U.S. Fish & Wildlife Service

# Wetlands and Waters of Connecticut: Status 2010

*March 2013*

Cover: Cattail marsh (Palustrine emergent wetland, semipermanently flooded. (Ralph Tiner photo)

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# Wetlands and Waters of Connecticut: Status 2010

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March 2013

This report should be cited as: Tiner, R.W. 2013. *Wetlands and Waters of Connecticut: Status 2010*. With technical support from the Conservation Management Institute, Virginia Tech, Blacksburg, VA. Prepared for the State of Connecticut, Department of Energy and Environmental Protection, Hartford, CT. U.S. Fish and Wildlife Service, Northeast Region, Hadley, MA. 33 pp. plus appendices.

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Palustrine mixed scrub-shrub/emergent wetland along an inland lake. (Ralph Tiner photo)

# Introduction

The State of Connecticut has cooperated with the U.S. Fish and Wildlife Service (FWS) to produce wetland inventories of the state's wetlands since the 1960s. In the late 1980s, the FWS and Connecticut Department of Energy and Environmental Protection (CTDEEP) conducted the first comprehensive inventory of wetlands based on aerial photointerpretation techniques. The results of that survey were published in "Wetlands of Connecticut" (Metzler and Tiner 1992). In 2010, the FWS and CTDEEP developed a cooperative agreement to conduct an update of the wetlands inventory that included more detailed characterization of wetlands, a statewide landscape-level assessment of wetland functions, a general analysis of recent wetland trends, and an inventory of potential wetland restoration sites. The work was completed in 2012 and a series of reports are being prepared to summarize study findings. This is the first of these reports and will focus on the extent of wetlands in 2010.

**Study Area**

The study area is the state of Connecticut. The state is bordered by Massachusetts on the north, Long Island Sound on the south, Rhode Island on the east, and New York on the west. Connecticut encompasses 4,845 square miles of land area in southern New England and is divided into eight counties: Fairfield, Hartford, Litchfield, Middlesex, New Haven, New London, Tolland, and Windham (Figure 1; Table 1). Three watersheds dominate the state's landscape: Connecticut River, Thames River, and Housatonic River (Figure 2; Table 2). Coastal watersheds and small portions of the Hudson River drainage system and Pawcatuck River watershed account for the rest of the state.

Figure 1. Connecticut and its counties.

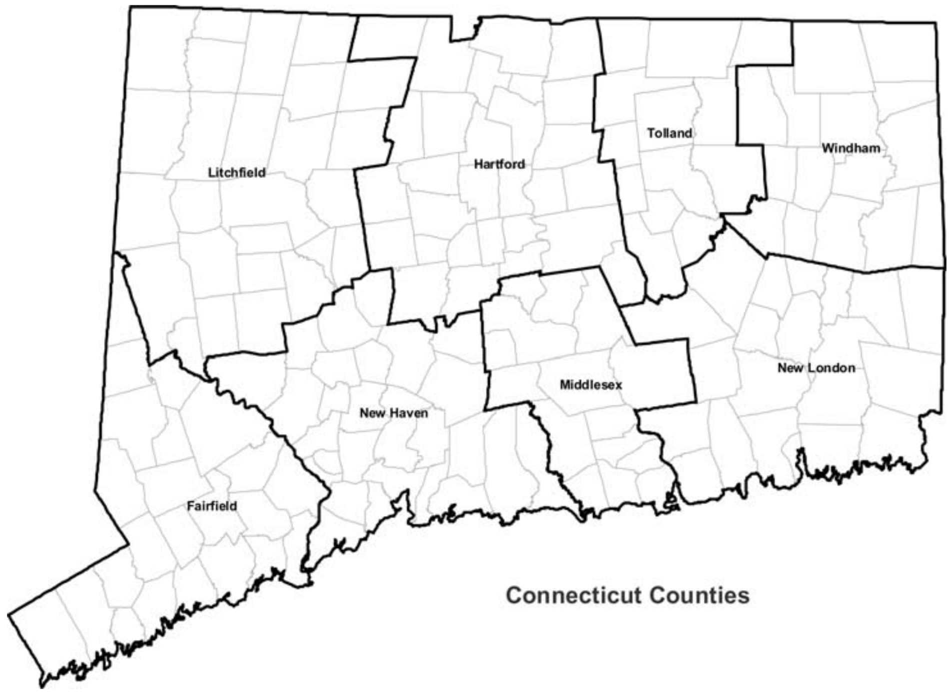


Table 1. Land-water area and land area of Connecticut counties and percent of state. The land-water area of the coastal counties includes a portion of Long Island Sound for a state total of 5,549.6 square miles; the state's land area is reported as 4,845.4 square miles by the State of Connecticut, Department of Economic and Community Development.

| **County** | **Land-Water Area** | | **% of State** | **Land Area** | **% of State** |
|---|---|---|---|---|---|
| | **Sq. Miles** | **Acres** | **(incl. LI Sound)** | **Sq. Miles** | |
| Fairfield | 834.1 | 533,810 | 15.1 | 625.9 | 12.9 |
| Hartford | 750.6 | 480,393 | 13.5 | 735.5 | 15.2 |
| Litchfield | 944.7 | 604,628 | 17.0 | 920.0 | 19.0 |
| Middlesex | 441.1 | 282,318 | 7.9 | 369.3 | 7.6 |
| New Haven | 866.3 | 554,426 | 15.7 | 605.8 | 12.5 |
| New London | 774.2 | 495,454 | 13.9 | 661.1 | 13.6 |
| Tolland | 417.2 | 267,031 | 7.5 | 410.1 | 8.5 |
| Windham | 521.4 | 333,686 | 9.4 | 512.8 | 10.6 |

Figure 2.  Connecticut's major watersheds.

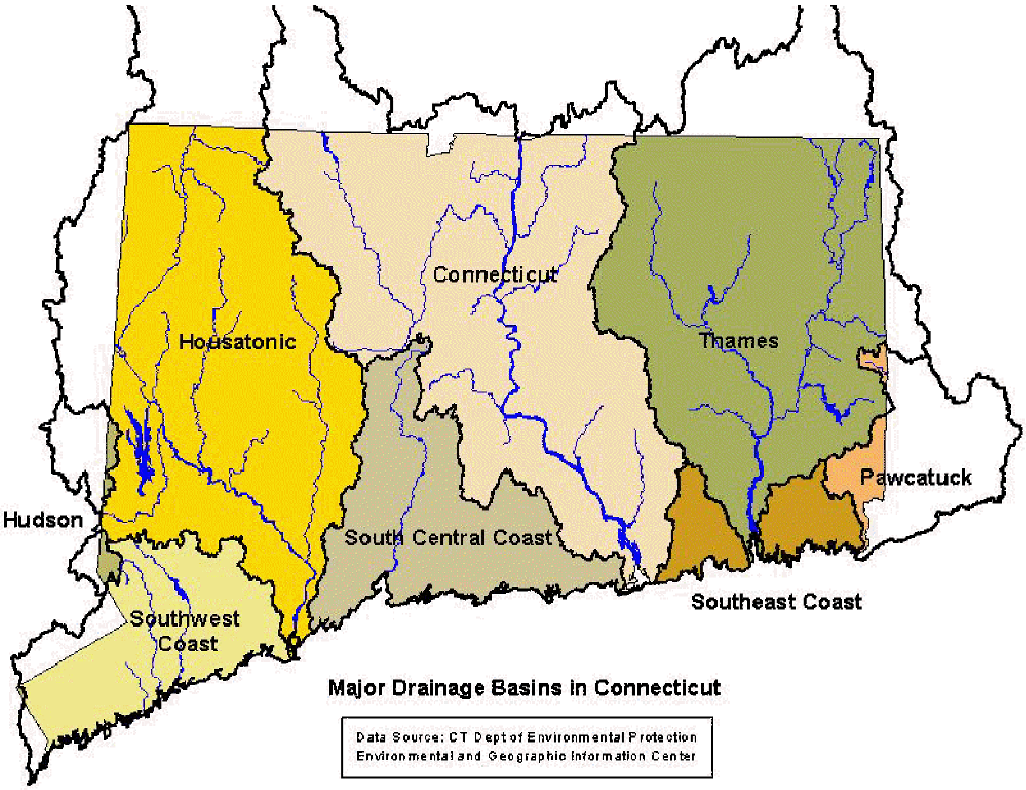


Table 2. Area of major watersheds and percent of state. *Note*: The total area is higher than the state's land area due to the inclusion of waterbodies, except Long Island Sound.

| Watershed | Area (sq. mi.) | Percent of State |
|---|---|---|
| Connecticut | 1,436.3 | 28.8 |
| Housatonic | 1,235.2 | 24.8 |
| Hudson | 22.3 | 0.4 |
| Pawcatuck | 56.7 | 1.1 |
| South Central Coast | 512.3 | 10.3 |
| Southeast Coast East | 87.2 | 1.8 |
| Southeast Coast West | 76.2 | 1.5 |
| Southwest Coast | 391.9 | 7.9 |
| Thames | 1,161.9 | 23.3 |
| State Total | 4,980.0 | |

## General Wetland Types

Connecticut's wetlands fall into four ecological systems: 1) estuarine (wetlands associated with estuaries), 2) palustrine (freshwater wetlands), 3) riverine (wetlands within the banks of rivers, excluding floodplains), and 4) lacustrine (lakeshore wetlands). The overwhelming majority of the state's wetlands fall into the first two systems. Estuarine wetlands are mostly comprised of salt marshes, coastal beaches, and tidal flats (Figures 3 and 4). Palustrine wetlands are represented by wooded swamps (forested or shrub), marshes, wet meadows, and ponds (Figures 5-8). The state's remaining wetlands consist of aquatic beds and nonvegetated types associated with the shallow water (littoral) zone of lakes and reservoirs or the banks of rivers (Figure 9). The state's wetlands have been well described in an earlier report "Wetlands of Connecticut" (Metzler and Tiner 1992) that is available online at: http://www.fws.gov/northeast/EcologicalServices/pdf/WetlandsofConnecticut.pdf.

Figure 3. A Connecticut salt marsh (Estuarine intertidal emergent wetland). (Mike Salter photo)

Figure 4. Beach along Connecticut's Long Island Sound shoreline (Estuarine intertidal unconsolidated shore – sand). (Ralph Tiner photo)

Figure 5. Connecticut wooded swamp (Palustrine forested wetland). (Mike Salter photo)

Figure 6. Shrub swamp (Palustrine scrub-shrub wetland) with marsh around small pond and in background (Palustrine emergent wetland). (Mike Salter photo)

Figure 7. A seasonally flooded marsh (Palustrine emergent wetland). (Mike Salter photo)

Figure 8.  Beaver-modified wetland (Palustrine unconsolidated bottom and dead scrub-shrub wetland, beaver). (Ralph Tiner photo)

Figure 9. Aquatic bed and shallow-water marsh in lake (Lacustrine littoral aquatic bed and nonpersistent emergent wetland, respectively). (Ralph Tiner photo)

# Methods

## Updating the Original Wetland Inventory

For updating purposes, recent digital imagery was examined to inventory wetlands and deepwater habitats using ESRI's ArcMap 10.0. Wetlands and deepwater habitats were classified according to the official FWS classification system (Cowardin et al. 1979; Appendix A).[1] A geospatial wetland-deepwater habitat data layer was created through the following process. The 2004 (black and white, leaf-off) and 2010 (color infrared, leaf-on) digital imagery were the primary sources for interpretation. The 2004 imagery was in a leaf-off condition that allowed for best detection of forested wetlands, while the 2010 imagery was examined to produce an effective date of the inventory of 2010 and facilitated detection of aquatic beds. The imagery was viewed at a working scale of 1:10,000 while in some cases, image analysts zoomed to larger scales to check signatures and refine boundaries. During this process, the FWS's original wetland geospatial data (1980s wetlands) were reviewed using GIS techniques. Areas mapped as a wetland in the previous inventory that remained unaltered were included in this update unless interpreters felt that such areas were incorrectly identified due to topography or other factors. In many cases, orientation and configuration of many, if not most, of these wetlands were adjusted to match the recent imagery. (*Note*: Prior inventory data were transferred from aerial imagery to hardcopy topographic basemaps via conventional cartographic techniques, i.e., zoom transfer scope.) The 2010 data were designed to be viewed at a scale of 1:12,000, although they can be examined at larger or smaller scales through the zoom capability of various mapping tools. The location of estuarine aquatic beds for the eastern end of Long Island Sound were taken from a 2009 eelgrass survey (Tiner et al. 2010; vector data), while other beds were interpreted from imagery. Other sources of collateral data included 1990 black and white (leaf-off) digital imagery and U.S. Department of Agriculture soil survey data (i.e., hydric soil map units) (Table 3).

## Adding Other Areas that May Support Wetlands

While the mapping methods relied on interpretation of aerial imagery, the inventory also made use of existing soil survey data. These surveys identified hydric soil mapping units that in their unaltered condition should support wetlands. Many of the hydric soil mapping units had photo-signatures that were interpretable as wetlands and were therefore classified as wetlands. There were, however, many other hydric soil units or portions of such units that did not. Some of the latter areas were developed (e.g., residential areas, impervious surfaces, or farmland) while others remained in "natural vegetation." The latter sites may include at least some wetland and were therefore

[1] This classification was adopted by the Federal Geographic Data Committee as the national standard for classifying wetlands when creating federally supported geospatial data (Federal Geographic Data Committee 1996).

designated as “P-wet areas” – areas with potential to support wetlands based on soil mapping.

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Table 3. Data sources used in the inventory. (Note: 2009 eelgrass data for eastern Long Island Sound was also used, but is not available for downloading.)

**Data Type and Source**

Digital Imagery: 2010 4-Band Color 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

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**Data Analysis and Compilation**

ArcInfo 10.0 was used to analyze the data and produce wetland statistics (acreage summaries) for the study areas. Tables were prepared to summarize the results of the inventory (i.e., the extent of different wetland types by Cowardin et al. classifications – commonly referred to as National Wetlands Inventory [NWI] types). After running the analyses, the data were used to produce a set of data layers that could be viewed via an online mapper (http://aswm.org/wetland-science/wetlands-one-stop-mapping/2836-nwi). Statistics (acreage summaries) were mostly generated from Microsoft's Access program. Excel spreadsheets were also used to compile the summary statistics. *Special Note: When summarizing data, percentages given usually refer to percent of wetland acreage, while for convenience, the narrative will refer to them as “percent of wetlands.”*

**Field Work**

Since extensive field work had been conducted during the late 1980s survey, the 2010 inventory did not require a considerable investment in field investigation. A few days of field work was done in the fall of 2010 and spring of 2011 to check preliminary interpretations by image analysts. Personnel from FWS and CTDEEP participated in these investigations.

# General Scope and Limitations of the Inventory

Since the wetland data were derived from 2010 imagery, changes in some wetlands have occurred since then that are not reflected in the database. These changes may be due to: 1) permitted alterations by Federal, state, and local governments, unauthorized activities, 2) natural process including erosion, accretion, and sea-level rise, and 3) differences in the interpretation based on the quality of the source imagery. Despite this, the 2010 database should reasonably reflect contemporary conditions because wetlands in this state are subject to regulation at Federal, state, and local levels.

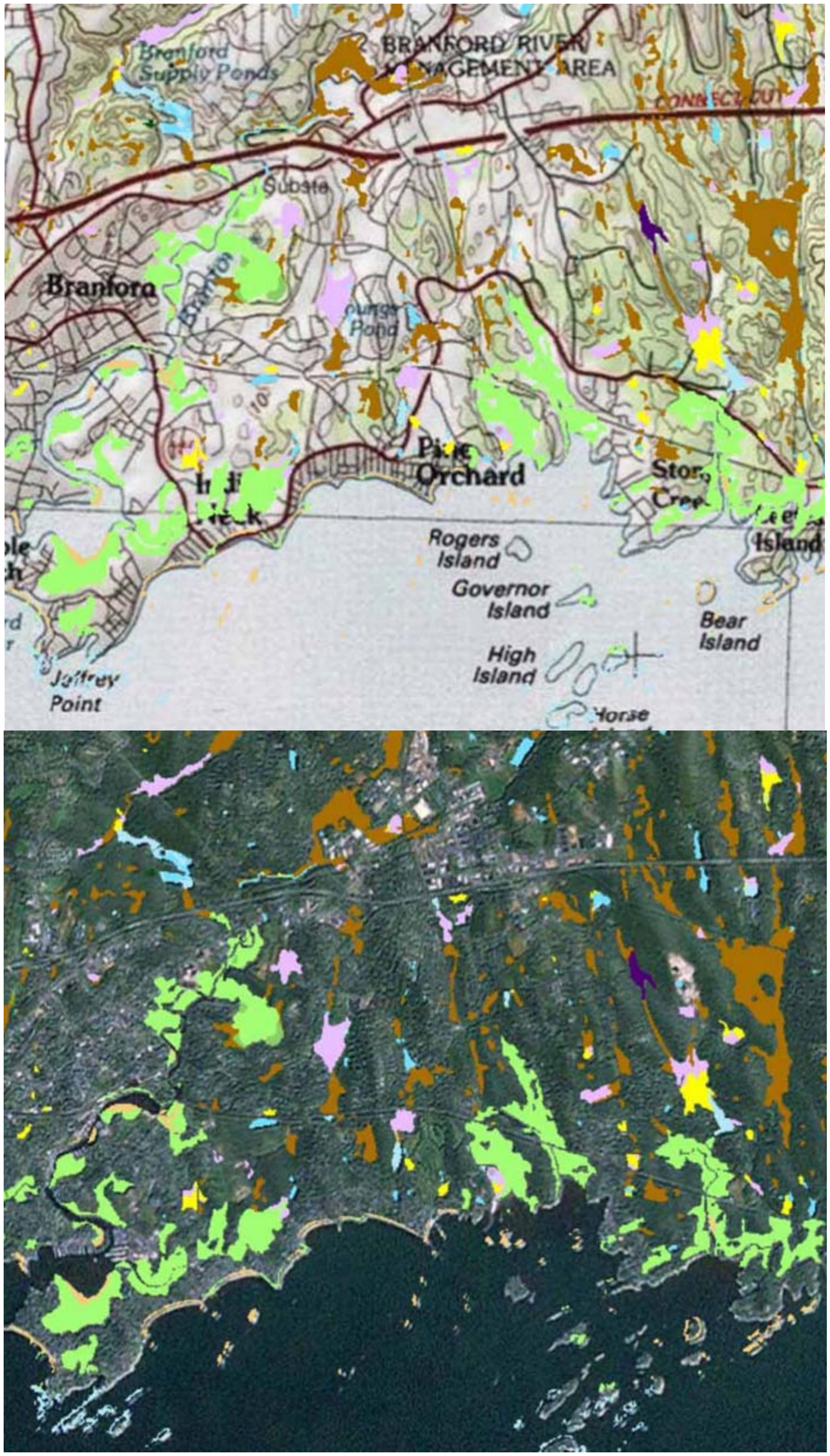
During 2010, Connecticut experienced drought and many reservoirs and lakes experienced significant drawdown. At this time many normally shallow water areas were exposed. These areas were classified as lacustrine littoral unconsolidated shore, although during years of normal precipitation they may be shallow water areas and perhaps even support aquatic beds. Since leaf-on 2010 imagery was used for this project, many freshwater aquatic beds in these deepwater habitats were visible and mapped, yet other beds either went undetected or were too small to map. It should be recognized that there can be yearly variation in bed development due to environmental conditions.

Tidal flats posed a unique challenge for inventory. Since this project relied on existing imagery and low-tide imagery did not exist for the entire coast, tidal flats were conservatively mapped. Their locations were interpreted from both the imagery and the U.S.G.S. topographic maps. Their limits should therefore be considered approximate.

It is important to recognize the limitations of any wetland mapping effort derived mainly through photointerpretation techniques (see Tiner 1990 and 1999 for details). Wetland data derived from these techniques do not show all wetlands. Some wetlands are simply too small to map given the imagery used, while others avoid detection due to evergreen tree cover, dry surface conditions, or other factors. The minimum target mapping unit was a one-half acre wetland, but many wetlands (especially ponds) smaller than this were mapped. Mapped wetlands may contain small areas that are different from the mapped type – inclusions – due to scale and map complexity issues. For example, a 10-acre forested wetland may include a 0.5-acre stand of emergent wetland and a 0.5-acre upland island that may not be pulled out of the larger wetland forest unit. Drier-end wetlands such as seasonally saturated and temporarily flooded palustrine wetlands are often difficult to separate from nonwetlands through photointerpretation. To minimize their omission from the inventory, we created the "P-wet areas" data layer (described in the methods section) by using hydric soil data to identify locations where such wetlands may exist. While P-wet areas were intended to represent undeveloped hydric soil areas not mapped as wetlands, some P-wet areas included small portions of developed areas due to scale and land use changes since the survey. Other areas that may support wetlands can be interpreted from USDA soils data – look for special feature symbols (i.e., the crow foot) that indicate wet spots detected during soil surveys. Finally, despite our best attempts at quality control, some errors of interpretation and classification are likely to occur due to the sheer number of polygons in the wetland database (over 80,000).

Figure 10. Hardwood swamp in western Connecticut (Palustrine forested wetland, broad-leaved deciduous, seasonally flooded/saturated). (Ralph Tiner photo)

Figure 11. Map displays for the coastal area from Branford to Guilford from online NWI+ Web Mapper: color-coded wetlands on “USA topo map” (top) and on “imagery” (bottom).



# Results

## Geospatial Data and Maps

The results of the inventory are contained within a geospatial database that records the location and classification of each wetland and deepwater habitat mapped during the survey. The database was used to prepare a data layer that produces a digital wetland map for the state. This map can be viewed online via the NWI+ Web Mapper at http://aswm.org/wetland-science/wetlands-one-stop-mapping/2836-nwi (see Appendix B for an introduction to this tool). This ESRI-supported online mapping tool allows users to zoom in for more detail, to display results on a variety of basemaps, and to print maps for areas of interest. Figure 11 shows examples of the same wetlands displayed on two difference basemaps: topographic map and aerial imagery. When zoomed in to the USA topography version, more detail (e.g., contours and place names) will be seen (Figure 12). A color-coded legend is available by clicking on the name of the data layer and then on the word "legend" that will appear. Detailed wetland classifications can be obtained by activating the "Wetland Codes" layer in "Map Contents" (Figure 13).

Figure 12. Example of more topographic detail shown when zoomed in to the USA topography base.

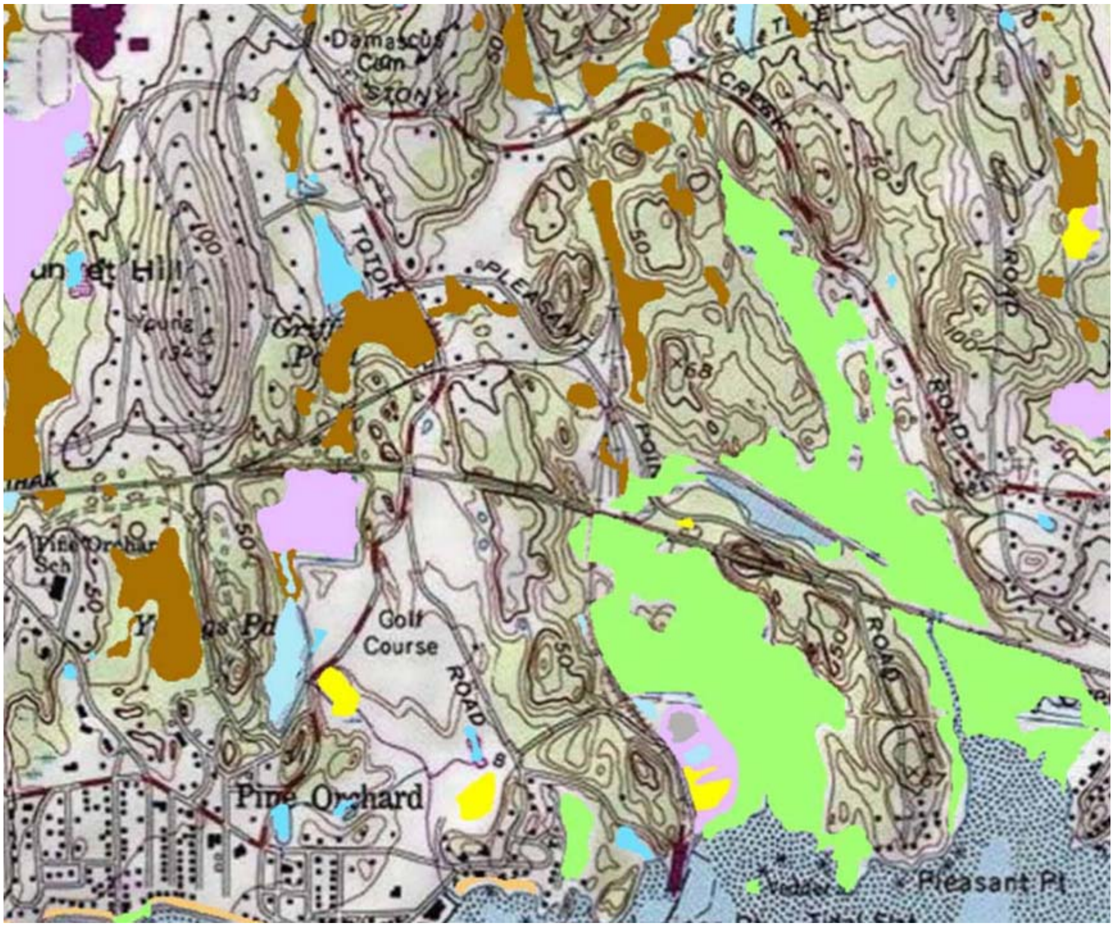
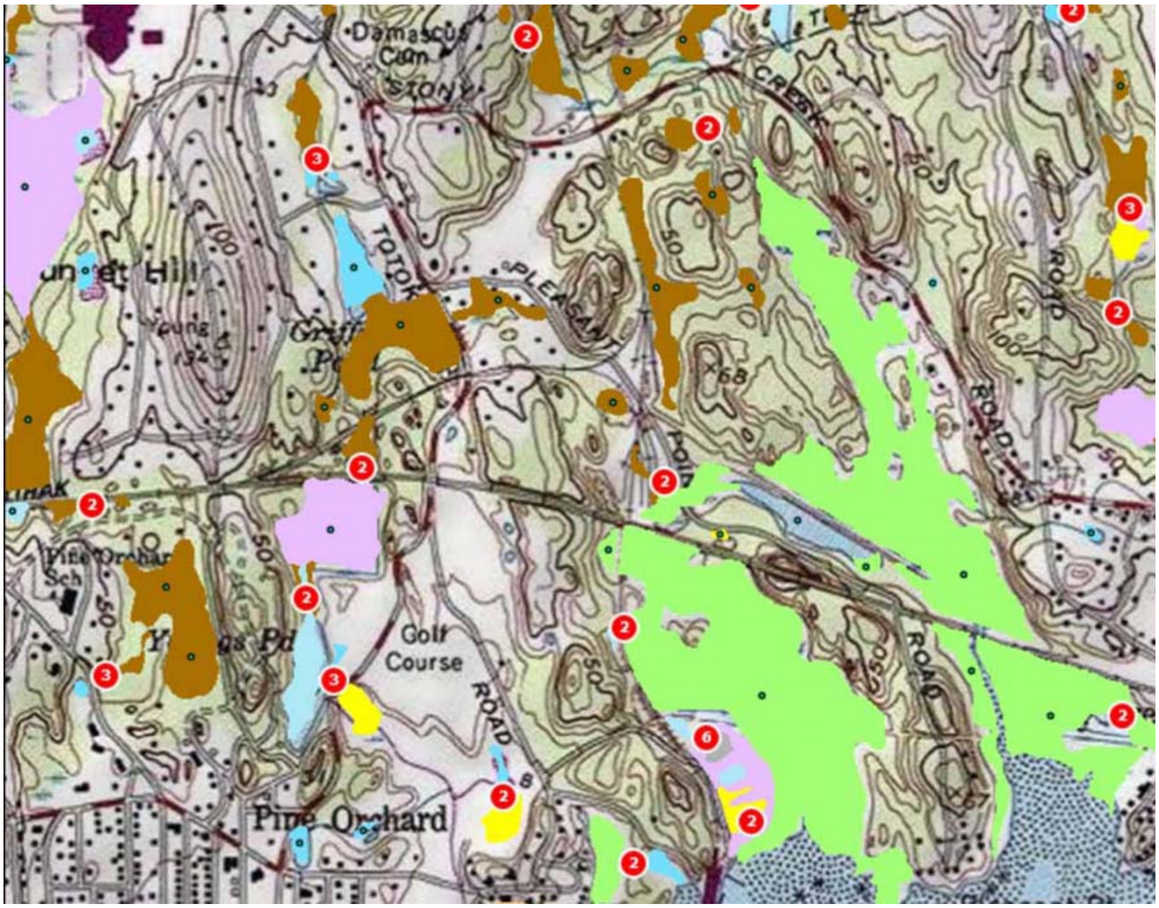


Figure 13. Wetlands and waterbodies on USA topo map with “Wetland Code” layer turned on showing dots to get the wetland classification. Clicking on a dot will produce a pop-up table listing the NWI type and LLWW classification for that area. A red circle surrounding a number indicates the number of polygons in that area; you have to zoom in closer to get the dots for the wetland complex.



## State Summary

*Wetlands*

Nearly 220,000 acres of wetlands were inventoried (Table 4), 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 composed of forested wetlands, shrub swamps, wet meadows, marshes, bogs, and ponds. They make up 91 percent of the state's wetlands. Forested wetlands are the major palustrine type, comprising almost two-thirds (62%) of these freshwater wetlands. 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 about 8 percent of the state's wetlands. The emergent type (salt and brackish marshes) dominate the estuarine wetlands, comprising almost three-quarters (73%) of these saline wetlands. Unconsolidated shores (beaches and tidal flats) account for most of the rest of the estuarine wetlands (25% of them). Lacustrine wetlands are mostly shallow bottoms of lakes and reservoirs and associated aquatic beds. The latter were quite evident 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 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.

*Deepwater Habitats*

Nearly 447,000 acres of deepwater habitats were mapped for Connecticut (Table 5). This amounts to almost 13 percent (12.6%) of the state's land-water area. Eighty-seven percent of these waters are estuarine waters with most of this area being the state's portion of Long Island Sound. A total of 143 acres of estuarine waters were mapped as excavated and 87 acres as impounded. Lacustrine waters (lakes, reservoirs, and large impoundments) accounted for most (78%) of the state's fresh waterbodies or 11 percent of the state's waters. Ninety-five percent of these waters were impounded whereas only 1 percent was excavated. Rivers (excluding streams too small to map as polygons) represented the remaining water acreage – 22 percent of the state's fresh waterbodies and less than 2 percent (1.6%) of the state's waters (Figure 14).

*Potentially Wet Areas*

Many undeveloped portions of hydric soil map units did not display a reliable wetland photo-signature that could be interpreted as wetlands by this survey's methods. Given that these areas are part of map units that reportedly contain more than 80 percent hydric soil there is a high probability that they support wetlands to some extent, although they could represent upland inclusions as well. A total of 221,757 acres of these areas were identified (Table 6). They can be viewed via the NWI+ Web Mapper. Interestingly, this total is slightly more than the area identified as wetland by the current survey or much more than the wetland total reported from the prior wetland inventory (Metzler and Tiner 1992). The combination of wetlands and these sites covers about 14 percent of the state's land area.

Figure 14. The Farmington River in Collinsville. (Mike Salter photo)

Table 4. Acreage of wetlands for Connecticut based on 2010 imagery and classified according to Cowardin et al. (1979). <u>Note</u>*: Palustrine wetlands have been separated into tidal and nontidal "subsystems," although these subsystems are not recognized in the Cowardin et al. (1979) classification system.*

| **System** | **Subsystem** | **Class** | **Acreage** |
|---|---|---|---|
| Estuarine | Intertidal | Aquatic Bed | 91.7 |
| | | Emergent | 12,350.9 |
| | | Emergent/Scrub-Shrub | 35.9 |
| | | Emergent/Other | 30.5 |
| | | Scrub-Shrub | 205.6 |
| | | Scrub-Shrub/Emergent | 9.2 |
| | | *(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 Deciduous | 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 | 23,603.0 |
| | | Emergent/Scrub-Shrub | 3,598.7 |
| | | Emergent/Other | 137.3 |
| | | *(Emergent Subtotal)* | *(27,339.0)* |
| | | Forested Broad-leaved Deciduous | 104,963.2 |
| | | Forested Needle-leaved Evergreen | 4,834.1 |
| | | Forested Deciduous/Evergreen | 8,201.5 |
| | | Forested/Scrub-Shrub | 4,423.0 |
| | | Forested/Emergent | 247.2 |
| | | Forested/Other | 273.8 |
| | | *(Forested Subtotal)* | *(122,942.8)* |

| | | | |
|---|---|---|---|
| | | Scrub-Shrub Deciduous | 19,046.0 |
| | | Scrub-Shrub Evergreen | 680.4 |
| | | Scrub-Shrub Mixed | 586.0 |
| | | Scrub-Shrub/Emergent | 3,078.4 |
| | | Scrub-Shrub/Forested | 2,036.7 |
| | | Scrub-Shrub/Other | 47.4 |
| | | *(Scrub-Shrub Subtotal)* | *(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* |
| | Lower Perennial | Aquatic Bed | 118.6 |
| | | Unconsolidated Shore | 10.8 |
| | | Rocky Shore | 1.2 |
| | | *Total Lower Perennial* | *130.6* |
| | Upper Perennial | Aquatic Bed | 1.7 |
| | | Unconsolidated Shore | 3.7 |
| | | *Total Upper Perennial* | *5.4* |
| | *All Riverine* | *(Vegetated Total)* | *(133.3)* |
| | | *(Nonvegetated Total)* | *(53.2)* |
| | ***Total Riverine*** | | ***186.5*** |
| **TOTAL MAPPED** | | | **219,556.4** |

Table 5. Acreage of waterbodies in Connecticut classified according to Cowardin et al. (1979). Data includes portion of Long Island Sound within state boundary.

| **System** | **Subsystem** | **Class** | **Acreage** |
|---|---|---|---|
| Estuarine | Subtidal | Aquatic Bed | 2,653.6 |
| | | Unconsolidated Bottom | 386,241.8 |
| | ***Total Estuarine*** | | ***388,895.4*** |
| Lacustrine | Limnetic (Tidal) | Aquatic Bed | 12.3 |
| | | Unconsolidated Bottom | 234.9 |
| | | *Total Tidal* | *247.2* |
| | Limnetic (Nontidal) | Aquatic Bed | 4,452.7 |
| | | Unconsolidated Bottom | 45,963.1 |
| | | *Total Nontidal* | *50,415.8* |
| | ***Total Lacustrine*** | | ***50,663.0*** |
| Riverine | Tidal | Unconsolidated Bottom | 7,278.8 |
| | Lower Perennial | Unconsolidated Bottom | 5,451.2 |
| | Upper Perennial | Unconsolidated Bottom | 1,658.1 |
| | ***Total Riverine*** | | ***7,278.8*** |
| **TOTAL MAPPED** | | | **446,837.2** |

Table 6. Acreage of potentially wet areas (P-wet areas) based on USDA soil mapping. These are areas of hydric soil that were not developed and not mapped as wetlands by this survey since they lacked an interpretable wetland photo-signature. They may support wetlands as the hydric soil map units reportedly contained 80% or more hydric soils with one exception – the Fluvaquents-Udifluvents complex which represent floodplain soils.

| Soil Name | Drainage Class | Percent Hydric | Acres |
|---|---|---|---|
| Brayton-Loonmeadow complex, extremely stony | Poorly Drained | 94 | 3433.8 |
| Brayton loam | Poorly Drained | 94 | 57.4 |
| Brayton mucky silt loam, 0 to 8 percent slopes, very stony | Poorly Drained | 94 | 294.0 |
| Bucksport muck | Very Poorly Drained | 99 | 197.5 |
| Catden and Freetown soils | Very Poorly Drained | 100 | 6440.7 |
| Fluvaquents-Udifluvents complex, frequently flooded | Poorly Drained | 61 | 5489.0 |
| Fredon silt loam | Poorly Drained | 90 | 445.4 |
| Fredon silt loam, cold | Poorly Drained | 90 | 14.8 |
| Halsey silt loam | Very Poorly Drained | 90 | 622.0 |
| Halsey silt loam, cold | Very Poorly Drained | 98 | 57.3 |
| Ipswich mucky peat | Very Poorly Drained | 100 | 28.9 |
| Leicester fine sandy loam | Poorly Drained | 89 | 2116.1 |
| Limerick and Lim soils | Poorly Drained | 95 | 2280.3 |
| Medomak silt loam | Very Poorly Drained | 100 | 51.6 |
| Moosilauke sandy loam | Poorly Drained | 82 | 55.6 |
| Mudgepond and Alden soils, extremely stony | Poorly Drained | 80 | 1237.9 |
| Mudgepond and Alden soils, extremely stony, cold | Poorly Drained | 90 | 124.0 |
| Mudgepond silt loam | Poorly Drained | 91 | 491.6 |
| Mudgepond silt loam, cold | Poorly Drained | 92 | 12.1 |
| Pawcatuck mucky peat | Very Poorly Drained | 100 | 71.7 |
| Raynham silt loam | Poorly Drained | 90 | 832.4 |
| Raypol silt loam | Poorly Drained | 84 | 7330.0 |
| Ridgebury fine sandy loam | Poorly Drained | 84 | 4604.4 |
| Ridgebury, Leicester, and Whitman soils, extremely stony | Poorly Drained | 92 | 126572.1 |
| Rippowam fine sandy loam | Poorly Drained | 87 | 10863.8 |
| Rumney fine sandy loam | Poorly Drained | 95 | 20.9 |
| Saco silt loam | Very Poorly Drained | 92 | 7642.6 |
| Scarboro muck | Very Poorly Drained | 94 | 7454.9 |
| Scarboro muck, cold | Very Poorly Drained | 97 | 36.6 |
| Scitico, Shaker, and Maybid soils | Poorly Drained | 85 | 4131.7 |
| Timakwa and Natchaug soils | Very Poorly Drained | 100 | 8848.3 |
| Walpole sandy loam | Poorly Drained | 85 | 8021.8 |
| Westbrook mucky peat | Very Poorly Drained | 100 | 449.3 |
| Westbrook mucky peat, low salt | Very Poorly Drained | 100 | 265.2 |
| Wilbraham and Menlo soils, extremely stony | Poorly Drained | 85 | 8886.1 |
| Wilbraham silt loam | Poorly Drained | 84 | 2022.1 |
| Wonsqueak mucky peat | Very Poorly Drained | 99 | 252.5 |

## County Summaries

New London County had the most wetland acreage with nearly 39,000 acres (Table 7). Three other counties had more than 30,000 acres: Litchfield, Hartford, and Windham. Windham and New London Counties exhibited the highest density of wetlands with 9.2 percent of their land area occupied by wetlands, while the other counties had from 5.6 to 8.2 percent of their land represented by wetlands. Estuarine wetlands were most abundant in New Haven County with more than 6,500 acres mapped. Estuarine vegetated wetlands (mostly salt marshes) were dominant in this county, while estuarine nonvegetated types were most abundant in Fairfield County. Middlesex County had the most acreage of freshwater tidal wetlands – over 1,300 acres. Palustrine vegetated wetlands were most common in four counties: New London, Litchfield, Windham, and Hartford in order of abundance. Over 2,000 acres of palustrine nonvegetated wetlands (mostly ponds) were mapped in three counties: Litchfield, Fairfield, and Hartford. Lacustrine wetlands were best represented in Litchfield, New Haven, and Fairfield Counties.

P-wet areas were most extensive in Litchfield and Windham Counties (Table 8). These two counties plus Fairfield and Tolland Counties possessed more P-wet acreage than wetland acreage. The other counties had less amounts of P-wet areas than wetlands.

The coastal counties had, by far, the most deepwater habitat acreage due to the occurrence of estuarine waters (including a portion of Long Island Sound; Table 8). New Haven County led all counties with nearly 166,000 acres followed by Fairfield County with roughly 131,000 acres. The other two coastal counties – New London and Middlesex – had about 69,000 and 45,000 acres of deepwater habitat, respectively. Lacustrine waters were most abundant in Litchfield County with over 13,000 acres, while Fairfield County was a close second with slightly more than 10,000 acres. Since this survey had access to leaf-on imagery, extensive areas of aquatic beds were mapped in lakes. Some of these beds may be in shallow water and technically wetland, but it was not possible to estimate the depth and many of the beds may be represented by floating species. Most of the state's tidal fresh water was found in Middlesex and Hartford Counties (3,974 and 2,960 acres, respectively). Nontidal river waters were most abundant in Hartford and Litchfield Counties (2,037 and 1,852 acres, respectively) which had nearly twice the acreage of the next ranked county – Windham (1,075). The acreage of riverine waters excluded small streams that were not mapped as polygonal features.

Table 7. Acreage of major wetland types for Connecticut based on 2010 imagery and percent of county's land area occupied by wetland.

| **County** | **Estuarine Wetland**<br>**Vegetated** | <br>**Nonveg** | **Palustrine Wetland**<br>**Vegetated*** | <br>**Nonveg*** | **Riverine and Lacustrine**<br>**Vegetated*** | <br>**Nonveg*** | **Total Wetland**<br>**(% of County)** | **Rank** |
|---|---|---|---|---|---|---|---|---|
| Fairfield | 1,716 | 2,063 | 17,342<br>(48) | 2,497<br>(11) | 3l L | 288 L | 23,936 (6.0) | #6 |
| Hartford | -- | -- | 28,710<br>(130) | 2,070<br>(21) 16f | 31 L<br>15 R (1) | 49 L (4)<br>30 R (28) | 30,921 (6.6) | #3 |
| Litchfield | -- | -- | 29,487 | 2,595 | 396 L<br>21 R | 455 L<br>4 R | 32,958 (5.6) | #2 |
| Middlesex | 2,452 | 510 | 15,282<br>(1,285) | 1,055<br>(2) | 66 L<br>10 R (9) | 27 L<br>14 R (9) | 19,416 (8.2) | #7 |
| New Haven | 5,341 | 1,265 | 17,626<br>(160) | 1,704<br>(7) 2f | 260 L | 139 L<br>2 R | 26,339 (6.8) | #5 |
| New London | 3,215 | 420 | 33,511<br>(653) | 1,466<br>(4) | 65 L<br>40 R (3) | 32 L<br>3 R | 38,752 (9.2) | #1 |
| Tolland | -- | -- | 15,445 | 1,260<br>13f | 181 L<br>4 R | 7 L | 16,910 (6.4) | #8 |
| Windham | -- | -- | 28,647 | 1,450<br>23f | 134 L<br>43 R | 29 L | 30,326 (9.2) | #4 |

* Codes: L = lacustrine; R = riverine; acres of freshwater tidal wetlands are noted in parentheses and are included in the palustrine and riverine totals. Farmed wetlands are listed separately and marked with "f".

Table 8. Acreage of other areas (P-wet areas) that may support some wetlands based on soil mapping. These areas were mapped as hydric soils but did not show a recognizable wetland signature and were not classified as wetland by this survey. The county's wetland acreage is shown for comparison. It is important to emphasize that these are areas that in all likelihood contain both upland (non-wetland) and wetland.

| **County** | **P-Wet Area Acreage** | **Wetland Acreage** |
|---|---|---|
| Fairfield | 30,646 | 23,935 |
| Hartford | 27,471 | 30,911 |
| Litchfield | 36,762 | 32,955 |
| Middlesex | 15,940 | 19,416 |
| New Haven | 25,437 | 26,339 |
| New London | 30,140 | 38,741 |
| Tolland | 20,490 | 16,905 |
| Windham | 34,871 | 30,315 |

Table 9. Acreage of deepwater habitats in Connecticut counties. Codes: T = freshwater tidal; NT = Nontidal. *Note*: The number in parenthesis is aquatic bed acreage that is included in the deepwater habitat system total; estuarine deepwater habitat extends beyond the county's land area into Long Island Sound.

| County | Estuarine DWH Acreage | Lacustrine DWH Acreage | Riverine DWH Acreage | Total DWH Acreage | Rank |
|---|---|---|---|---|---|
| Fairfield | 120,227 (941) | 20 T<br>10,303 NT (128) | 119 T<br>391 NT | 131,060 | #2 |
| Hartford | -- | 206 T (5)<br>13,798 NT (155) | 2,754 T<br>2,037 NT | 8,795 | #6 |
| Litchfield | -- | 3,195 NT (647) | 1,852 NT | 15,047 | #5 |
| Middlesex | 38,095 (31) | 21 T (8)<br>3,089 NT (385) | 3,953 T<br>79 NT | 45,237 | #4 |
| New Haven | 159,506 (77) | 5,437 NT (324) | 208 T<br>687 NT | 165,838 | #1 |
| New London | 61,005 (1,605) | 7,164 NT (1,137) | 244 T<br>727 NT | 69,140 | #3 |
| Tolland | -- | 3,683 NT (593) | 261 NT | 3,944 | #8 |
| Windham | -- | 3,748 NT (1,084) | 1,075 NT | 4,823 | #7 |

## Watershed Summaries

The Connecticut River and Thames River watersheds had the most wetland acreage of all counties, each with about 60,000 acres inventoried (Table 10). Other watersheds containing a large portion of the state's wetlands were the Housatonic watershed with about 40,000 acres and the South Central Coast watershed with about 27,000 acres. The other watersheds had less than 15,000 acres of wetlands, with the Hudson watershed, the state's smallest watershed, possessing just over 1,000 acres. Clearly the size of the watershed was a factor in these numbers as the Connecticut, Housatonic, and Thames watersheds comprise over three-quarters of the state.

The extent of P-wet areas in each watershed is shown in Table 11. Their acreage was greatest in the Thames, Connecticut, and Housatonic watersheds which is not surprising since these systems dominate the state's landscape.

Deepwater habitats were most extensive in the Connecticut watershed (over 27,000 acres), while the Housatonic watershed ranked second in this category with nearly 22,000 acres, followed by the Thames watershed with roughly 16,000 acres (Table 12). Each of the remaining watersheds had less than 6,000 acres of deepwater habitat.

Figure 15. Nonvegetated and vegetated wetlands occur in periodically flooded areas along the Housatonic River at West Cornwall (Riverine unconsolidated shore, cobble-gravel and nonpersistent emergent wetland). (Mike Salter photo)

Table 10. 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<br>52,376 | 24 T 29f<br>3,587 | 4 T<br>290 | 50 T<br>27 | 61,067 (27.8) |
| Housatonic | 503 | 121 | 44 T<br>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<br>18,574 | 7 T 2f<br>1,576 | 490 | -- | 27,277 (12.4) |
| Southeast Coast (east) | 910 | 30 | 119 T<br>4,468 | 3 T<br>194 | 6 | -- | 5,730 (2.6) |
| Southeast Coast (west) | 406 | 135 | 26 T<br>2,869 | 184 | 13 | -- | 3,633 (1.7) |
| Southwest Coast | 1,150 | 424 | 25 T<br>9,636 | 19 T<br>1,750 | 247 | -- | 13,251 (6.0) |
| Thames | 36 | 20 | 12 T<br>55,912 | 3,118<br>23f | 427 | 76 | 59,624 (27.2) |

Table 11. Extent of P-wet areas in each watershed. A total of 70 acres of P-wet areas were not associated with any watershed.

| Watershed | Acreage of P-wet Areas |
|---|---|
| Connecticut | 56,561 |
| Housatonic | 49,220 |
| Hudson | 944 |
| Pawcatuck | 2,515 |
| South Central Coast | 21,969 |
| Southeast Coast-East | 3,407 |
| Southeast Coast-West | 3,067 |
| Southwest Coast | 19,154 |
| Thames | 64,851 |

Table 12. Deepwater habitat acreage by watershed. Coding: T = fresh tidal; NT = nontidal. Numbers in parentheses are the acreage of aquatic bed included in the system total.

| Watershed | Estuarine Water | Lacustrine Water | Riverine Water Tidal | Riverine Water Lower Perennial | Riverine Water Upper Perennial | Total |
|---|---|---|---|---|---|---|
| Connecticut | 5,536 (8) | 227 T (12) 12,031 NT (1,040) | 6,948 | 2,030 | 339 | 27,111 |
| Housatonic | 901 | 20 T 18,359 NT (740) | 261 | 1,427 | 999 | 21,967 |
| Hudson | -- | 171 NT (1) | -- | -- | -- | 171 |
| Pawcatuck | 306 | 214 NT (69) | 2 | 60 | -- | 582 |
| South Central Coast | 1,441 (3) | 3,593 NT (213) | 42 | 157 | -- | 5,233 |
| Southeast Coast (east) | 774 (17) | 924 NT (109) | -- | -- | -- | 1,698 |
| Southeast Coast (west) | 1,199 (165) | 934 NT (131) | -- | -- | -- | 2,133 |
| Southwest Coast | 1,011 (81) | 3,135 NT (59) | 27 | 94 | 40 | 4,307 |
| Thames | 3,167 (5) | 11,056 NT (2,091) | -- | 1,647 | 281 | 16,151 |

# Discussion

## Comparison with the 1980s Inventory

The main purpose of the updated inventory was to utilize improved techniques to produce more detailed information about Connecticut's wetlands. The current methods provided an opportunity to produce a more comprehensive inventory than the 1980s survey and the study findings support this objective. It was no surprise that the 2010 inventory mapped more wetlands and more acreage than the 1980s survey (Table 13). The latter was based on 1:80,000 black and white aerial photographs (late 1970s-early 1980s) supplemented with 1:12,000 black and white photos. With imagery of that scale, the minimum mapping unit ranged from 3-5 acres in size, although some smaller conspicuous wetlands (mainly ponds) were mapped. The black and white imagery also is not as good as color infrared imagery for detecting vegetation patterns. The 2010 inventory used higher resolution, multi-temporal imagery including both leaf-on and leaf-off conditions that made it possible to map smaller wetlands (0.5 acre minimum) and aquatic beds as well as refine wetland boundaries. It was therefore not unexpected for the current survey to identify more wetland (219,556) than the prior inventory (172,548). This difference of 47,008 was attributed to additional acreage mapped as palustrine (48,407 acres; 200,198 v. 151,791) and lacustrine and riverine types (448 acres; 2,377 v. 1,929), whereas the current acreage of estuarine wetlands dropped by 1,846 acres (16,982 v. 18,828). The improved survey techniques allowed much more wetland to be mapped. Increases in Tolland, Hartford, Litchfield and New Haven counties made up the bulk of the state's 27 percent rise in wetland acreage. It must be emphasized that the added acreage is not new or created wetlands, but rather pre-existing wetlands that were not detected by the prior survey due to limitations largely by the scale, emulsion (black and white panchromatic film), and overall quality of the 1980s imagery.

Table 13. Comparison of wetland acreage from 2010 and 1980/81 inventories showing a significant increase due to mapping methods not to new wetlands forming on the landscape.

| County | 1980/81 Wetlands | 2010 Wetlands | Increase in Total Mapped | Percent Increase in Mapping |
|---|---|---|---|---|
| Fairfield | 19,321 | 23,936 | 4,615 | 24% |
| Hartford | 21,166 | 30,921 | 9,755 | 46% |
| Litchfield | 22,761 | 32,958 | 10,197 | 45% |
| Middlesex | 15,402 | 19,416 | 4,014 | 26% |
| New Haven | 19,465 | 26,339 | 6,874 | 35% |
| New London | 34,819 | 38,752 | 3,933 | 11% |
| Tolland | 11,512 | 16,910 | 5,398 | 47% |
| Windham | 28,102 | 30,326 | 2,224 | 8% |

During the past three decades, alterations of the state's wetlands were subject to Federal, state, and in some cases, local regulations that should have minimized losses compared to pre-regulation times  It is therefore not appropriate to simply compare the two surveys to produce information on wetland changes.  To do so would be like comparing apples to bananas.  The two inventories do not produce comparable results.  To identify changes in wetlands, they must be examined by aerial image to aerial image interpretation (photo to photo comparisons).  This has been done for two recent decades and is the subject of a companion report on Connecticut wetland trends – "Connecticut Wetlands: Changes from 1990 to 2010."

# Summary

Considerably more areas of wetland were detected by this survey than the prior inventory largely due to the use of higher resolution and larger scale imagery. The imagery for the current survey allowed image analysts to zoom into questionable areas to improve their ability to detect, delineate and classify wetlands. The 2010 imagery was captured during summer drought conditions which allowed interpretation of aquatic beds and exposed shorelines that were not observed on the leaf-off imagery (late 1970s-early 1980s) from the previous inventory. The leaf-off 2004 imagery was used to identify wetlands from non-wetlands as the absence of leaves permitted better detection of forested wetlands and early spring conditions with accompanying seasonal high water facilitated separation of wetlands from non-wetlands. Nonetheless, this survey like others of its kind based largely on interpretation of aerial imagery did not identify all wetlands in the state as some are simply difficult to detect by these methods (Tiner 1990). The inclusion of "P-wet areas" in this inventory was an attempt to identify other areas that may support wetlands based on the results of prior U.S. Department of Agriculture (USDA) soil surveys.

This survey mapped nearly 220,000 acres of wetlands and almost 447,000 acres of deepwater habitat in Connecticut. Wetlands comprised about 7 percent of the state's land area. Palustrine wetlands dominated accounting for 91 percent of the state's wetlands and most of these were forested types. Estuarine wetlands represented most of the remaining wetlands (8% of the state's wetlands) and emergent types (salt and brackish marshes) dominated. About two-thirds of the state's wetlands were found in New London, Litchfield, Hartford, and Windham counties. From the watershed perspective, nearly three-quarters of the state's wetlands were located in three river basins: Connecticut, Thames, and Housatonic. This inventory also identified other areas that may support wetlands based on soil mapping by the USDA Natural Resources Conservation Service. These potentially wet areas ("P-wet areas") accounted for an additional 221,757 acres – an amount slightly more than the acreage mapped as wetlands by this survey. The location and types of wetlands, deepwater habitats, and P-wet areas identified by this inventory can be viewed online via the NWI+ Web Mapper: http://aswm.org/wetland-science/wetlands-one-stop-mapping/2836-nwi.

# Acknowledgments

Many people have contributed to this report. Ralph Tiner, Regional Wetland Coordinator for the U.S. Fish and Wildlife Service's Northeast Region designed the inventory and oversaw all aspects of this project. Bob Gilmore was project officer for the Connecticut Department of Energy and Environmental Protection (DEEP). Image analysis, database development, and production of maps were performed by staff at Virginia Tech's Conservation Management Institute (CMI) under the direction of Kevin McGuckin: mainly Nicole Fuhrman, Dave Orndorff, Jason Herman, and Brian Diggs. Other CMI staff assisting in this project included: Ingrid Mans, Erik Olson, Jesse Parker, Allison Sullivan, Daniel Cross, Kyle Nixon, and Richard Mittler. Todd Nuerminger assisted by performing quality control on CMI draft interpretations. Jason Herman (CMI) did the GIS analysis and produced tables for this report. Ralph Tiner also performed quality control/assurance, and reviewed the database, assisted in final editing, and prepared the report. Bob Gilmore and Mike Salter assisted in reviewing draft data and field work; Mike also provided photographs of Connecticut's wetlands for use in this report. Carl Zimmerman provided digital data comparing the current survey with the former survey and hydric soils data and Kevin O'Brien provided comments on the final version. The draft report was peer reviewed by Bill Wilen (FWS) and Bob Gilmore (DEEP). Gina Jones (FWS) prepared the cover.

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# APPENDICES

## Appendix A. Chart showing wetland and deepwater habitat types according to Cowardin et al. 1979.

# WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

## SYSTEM: M - MARINE

### SUBSYSTEM: 1 - SUBTIDAL

| CLASS | RB – ROCK BOTTOM | UB – UNCONSOLIDATED BOTTOM | AB – AQUATIC BED | RF - REEF | OW - *OPEN WATER/ Unknown Bottom* |
|---|---|---|---|---|---|
| Subclass | 1 Bedrock<br>2 Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic | 1 Algal<br>3 Rooted Vascular<br>5 *Unknown Submergent* | 1 Coral<br>3 Worm | |

### SUBSYSTEM: 2 - INTERTIDAL

| CLASS | AB – AQUATIC BED | RF– REEF | RS – ROCKY SHORE | US - UNCONSOLIDATED SHORE |
|---|---|---|---|---|
| Subclass | 1 Algal<br>3 Rooted Vascular<br>5 *Unknown Submergent* | 1 Coral<br>3 Worm | 1 Bedrock<br>2 Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic |

## SYSTEM: E - ESTUARINE

### SUBSYSTEM: 1 - SUBTIDAL

| CLASS | RB - ROCK BOTTOM | UB – UNCONSOLIDATED BOTTOM | AB – AQUATIC BED | RF – REEF | OW - *OPEN WATER/ Unknown Bottom* |
|---|---|---|---|---|---|
| Subclass | 1 Bedrock<br>2. Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic | 1 Algal<br>3 Rooted Vascular<br>4 Floating Vascular<br>5 *Unknown Submergent*<br>6 *Unknown Surface* | 1 Mollusc<br>2 Worm | |

### SUBSYSTEM: 2 - INTERTIDAL

| CLASS | AB – AQUATIC BED | RF– REEF | SB – STREAMBED | RS - ROCKY SHORE | US – UNCONSOLIDATED SHORE | EM -EMERGENT | SS – SCRUB-SHRUB | FO – FORESTED |
|---|---|---|---|---|---|---|---|---|
| Subclass | 1 Algal<br>3 Rooted Vascular<br>4 Floating Vascular<br>5 *Unknown Submergent*<br>6 *Unknown Surface* | 1 Mollusc<br>2 Worm | 1 Cobble Gravel<br>2 Sand<br>3 Mud<br>4 Organic | 1 Bedrock<br>2 Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic | 1 Persistent<br>2 Nonpersistent | 1 Broad-Leaved Deciduous<br>2 Needle-Leaved Deciduous<br>3 Broad-Leaved Evergreen<br>4 Needle-Leaved Evergreen<br>5 Dead<br>6 *Deciduous*<br>7 *Evergreen* | 1 Broad-Leaved Deciduous<br>2 Needle-Leaved Deciduous<br>3 Broad-Leaved Evergreen<br>4 Needle-Leaved Evergreen<br>5 Dead<br>6 *Deciduous*<br>7 *Evergreen* |

## SYSTEM: R - RIVERINE

SUBSYSTEM: 1 – TIDAL; 2 – LOWER PERENNIAL; 3 – UPPER PERENNIAL; 4 – INTERMITTENT; 5 – *UNKNOWN PERENNIAL*

| CLASS | RB – ROCK BOTTOM | UB – UNCONSOLIDATED BOTTOM | *SB – STREAMBED | AB – AQUATIC BED | RS – ROCKY SHORE | US – UNCONSOLIDATED SHORE | **EM – EMERGENT | OW – *OPEN WATER/ Unknown Bottom* |
|---|---|---|---|---|---|---|---|---|
| Subclass | 1 Bedrock<br>2 Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic | 1 Bedrock<br>2 Rubble<br>3 Cobble Gravel<br>4 Sand<br>5 Mud<br>6 Organic<br>7 Vegetated | 1 Algal<br>2 Aquatic Moss<br>3 Rooted Vascular<br>4 Floating Vascular<br>5 *Unknown Submergent*<br>6 *Unknown Surface* | 1 Bedrock<br>2 Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic<br>5 Vegetated | 2 Nonpersistent | |

* STREAMBED is limited to TIDAL and INTERMITTENT SUBSYSTEMS, and comprises the only CLASS in the INTERMITTENT SUBSYSTEM.
** EMERGENT is limited to TIDAL and LOWER PERENNIAL SUBSYSTEMS.

*Classification of Wetlands and Deepwater Habitats of the United States*
*Cowardin ET AL. 1979 as modified for National Wetland Inventory Mapping Convention*

# WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

**SYSTEM:** L- LACUSTRINE

**SUBSYSTEM:** 1 - LIMNETIC

| CLASS | RB – ROCK BOTTOM | UB – UNCONSOLIDATED BOTTOM | AB – AQUATIC BED | OW – *OPEN WATER/ Unknown Bottom* |
|---|---|---|---|---|
| Subclass | 1 Bedrock<br>2. Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic | 1 Algal<br>2 Aquatic Moss<br>3 Rooted Vascular<br>4 Floating Vascular<br>5 *Unknown Submergent*<br>6 *Unknown Surface* | |

**SUBSYSTEM:** 2 - LITTORAL

| CLASS | RB – ROCK BOTTOM | UB – UNCONSOLIDATED BOTTOM | AB – AQUATIC BED | RS – ROCKY SHORE | US – UNCONSOLIDATED SHORE | EM – EMERGENT | OW – *OPEN WATER/ Unknown Bottom* |
|---|---|---|---|---|---|---|---|
| Subclass | 1 Bedrock<br>2. Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic | 1 Algal<br>2 Aquatic Moss<br>3 Rooted Vascular<br>4 Floating Vascular<br>5 *Unknown Submergent*<br>6 *Unknown Surface* | 1 Bedrock<br>2. Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic<br>5 Vegetated | 2 Nonpersistent | |

**SYSTEM:** P - PALUSTRINE

| CLASS | RB – ROCK BOTTOM | UB – UNCONSOLIDATED BOTTOM | AB – AQUATIC BED | US – UNCONSOLIDATED SHORE | ML – MOSS-LICHEN | EM – EMERGENT | SS – SCRUB-SHRUB | FO – FORESTED | OW – *OPEN WATER/ Unknown Bottom* |
|---|---|---|---|---|---|---|---|---|---|
| Subclass | 1 Bedrock<br>2. Rubble | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic | 1 Algal<br>2 Aquatic Moss<br>3 Rooted Vascular<br>4 Floating Vascular<br>5 *Unknown Submergent*<br>6 *Unknown Surface* | 1 Cobble-Gravel<br>2 Sand<br>3 Mud<br>4 Organic<br>5 Vegetated | 1 Moss<br>2 Lichen | 1 Persistent<br>2 Nonpersistent | 1 Broad-Leaved Deciduous<br>2 Needle-Leaved Deciduous<br>3 Broad-Leaved Evergreen<br>4 Needle-Leaved Evergreen<br>5 Dead<br>6 *Deciduous*<br>7 *Evergreen* | 1 Broad-Leaved Deciduous<br>2 Needle-Leaved Deciduous<br>3 Broad-Leaved Evergreen<br>4 Needle-Leaved Evergreen<br>5 Dead<br>6 *Deciduous*<br>7 *Evergreen* | |

## MODIFIERS

In order to more adequately describe the wetland and deepwater habitats one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

### WATER REGIME

| Non-Tidal | | Tidal | |
|---|---|---|---|
| A Temporarily Flooded<br>B Saturated<br>C Seasonally Flooded<br>D *Seasonally Flooded/ Well Drained*<br>E *Seasonally Flooded/ Saturated*<br>F Semipermanently Flooded<br>G Intermittently Exposed | H Permanently Flooded<br>J Intermittently Flooded<br>K Artificially Flooded<br>W Intermittently Flooded/Temporary<br>Y Saturated/Semipermanent/ Seasonal<br>Z Intermittently Exposed/Permanent<br>U *Unknown* | K *Artificially Flooded*<br>L Subtidal<br>M Irregularly Exposed<br>N Regularly Exposed<br>P Irregularly Flooded | *S Temporary-Tidal<br>*R Seasonal-Tidal<br>*T Semipermanent-Tidal<br>*V Permanent-Tidal<br>U *Unknown* |

*These water regimes are only used in tidally influenced, freshwater systems.

### WATER CHEMISTRY

| Coastal Halinity | Inland Salinity | pH Modifiers for all Fresh Water |
|---|---|---|
| 1 Hyperhaline<br>2 Euthaline<br>3 Mixohaline *(Brackish)*<br>4 Polyhaline<br>5 Mesohaline<br>6 Oligohaline<br>0 Fresh | 7 Hypersaline<br>8 Eusaline<br>9 Mixosaline<br>0 Fresh | a Acid<br>t Circumneutral<br>i Alkaline |

### SOIL

g Organic
n Mineral

### SPECIAL MODIFIERS

| | |
|---|---|
| b *Beaver*<br>d *Partially Drained/Ditched*<br>f Farmed | h *Diked/Impounded*<br>r Artificial Substrate<br>s *Spoil*<br>x Excavated |

NOTE: Italicized terms were added for mapping by the National Wetlands Inventory program.

## APPENDIX B. NWI+ Web Mapper.

## NWI+ Web Mapper

The NWI+ Web Mapper is an online mapping tool that allows users to view special project data prepared by the U.S. Fish and Wildlife Service (FWS) but not available through its "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.

### 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* – 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). 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.). To view the legend for these types click on the layer name "NWI Types" and then on the "legend" sublayer name, the legend will then be displayed beneath the layer name. 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. A link to the Cowardin et al. document can be found under the main topic – "National Wetlands Inventory (NWI)" – or accessed through the FWS Conservation Library Wetland Publications page.

*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 a link to the classification document – dichotomous keys and mapping codes). 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.

_______ *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, click on the name of the layer (e.g., SWD Function for surface water detention) and then on the sublayer “Legend.”

*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.

U.S. Fish & Wildlife Service
http://www.fws.gov

March 2013