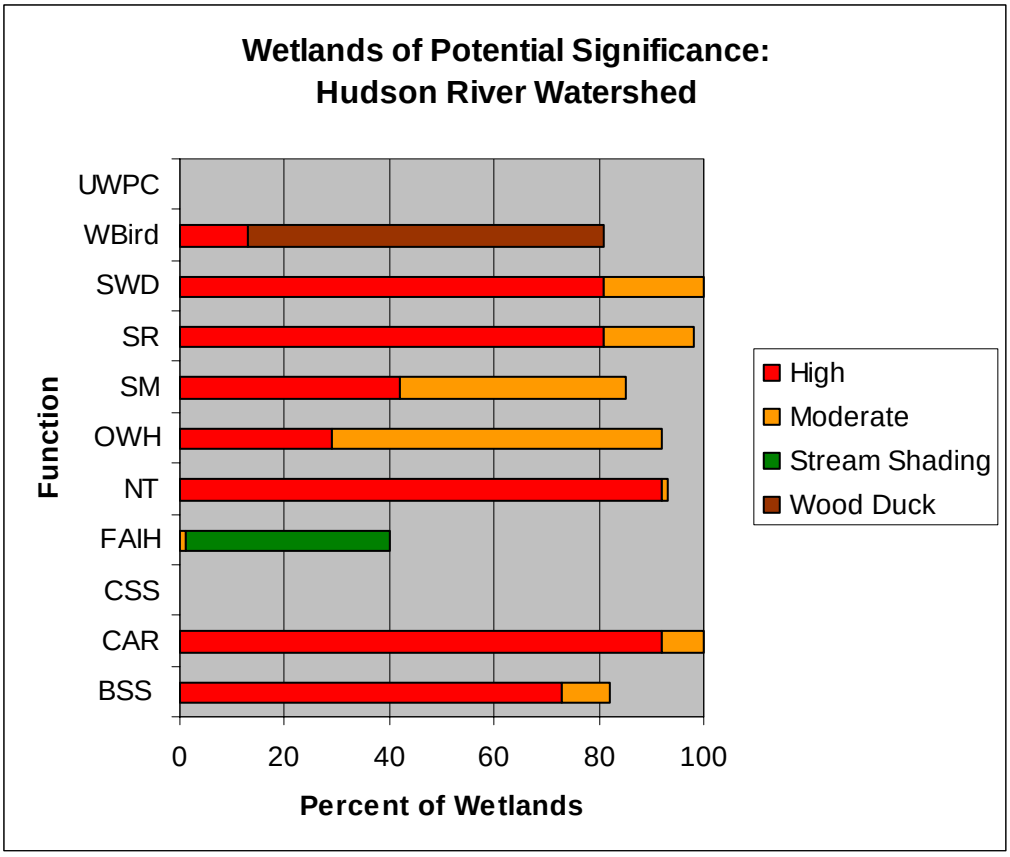
Waterbody Type	**Acres**
Pond (PD)	110.6
Lake (LK)	171.2
Total Freshwater	**281.8**

Water Flow Path	**Acres**	
	Lake	Pond
IS		14.1
OA	0.1	14.2
OU		0.3
TH	171.1	82.1
Total	***171.2***	***110.7***

Table HuR-3. Extent of wetlands predicted to perform certain functions at high and moderate levels for the Hudson River watershed. For waterfowl/waterbird habitat and, fish/aquatic invertebrate habitat, other wetlands of significance have also been identified: important for wood duck in the former and for stream shading to moderate water temperatures for the latter organisms. Percent of area's wetlands designated as significant is also given. *Coding for functions: BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = unique, uncommon, or highly diverse wetland plant communities.*

Function Code	**Acres High**	**Acres Moderate**	**Acres Other Signif**	**Total Acres**	**% of Area's Wetlands**
BSS	812	88	-	900	82
CAR	1,014	86	-	1,100	100
CSS	-	-	-	-	0
FAIH	0.1	7	436	443	40
NT	1,014	7	-	1,021	93
OWH	322	698	-	1,020	93
SM	464	470	-	934	85
SR	888	188	-	1,076	98
SWD	888	212	-	1,100	100
WBIRD	138	8	744	890	81
UWPC	2	-	-	2	0.2

Figure HuR-1. Wetlands of potential significance for eleven functions in the Hudson River watershed.



Key to Function Codes: BSS (bank and shoreline stabilization), CAR (carbon sequestration), CSS (coastal storm surge detention), FAIH (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI and LLWW codes only), and WBIRD (waterfowl and waterbird habitat).

Table PR-1. Wetlands of the Pawcatuck River watershed (excluding ponds). Mapping codes are provided. Any difference in sums is due to round-off procedures.

Landscape Position (code)	**Acres**
Estuarine (ES)	42.1
Lentic (LE)	261.9
Lotic River (LR)	232.5
Lotic Stream (LS)	2,218.1
Terrene (TE)	785.8
Total	**3,540.4**

Landform	**Acres**
Basin (BA)	3,078.1
Flat (FL)	116.0
Floodplain (FP)	223.3
Fringe (FR)	70.9
Island (IL)	5.0
Slope (SL)	47.2
Total	**3,540.5**

Water Flow Path	**Acres**
Bidirectional-nontidal Throughflow (TB)	261.9
Bidirectional-tidal (BT)	42.1
Isolated (IS)	548.4
Outflow-intermittent (OI)	27.8
Outflow-perennial (OU)	209.7
Throughflow-intermittent (TI)	41.7
Throughflow-perennial (TH)	2,408.8
Total	**3,540.4**

Table PR-2. Water area in the Pawcatuck River watershed. Mapping codes are provided. See accompanying wetland table for water flow path types as only mapping codes are given here.

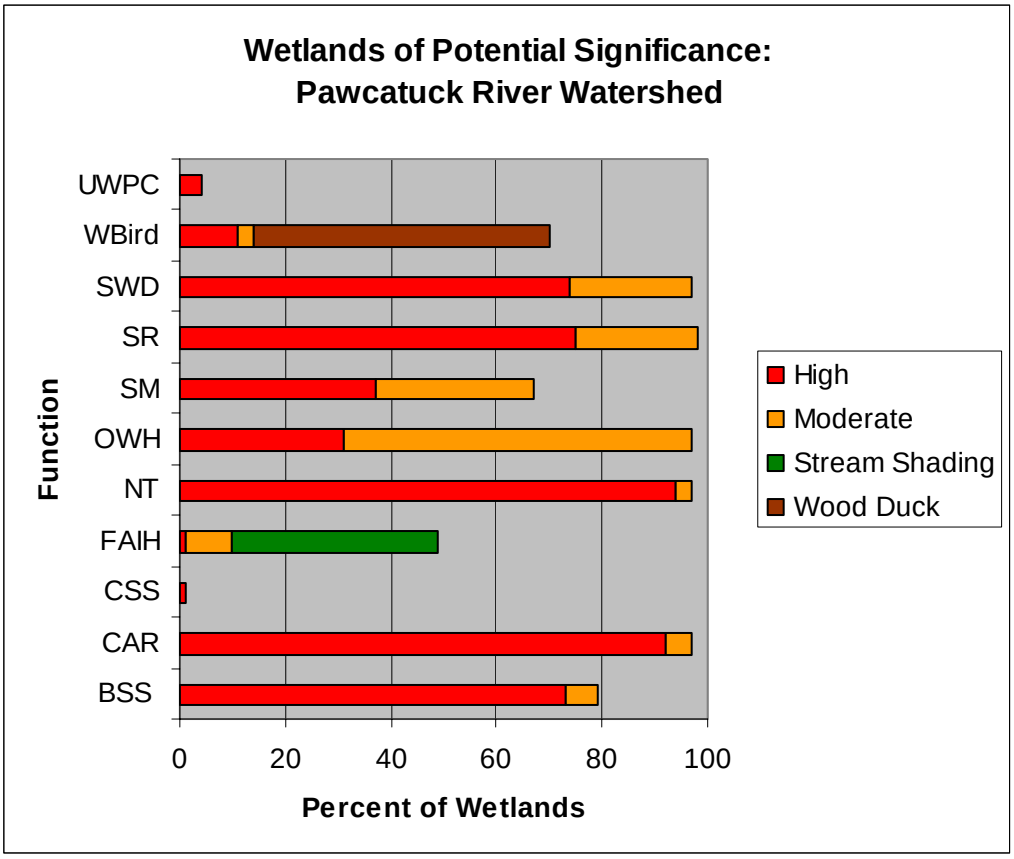
Waterbody Type	**Acres**
Pond (PD)	232.2
Lake (LK)	213.8
River (RV)	62.1
Total Freshwater	508.1
Estuary (EY)	306.1
Total Saltwater	**306.1**
Grand Total	**814.2**

Water Flow Path	**Acres**			
	Estuary	Lake	Pond	River
BT	306.1			1.9
IS			44.1	
OI			1.3	
OU			30.1	
TH		213.8	154.1	60.2
TI			2.6	
Total	***306.1***	***213.8***	***232.2***	***62.1***

Table PR-3. Extent of wetlands predicted to perform certain functions at high and moderate levels for the Pawcatuck River watershed. For waterfowl/waterbird habitat and, fish/aquatic invertebrate habitat, other wetlands of significance have also been identified: important for wood duck in the former and for stream shading to moderate water temperatures for the latter organisms. Percent of area's wetlands designated as significant is also given. *Coding for functions: BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = unique, uncommon, or highly diverse wetland plant communities.*

Function Code	**Acres High**	**Acres Moderate**	**Acres Other Signif**	**Total Acres**	**% of Area's Wetlands**
BSS	2,755	211	-	2,966	79
CAR	3,554	203	-	3,757	100
CSS	42	1	-	43	1
FAIH	43	350	1,458	1,851	49
NT	3,543	121	-	3,664	97
OWH	1,179	2,501	-	3,680	98
SM	1,411	1,148	-	2,559	68
SR	2,812	864	-	3,676	98
SWD	2,780	876	-	3,666	97
WBIRD	418	119	2,096	2,633	70
UWPC	167	-	-	167	4

Figure PR-1. Wetlands of potential significance for eleven functions in the Pawcatuck River watershed.



Key to Function Codes: BSS (bank and shoreline stabilization), CAR (carbon sequestration), CSS (coastal storm surge detention), FAIH (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI and LLWW codes only), and WBIRD (waterfowl and waterbird habitat).

Table SCC-1. Wetlands of the South Central Coast watershed (excluding ponds). Mapping codes are provided. Any difference in sums is due to round-off procedures.

Landscape Position (code)	**Acres**
Estuarine (ES)	6,480.5
Lentic (LE)	891.5
Lotic River (LR)	807.6
Lotic Stream (LS)	9,974.1
Terrene (TE)	6,893.3
Total	**25,047.0**

Landform	**Acres**
Basin (BA)	19,555.1
Flat (FL)	836.5
Floodplain (FP)	806.2
Fringe (FR)	3,849.0
Total	**25,046.8**

Water Flow Path	**Acres**
Bidirectional-nontidal Throughflow (TB)	781.0
Bidirectional-tidal (BT)	6,630.3
Isolated (IS)	4,356.8
Outflow-artificial (OA)	11.3
Outflow-intermittent (OI)	392.0
Outflow-perennial (OU)	2,128.4
Throughflow-artificial (TA)	4.8
Throughflow-intermittent (TI)	1,228.3
Throughflow-perennial (TH)	9,513.9
Total	**25,046.8**

Table SCC-2. Water area in the South Central Coast watershed. Mapping codes are provided. See accompanying wetland table for water flow path types as only mapping codes are given here.

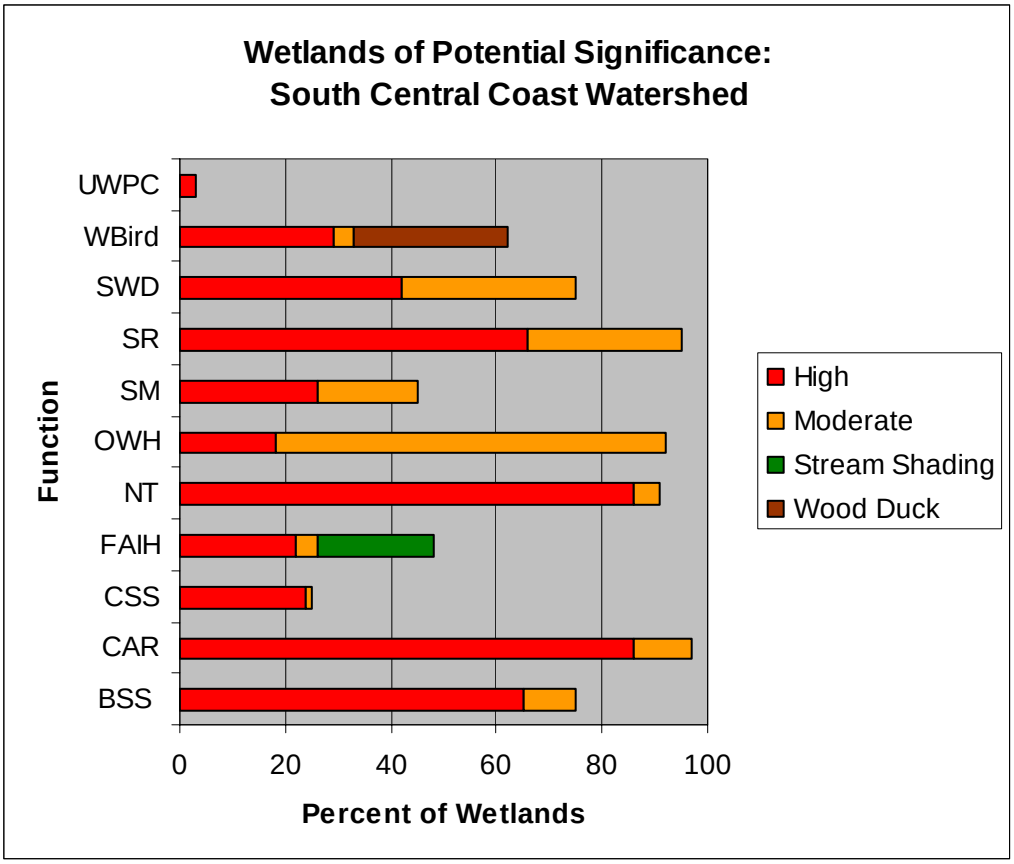
Waterbody Type	**Acres**
Pond (PD)	2,230.2
Lake (LK)	3,592.7
River (RV)	198.5
Total Freshwater	**6,021.4**
Estuary (EY)	1,441.0
Total Saltwater	**1,441.0**
Grand Total	**7,462.4**

Water Flow Path	**Acres**			
	Estuary	Lake	Pond	River
BT	1,441.0		2.5	41.5
IS		70.0	689.9	
OA		51.8	16.4	
OI			16.3	
OU			320.0	
TA			21.2	
TH		3,470.9	1,088.4	157.0
TI			75.5	
Total	***1,441.0***	***3,592.7***	***2,230.2***	***198.5***

Table SCC-3. Extent of wetlands predicted to perform certain functions at high and moderate levels for the South Central Coast watershed. For waterfowl/waterbird habitat and, fish/aquatic invertebrate habitat, other wetlands of significance have also been identified: important for wood duck in the former and for stream shading to moderate water temperatures for the latter organisms. Percent of area's wetlands designated as significant is also given. *Coding for functions: BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = unique, uncommon, or highly diverse wetland plant communities.*

Function Code	**Acres High**	**Acres Moderate**	**Acres Other Signif**	**Total Acres**	**% of Area's Wetlands**
BSS	17,675	2,719	-	20,394	75
CAR	23,589	2,892	-	26,481	97
CSS	6,474	324	-	6,798	25
FAIH	5,874	1,201	6,092	13,167	48
NT	23,576	1,329	-	24,905	91
OWH	4,884	20,081	-	24,965	92
SM	7,115	5,163	-	12,278	45
SR	17,920	7,909	-	25,829	95
SWD	11,495	8,995	-	20,490	75
WBIRD	7,919	1,151	7,776	16,846	62
UWPC	860	-	-	860	3

Figure SCC-1. Wetlands of potential significance for eleven functions in the South Central Coast watershed.



Key to Function Codes: BSS (bank and shoreline stabilization), CAR (carbon sequestration), CSS (coastal storm surge detention), FAIH (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI and LLWW codes only), and WBIRD (waterfowl and waterbird habitat).

Table SECe-1. Wetlands of the Southeast Coast-East watershed (excluding ponds). Mapping codes are provided. Any difference in sums is due to round-off procedures.

Landscape Position (code)	**Acres**
Estuarine (ES)	939.9
Lentic (LE)	26.7
Lotic River (LR)	55.0
Lotic Stream (LS)	3,034.8
Terrene (TE)	1,288.5
Total	**5,344.9**

Landform	**Acres**
Basin (BA)	4,554.8
Flat (FL)	44.3
Floodplain (FP)	55.0
Fringe (FR)	690.8
Total	**5,344.9**

Water Flow Path	**Acres**
Bidirectional-nontidal Throughflow (TB)	26.7
Bidirectional-tidal (BT)	994.9
Isolated (IS)	418.5
Outflow-artificial (OA)	3.2
Outflow-intermittent (OI)	433.4
Outflow-perennial (OU)	433.4
Throughflow-intermittent (TI)	573.9
Throughflow-perennial (TH)	2,460.8
Total	**5,344.8**

Table SECe-2. Water area in the Southeast Coast-East watershed. Mapping codes are provided. See accompanying wetland table for water flow path types as only mapping codes are given here. Any difference in sums is due to round-off procedures.

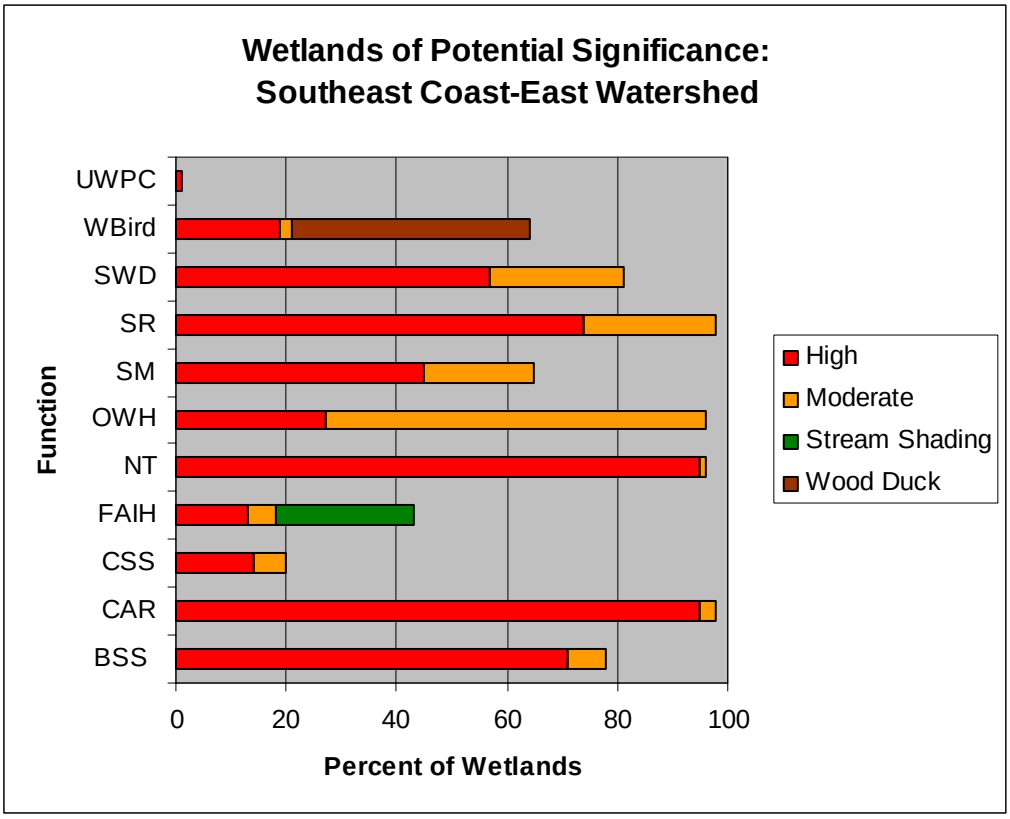
Waterbody Type	**Acres**
Pond (PD)	383.6
Lake (LK)	923.7
River (RV)	
Total Freshwater	**1,307.3**
Estuary (EY)	773.5
Total Saltwater	**773.5**
Grand Total	**2,080.8**

Water Flow Path		**Acres**	
	Estuary	Lake	Pond
BT	773.5		3.4
IS			73.9
OA			3.6
OI			31.5
OU			16.8
TH		923.7	238.9
TI			15.6
Total	***773.5***	***923.7***	***383.7***

Table SECe-3. Extent of wetlands predicted to perform certain functions at high and moderate levels for the Southeast Coast-East watershed. For waterfowl/waterbird habitat and, fish/aquatic invertebrate habitat, other wetlands of significance have also been identified: important for wood duck in the former and for stream shading to moderate water temperatures for the latter organisms. Percent of area's wetlands designated as significant is also given. *Coding for functions: BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = unique, uncommon, or highly diverse wetland plant communities..*

Function Code	**Acres High**	**Acres Moderate**	**Acres Other Signif**	**Total Acres**	**% of Area's Wetlands**
BSS	4,056	403	-	4,459	78
CAR	5,457	173	-	5,630	98
CSS	813	339	-	1,152	20
FAIH	739	274	1,407	2,420	42
NT	5,445	56	-	5,501	96
OWH	1,556	3,947	-	5,503	96
SM	2,590	1,166	-	3,706	65
SR	4,214	1,365	-	5,579	98
SWD	3,258	1,369	-	4,627	81
WBIRD	1,097	143	2,436	3,676	64
UWPC	83	-	-	83	1

Figure SECe-1. Wetlands of potential significance for eleven functions in the Southeast Coast-East watershed.



Key to Function Codes: BSS (bank and shoreline stabilization), CAR (carbon sequestration), CSS (coastal storm surge detention), FAIH (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI and LLWW codes only), and WBIRD (waterfowl and waterbird habitat).

Table SECw-1. Wetlands of the Southeast Coast-West watershed (excluding ponds). Mapping codes are provided.

Landscape Position (code)	**Acres**
Estuarine (ES)	540.5
Lentic (LE)	43.1
Lotic River (LR)	24.7
Lotic Stream (LS)	1,953.2
Terrene (TE)	742.4
Total	**3,303.9**

Landform	**Acres**
Basin (BA)	2,807.4
Flat (FL)	77.4
Floodplain (FP)	24.7
Fringe (FR)	394.4
Total	**3,303.9**

Water Flow Path	**Acres**
Bidirectional-nontidal Throughflow (TB)	43.1
Bidirectional-tidal (BT)	565.1
Isolated (IS)	258.1
Outflow-intermittent (OI)	192.4
Outflow-perennial (OU)	291.9
Throughflow-intermittent (TI)	150.2
Throughflow-perennial (TH)	1,803.1
Total	**3,303.9**

Table SECw-2. Water area in the Southeast Coast-West watershed. Mapping codes are provided. See accompanying wetland table for water flow path types as only mapping codes are given here.

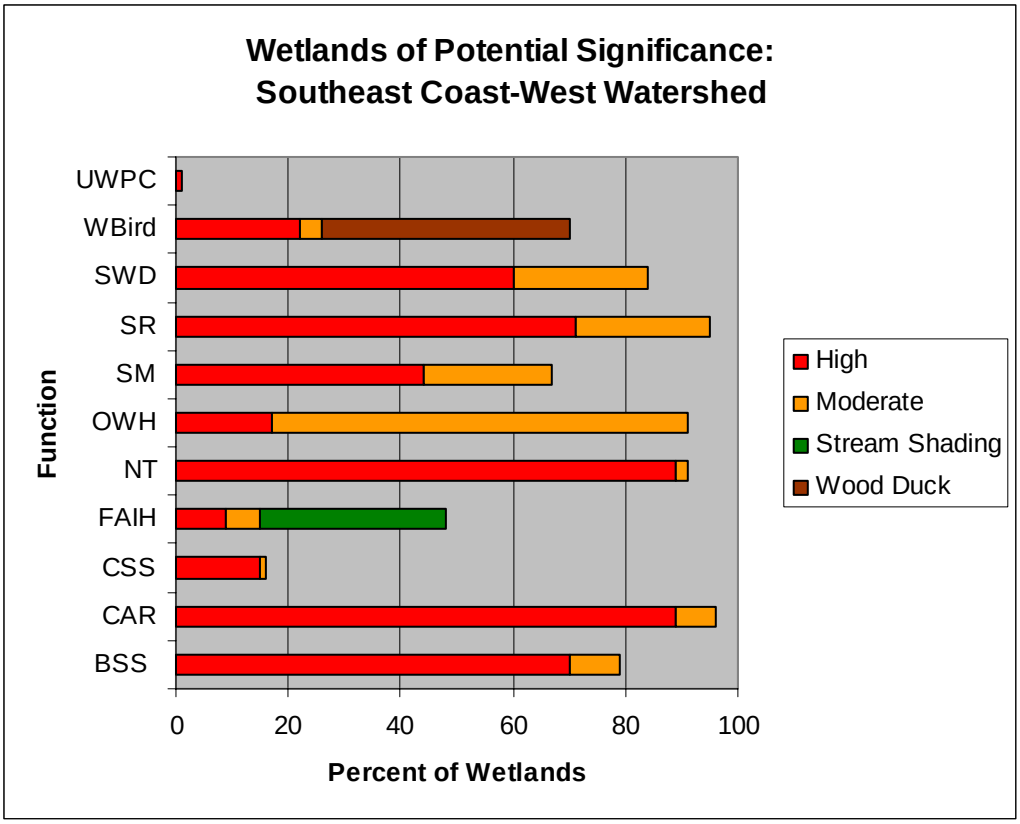
Waterbody Type	**Acres**
Pond (PD)	329.7
Lake (LK)	933.9
Total Freshwater	**1,263.6**
Estuary (EY)	1,198.9
Total Saltwater	**1,198.9**
Grand Total	**2,462.5**

Water Flow Path		**Acres**	
	Estuary	Lake	Pond
BT	1,198.9		0.1
IS			46.6
OA			1.9
OI			13.0
OU			11.9
TH		933.9	250.2
TI			6.0
Total	***1,198.9***	***933.9***	***329.7***

Table SECw-13. Extent of wetlands predicted to perform certain functions at high and moderate levels for the Southeast Coast-West watershed. For waterfowl/waterbird habitat and, fish/aquatic invertebrate habitat, other wetlands of significance have also been identified: important for wood duck in the former and for stream shading to moderate water temperatures for the latter organisms. Percent of area's wetlands designated as significant is also given. *Coding for functions: BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = unique, uncommon, or highly diverse wetland plant communities..*

Function Code	**Acres High**	**Acres Moderate**	**Acres Other Signif**	**Total Acres**	**% of Area's Wetlands**
BSS	2,528	337	-	2,865	79
CAR	3,229	244	-	3,473	96
CSS	541	33	-	574	16
FAIH	345	233	1,206	1,784	49
NT	3,227	82	-	3,309	91
OWH	617	2,693	-	3,310	91
SM	1,584	828	-	2,412	66
SR	2,595	859	-	3,454	95
SWD	2,169	888	-	3,057	84
WBIRD	786	157	1,617	2,560	70
UWPC	45	-	-	45	1

Figure SECw-1. Wetlands of potential significance for eleven functions in the Southeast Coast-West watershed.



Key to Function Codes: BSS (bank and shoreline stabilization), CAR (carbon sequestration), CSS (coastal storm surge detention), FAIH (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI and LLWW codes only), and WBIRD (waterfowl and waterbird habitat).

Table SWC-1. Wetlands of the Southwest Coast watershed (excluding ponds). Mapping codes are provided. Any difference in sums is due to round-off procedures.

Landscape Position (code)	**Acres**
Estuarine (ES)	1,574.2
Lentic (LE)	312.3
Lotic River (LR)	158.8
Lotic Stream (LS)	6,337.6
Terrene (TE)	2,641.7
Total	**11,024.6**

Landform	**Acres**
Basin (BA)	9,105.5
Flat (FL)	113.7
Floodplain (FP)	158.0
Fringe (FR)	1,647.5
Total	**11,024.7**

Water Flow Path	**Acres**
Bidirectional-nontidal Outflow (BO)	3.9
Bidirectional-nontidal Throughflow (TB)	281.1
Bidirectional-tidal (BT)	1,596.5
Isolated (IS)	1,526.8
Outflow-artificial (OA)	277.6
Outflow-intermittent (OI)	65.7
Outflow-perennial (OU)	771.7
Throughflow-intermittent (TI)	122.1
Throughflow-perennial (TH)	6,379.4
Total	**11,024.8**

Table SWC-2. Water area in the Southwest Coast watershed. Mapping codes are provided. See accompanying wetland table for water flow path types as only mapping codes are given here. Any difference in sums is due to round-off procedures.

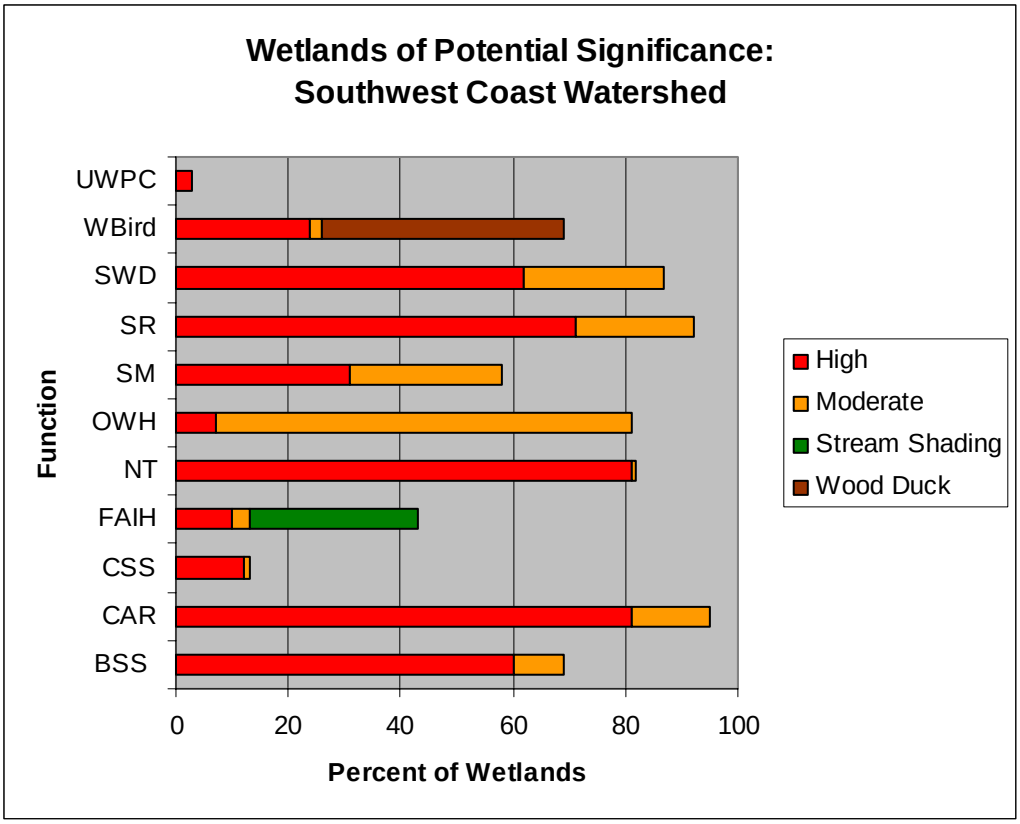
Waterbody Type	**Acres**
Pond (PD)	2,226.0
Lake (LK)	3,135.3
River (RV)	160.2
Total Freshwater	**5,521.5**
Estuary (EY)	1,011.4
Total Saltwater	**1,011.4**
Grand Total	**6,532.9**

Water Flow Path	**Acres**			
	Estuary	Lake	Pond	River
BT	1,011.4		11.1	26.8
IS			387.0	
OA		95.1	274.9	
OI			5.7	
OU			5.9	
TH		3,040.2	1,530.4	133.3
TI			11.1	
Total	***1,011.4***	***3,135.3***	***2,226.1***	***160.1***

Table SWC-3. Extent of wetlands predicted to perform certain functions at high and moderate levels for the Southwest Coast watershed. For waterfowl/waterbird habitat and, fish/aquatic invertebrate habitat, other wetlands of significance have also been identified: important for wood duck in the former and for stream shading to moderate water temperatures for the latter organisms. Percent of area's wetlands designated as significant is also given. *Coding for functions: BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = unique, uncommon, or highly diverse wetland plant communities..*

Function Code	**Acres High**	**Acres Moderate**	**Acres Other Signif**	**Total Acres**	**% of Area's Wetlands**
BSS	7,928	1,239	-	9,167	69
CAR	10,699	1,839	-	12,538	95
CSS	1,565	142	-	1,707	13
FAIH	1,277	338	3,928	5,543	42
NT	10,701	116	-	10,817	82
OWH	981	9,842	-	10,823	82
SM	4,127	3,548	-	7,675	58
SR	9,360	2,845	-	12,205	92
SWD	8,193	3,337	-	11,530	87
WBIRD	3,222	283	5,662	9,167	69
UWPC	360	-	-	360	3

Figure SWC-1. Wetlands of potential significance for eleven functions in the Southwest Coast watershed.



Key to Function Codes: BSS (bank and shoreline stabilization), CAR (carbon sequestration), CSS (coastal storm surge detention), FAIH (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI and LLWW codes only), and WBIRD (waterfowl and waterbird habitat).

Table TR-1. Wetlands of the Thames River watershed (excluding ponds). Mapping codes are provided. Any difference in sums is due to round-off procedures.

Landscape Position (code)	**Acres**
Estuarine (ES)	56.7
Lentic (LE)	2,664.0
Lotic River (LR)	3,561.9
Lotic Stream (LS)	35,368.5
Terrene (TE)	12,312.3
Total	**53,963.4**

Landform	**Acres**
Basin (BA)	47,490.2
Flat (FL)	1,129.3
Floodplain (FP)	3,403.6
Fringe (FR)	1,555.1
Island (IL)	1.2
Slope (SL)	384.1
Total	**53,963.5**

Water Flow Path	**Acres**
Bidirectional-nontidal Outflow (BO)	34.7
Bidirectional-nontidal Throughflow (TB)	2,537.8
Bidirectional-tidal (BT)	68.3
Isolated (IS)	4,758.8
Outflow-artificial (OA)	11.8
Outflow-intermittent (OI)	2,886.0
Outflow-perennial (OU)	4,702.5
Throughflow-artificial (TA)	11.9
Throughflow-intermittent (TI)	4,616.1
Throughflow-perennial (TH)	34,335.7
Total	**53,963.6**

Table TR-2. Water area in the Thames River watershed. Mapping codes are provided. See accompanying wetland table for water flow path types as only mapping codes are given here. Any difference in sums is due to round-off procedures.

Waterbody Type	**Acres**
Pond (PD)	5,661.3
Lake (LK)	11,056.0
River (RV)	1,927.9
Total Freshwater	**18,645.2**
Estuary (EY)	3,167.3
Total Saltwater	**3,167.3**
Grand Total	**21,812.5**

Water Flow Path	**Acres**			
	Estuary	Lake	Pond	River
BT	3,167.3			
IS			738.0	
OA			46.6	
OI			341.3	
OU		586.3	478.7	
TA			9.4	
TH		10,443.7	3,702.4	1,927.9
TI		26.1	344.9	
Total	***3,167.3***	***11,056.1***	***5,661.3***	***1,927.9***

Table TR-3. Extent of wetlands predicted to perform certain functions at high and moderate levels for the Thames River watershed. For waterfowl/waterbird habitat and, fish/aquatic invertebrate habitat, other wetlands of significance have also been identified: important for wood duck in the former and for stream shading to moderate water temperatures for the latter organisms. Percent of area's wetlands designated as significant is also given. *Coding for functions: BSS = bank and shoreline stabilization; CAR = carbon sequestration; CSS = coastal storm surge detention; FAIH = fish/aquatic invertebrate habitat; NT = nutrient transformation; OWH = other wildlife habitat; SM = streamflow maintenance; SR = sediment/other particulate retention; SWD = surface water detention; WBIRD = waterfowl/waterbird habitat; UWPC = unique, uncommon, or highly diverse wetland plant communities.*

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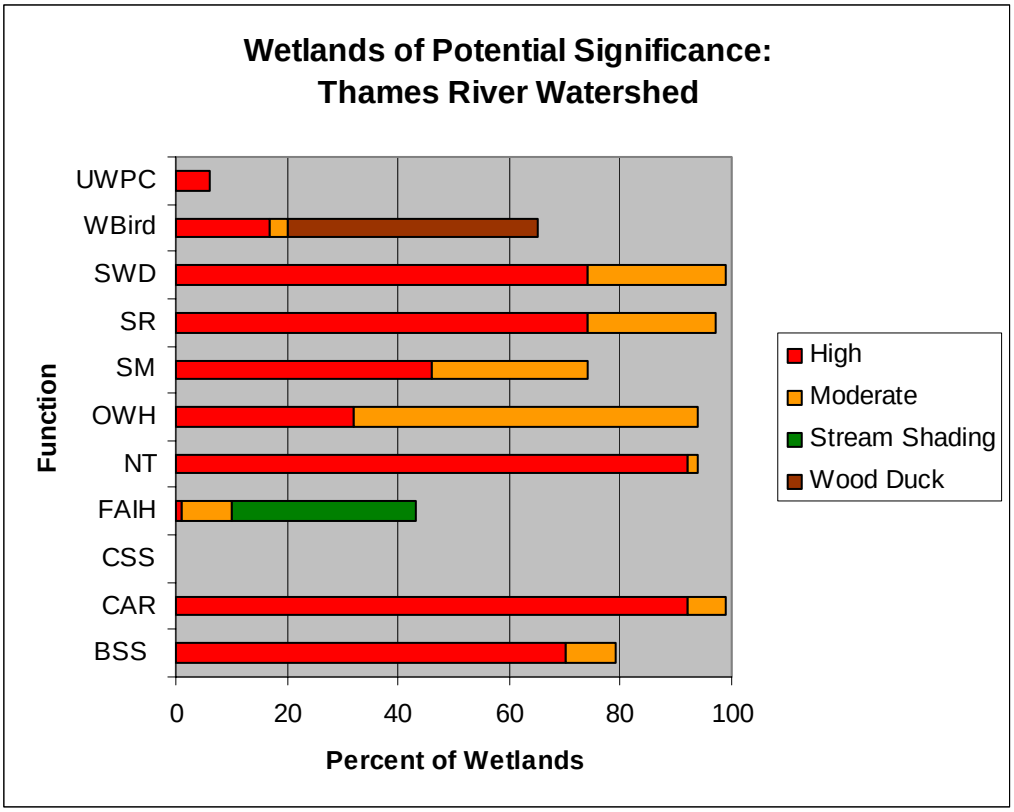
Function Code	**Acres High**	**Acres Moderate**	**Acres Other Signif**	**Total Acres**	**% of Area's Wetlands**
BSS	41,580	5,187	-	46,767	79
CAR	54,979	4,078	-	59,057	99
CSS	57	20	-	77	0.1
FAIH	687	5,517	19,560	25,764	43
NT	54,678	1,525	-	56,203	94
OWH	19,345	37,237	-	56,582	95
SM	27,648	16,469	-	44,117	74
SR	44,355	13,861	-	58,216	98
SWD	44,083	14,773	-	58,856	99
WBIRD	10,359	1,995	26,684	39,038	65
UWPC	3,333	-	-	3,333	6

Figure TR-1. Wetlands of potential significance for eleven functions in the Thames River watershed.



Key to Function Codes: BSS (bank and shoreline stabilization), CAR (carbon sequestration), CSS (coastal storm surge detention), FAIH (fish and aquatic invertebrate habitat), NT (nutrient transformation), OWH (other wildlife habitat), SM (streamflow maintenance), SR (sediment and other particulate retention), SWD (surface water detention – for freshwater wetlands only), UWPC (unique, uncommon or highly diverse wetland plant communities – based on NWI and LLWW codes only), and WBIRD (waterfowl and waterbird habitat).

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