Tiner, R.W. and H.C. Bergquist. 2007. The Hackensack River Watershed, New Jersey/New York Wetland Characterization, Preliminary Assessment of Wetland Functions, and Remotely Sensed Assessment of Natural Habitat Integrity. U.S. Fish and Wildlife Service, National Wetlands Inventory, Ecological Services, Region 5, Hadley, MA.

U.S. Fish & Wildlife Service

The Hackensack River Watershed, New Jersey/ New York:

Wetland Characterization, Preliminary Assessment of Wetland Functions, and Remotely-sensed Assessment of Natural Habitat Integrity

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Program
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Produced by the U.S. Fish and
Wildlife Service
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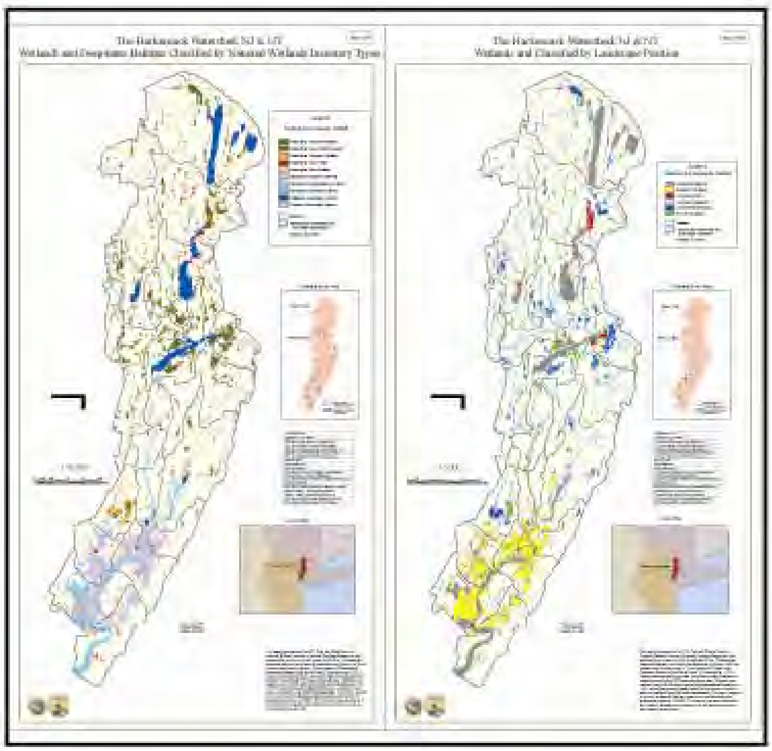
September 2007



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Note: The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official views of the Service.

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Introduction

Since the late 1970s, the U.S. Fish and Wildlife Service has been conducting fairly detailed wetland inventories through its National Wetlands Inventory Program (NWI). The maps and data produced from the NWI have been used to aid and strengthen efforts in wetland protection, conservation, and management. During the past 15 years, there has been significant progress made in the development of geographic information system (GIS) technology, availability of digital geospatial data, and knowledge of the relationships between wetland functions and characteristics. The Service's NWI Program now has the capability to use its extensive wetland geospatial database to produce wetland characterizations, functional assessments, and assessments of other natural resources for individual watersheds to support restoration planning and other activities.

The typical wetlands inventory characterizes wetlands mainly by their vegetation and expected hydrology (water regime), with other modifiers used to indicate human activities (e.g., diked/impounded, excavated, farmed, and partly drained) and beaver influence. In order to use the inventory data to predict functions (e.g., surface water detention, nutrient transformation, streamflow maintenance, and provision of fish and wildlife habitat), additional information on the hydrogeomorphic characteristics of wetlands is required. One needs to know where the wetland is located and its association with a waterbody. The Service has developed a set of attributes to better describe wetlands by landscape position, landform, water flow path, and waterbody type (LLWW descriptors; Tiner 2003a). When added to the NWI data, the enhanced NWI data have a predictive capability regarding wetland functions (Tiner 2003b, 2005a). In addition to the development of a preliminary wetland functional assessment tool, a set of remotely-sensed "natural habitat integrity indices" have been developed to characterize the general status of natural resources in watersheds through remote sensing techniques (Tiner 2004).

The Service's New Jersey Field Office (NJFO) is actively engaged with other federal and state agencies and others in natural resource conservation in the Hackensack River watershed including the Hackensack Meadowlands. NWI mapping in this area was recently updated and enhanced as part of a Service-wide strategic mapping initiative focused on updating wetland data for areas where mapping was older than 20 years and/or where significant wetland resources remain vulnerable to development. Given that New Jersey was the first state completed by the NWI with late 1970s aerial photography, the NWI maps and data were over 25 years old and in dire need of updating. Much has changed in this heavily populated state since then and the original mapping is of limited value for today's natural resource managers. Although the area had been remapped, no analysis of the data had been performed.

This report documents the findings of our watershed-wide assessment for the Hackensack River watershed including the results of the updated and enhanced NWI, a preliminary assessment of wetland functions, and an assessment of the overall extent of "natural habitat" in the watershed ("natural habitat integrity").

Study Area

The Hackensack River watershed covers a 197-square mile area in northeastern New Jersey and southern New York (Figure 1). Most (58%) of the watershed occurs in Bergen County, New Jersey, with 32 percent in Rockland County, New York and the remaining 10 percent in Hudson County, New Jersey. The uppermost portion of the watershed is less developed than the highly urbanized lower portion. The tidal reach of this watershed is mostly comprised by the Hackensack Meadowlands.

The watershed contains 19 subbasins (Figure 2): 1) De Forest Lake, 2) Upper Pascack Brook, 3) Hackensack-Nauranshaun Confluence, 4) Pascack Brook above Westwood gage, 5) Hackensack River above Tappan Bridge, 6) Hackensack River- Oradell to Tappan Bridge, 7) Pascack Brook below Westwood gage, 8) Dwars Kill, 9) Tenakill Brook, 10) Hirshfeld Brook, 11) Hackensack River – Fort Lee Road to Oradell gage, 12) Coles Brook-Van Saun Mill Brook, 13) Hackensack River – Bellman's Creek to Ft. Lee Road, 14) Overpeck Creek, 15) Hackensack River – Route 3 to Bellman's Creek, 16) Berry's Creek above Paterson Avenue, 17) Berry's Creek below Paterson Avenue, 18) Hackensack River – Amtrak bridge to Route 3, and 19) Hackensack River below Amtrack bridge. The latter nine subbasins are subject to tidal influence. Tidal action in the Coles Brook/Van Saun Mill Brook subbasin is limited to freshwater tidal fluctuations.

Figure 1. Major waterbodies and municipalities within the Hackensack River watershed. (Illustration copyright (c) 1996 by Karen L. Siletti)

Figure 2. Subbasins of the Hackensack watershed: 1) De Forest Lake, 2) Upper Pascack Brook, 3) Hackensack-Nauranshaun Confluence, 4) Pascack Brook above Westwood gage, 5) Hackensack River above Tappan Bridge, 6) Hackensack River- Oradell to Tappan Bridge, 7) Pascack Brook below Westwood gage, 8) Dwars Kill, 9) Tenakill Brook, 10) Hirshfeld Brook, 11) Hackensack River – Fort Lee Road to Oradell gage, 12) Coles Brook-Van Saun Mill Brook, 13) Hackensack River – Bellman's Creek to Ft. Lee Road, 14) Overpeck Creek, 15) Hackensack River – Route 3 to Bellman's Creek, 16) Berry's Creek above Paterson Avenue, 17) Berry's Creek below Paterson Avenue, 18) Hackensack River – Amtrak bridge to Route 3, and 19) Hackensack River below Amtrack bridge.

Methods

Classification and Characterization

One of the objectives of this project was to expand data in an up-to-date inventory of wetlands to include attributes for landscape position, landform, water flow path, and waterbody type (LLWW descriptors). For the updated NWI inventory, 1:40,000 color infrared photography acquired from 1994-1996 was interpreted following standard NWI procedures (1995 for New Jersey; 1994-1996 for New York).

After identifying and classifying wetlands according to the Service's official wetland classification system (Cowardin et al. 1979), three main descriptors (landscape position, landform, and water flow path) were applied to each wetland by interpreting available map information, and in some cases, consulting aerial photographs. "Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors" (Tiner 2003a; http://library.fws.gov/wetlands/dichotomouskeys0903.pdf) was used to classify these features. Other modifiers were added to depict features such as headwater, drainage-divide, and human-impacted wetlands; waterbodies (e.g., ponds and lakes) were also classified in more detail.

Landscape position defines the relationship between a wetland and an adjacent waterbody if present. For the Hackensack River watershed, four landscape positions were possible (map codes are given in parentheses): 1) estuarine (ES; along salt and brackish tidal waters), 2) lotic (along rivers [LR] and streams [LS] and on their active floodplains), 3) lentic (LE; along lakes and reservoirs), and 4) terrene (TE; typically surrounded by upland, but including wetlands serving as sources of streams). Lotic wetlands were divided into lotic river and lotic stream wetlands by their width on a 1:24,000-scale map. Watercourses mapped as linear (single-line) features on NWI maps and on U.S. Geological Survey topographic maps (1:24,000) were designated as streams, whereas two-lined channels (polygonal features on the maps) were classified as rivers. All lotic wetlands are in contact with streams or rivers and periodically inundated by overflow. Wetlands on floodplains surrounded by upland (nonhydric soil) were classified as terrene wetlands as were nontidal wetlands completely surrounded by dryland and wetlands that were the source of streams. Lentic wetlands were divided into two categories: natural and dammed, with the latter type separating wetlands associated with reservoirs from those along other controlled lakes, when possible.

Landform is the physical form or shape of a wetland. Six landform types were recognized in the study area: 1) basin (BA), 2) flat (FL), 3) slope (SL), 4) floodplain (FP), 5) island (IL), and 6) fringe (FR) (Table 1). The floodplain landform was restricted to wetlands bordering perennial rivers, while fringe wetlands are mostly associated with estuarine waters and semipermanently flooded vegetated wetlands elsewhere. Where an estuarine wetland is located behind a causeway (road or railroad) or otherwise partially cut off from the mainbody of a fringing wetland, the wetland was classified as a basin wetland. Other basin wetlands were depressional wetlands and seasonally flooded wetlands along streams. Flat wetlands occur on nearly level landforms and typically have a seasonally saturated or temporarily flooded water regime.

Table 1. Definitions and examples of landform types (Tiner 2003a).

Landform Type (code)	**General Definition**	**Examples**
Basin (BA)*	a depressional (concave) landform including artificially created ones by impoundments, causeways, and roads	lakefill bogs; wetlands in the saddle between two hills; wetlands in closed or open depressions, including narrow stream valleys; tidally restricted estuarine wetlands
Slope (SL)	a landform extending uphill (on a slope; typically crossing two or more contours on a 1:24,000 map)	seepage wetlands on hillside; wetlands along drainageways or mountain streams on slopes
Flat (FL)*	a relatively level landform, often on broad level landscapes	wetlands on flat areas with high seasonal ground-water levels; wetlands on terraces along rivers/streams; wetlands on hillside benches; wetlands at toes of slopes
Floodplain (FP)	a broad, generally flat landform occurring on a landscape shaped by fluvial or riverine processes	wetlands on alluvium; bottomland swamps
Fringe (FR)	a landform occurring within the banks of a nontidal waterbody (not on a floodplain) and often but not always subject to near permanent inundation and a landform along an estuary subject to unrestricted tidal flow or a regularly flooded landform along a tidal freshwater river or stream	buttonbush swamps; aquatic beds; semipermanently flooded marshes; river and stream gravel/sand bars; salt and brackish marshes and flats; regularly flooded tidal fresh marsh or flat
Island (IL)	a landform completely surrounded by water (including deltas)	deltaic and insular wetlands; floating bog islands

*May be applied as sub-landforms within the Floodplain landform (FPba and FPfl).

Water flow path descriptors characterize the flow of water associated with wetlands. Six patterns of flow were recognized for wetlands and ponds in the Hackensack watershed: 1) bidirectional-tidal flow (BT), 2) throughflow (TH), 3) outflow (OU), 4) bidirectional-nontidal flow (BI), 5) inflow (IN), and 6) isolated (IS). Bidirectional-tidal flow reflects tidal influence. Throughflow wetlands have either a watercourse (e.g., stream) or another type of wetland above and below it, so water passes through them (usually by way of a river or stream, but sometimes by ditches). The water flow path of lotic wetlands associated with perennial streams is throughflow. Lentic wetlands crossed by streams were also designated as throughflow, while those located in embayments or coves with no stream inflow were classified as bidirectional-nontidal flow since fluctuating lake or reservoir water levels appear to be the primary surface water source affecting their hydrology. Outflow wetlands have water leaving them all year-long, moving downstream via a watercourse (e.g., stream) or a slope wetland. (Note: Some outflow wetlands have intermittent flow and may be classified as Outflow Intermittent, but this was not done for this project.) Inflow wetlands or ponds are sinks where no outlet exists, yet water enters via an intermittent stream or seepage from an upslope wetland. Isolated wetlands are essentially closed depressions (geographically isolated) where water comes from surface water runoff and/or groundwater discharge. For this project, surface water connections are emphasized (e.g., mapped streams), since it is not possible to determine ground water linkages (especially outflow) without hydrologic investigations. Consequently, wetlands designated as isolated may have groundwater connections.

Other modifiers were applied to wetlands in the NWI database. The headwater descriptor (hw) was applied to lotic wetlands along intermittent streams and first- and second-order perennial streams and to terrene wetlands that are the sources of these streams. The pond modifer (pd) was applied to any wetland in contact with a pond. The pond may exert influence on the wetland vegetation or may simply have little or no influence on the wetland (e.g., where a pond represents only a small portion of the wetland such as bog eyelet pond or where an artificial pond was excavated within a vegetated wetland). Wetlands bordering ponds that were mapped by NWI as impounded should be significantly influenced by pond hydrology.

GIS Analysis and Data Compilation

The geographic information system (GIS) used for this project was Arc GIS 9.0. Several GIS analyses were performed to produce wetland statistics (acreage summaries), a preliminary assessment of wetland functions, the remotely-sensed indices of “natural habitat integrity,” and thematic maps. Tables summarizing the results of the inventory were prepared to show the extent of different wetland types by NWI classifications and by LLWW descriptors and to portray differences among the subbasins in these features, wetland functions and natural habitat integrity. NWI and LLWW wetland acreage totals differ because palustrine open water wetlands (NWI) were treated as ponds and, in some cases, as lakes according to LLWW.

Preliminary Functional Assessment

Ten functions were evaluated using the expanded NWI database: 1) surface water detention, 2) streamflow maintenance, 3) nutrient transformation, 4) sediment and other particulate retention, 5) coastal storm surge detention, 6) shoreline stabilization, 7) provision of fish and shellfish habitat, 8) provision of waterfowl and waterbird habitat, 9) provision of other wildlife habitat, and 10) conservation of biodiversity.

General Scope and Limitations of the Preliminary Wetland Functional Assessment

At the outset, it is important to emphasize that the functional assessment presented in this report is a preliminary evaluation based on wetland characteristics interpreted through remote sensing and using available data and the best professional judgment of the senior author with input from NJFO personnel and others. Wetlands believed to be providing potentially significant levels of performance for a particular function were highlighted. As the focus of this report is on wetlands, the assessment of waterbodies (e.g., lakes, rivers, and streams) at providing the listed functions was not done, despite their rather obvious significant performance of functions such as fish habitat, waterfowl and waterbird habitat, and surface water detention. No attempt was made to produce a more qualitative ranking for each function or for each wetland based on multiple functions since this was beyond the scope of the current study. For a technical review of wetland functions, see Mitsch and Gosselink (2000); for a broad overview of wetlands, see Tiner (2005b).

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 and compared to reference standards. The present study does not seek to replace the need for such assessments as they are the ultimate assessment of the functions for individual wetlands. For initial planning purposes, a more generalized assessment is worthwhile for targeting wetlands that may provide certain functions, especially for those functions dependent on landscape position and vegetation lifeform. Subsequently, these results can be field-verified when it comes to actually evaluating particular wetlands for acquisition or other purposes. 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.

This study employs a watershed assessment approach called "Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF). W-PAWF applies general knowledge about wetlands and their functions to develop a watershed overview that highlights possible wetlands of significance based on their predicted level of performance of various functions. To accomplish this objective, the relationships between wetlands and various functions must be simplified into a set of practical criteria or observable characteristics. Such assessments could also be further expanded 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.

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 right 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 first wetland is likely to trap more water-borne sediments than the latter at the present time, however should the forest above the latter wetland be cleared, the latter wetland will likewise trap any water-borne sediments. The W-PAWF is therefore designed to reflect the potential for a wetland to provide a function. W-PAWF also does not consider the condition of the adjacent upland (e.g., level of outside disturbance) or the actual water quality of the associated waterbody, both of which affect wetland functions and habitat quality. Collection and analysis of these data were beyond the scope of the study.

This preliminary assessment does not obviate the need for more detailed assessments of the various functions. It should be viewed as a starting point for more rigorous assessments, as it attempts to cull out wetlands that may likely produce significant levels of performance for certain functions based on generally accepted principles and the source information used for this analysis. This type of assessment is most useful for regional or watershed planning purposes.

It is also important to recognize limitations derived from source data including conservative interpretations of forested wetlands (especially evergreen types) and drier-end wetlands (e.g., wet meadows, especially those used as pastures; see Tiner 1997b for additional information), and the omission of small or narrow wetlands and small streams. Some wetlands classified as isolated types may actually be connected by a small stream that was not shown on a topographic map or digital hydrography layer. Wetlands directly across the road from other wetlands were assumed to be connected by a culvert or similar structure. Despite limitations of source data, the NWI dataset created for this project represents the most current database on the distribution, extent, and type of wetlands in the watershed. NWI data for this study were based on 1994-1996 aerial photography (1995 for New Jersey and variable photo dates for the New York portion).

Rationale for the Preliminary Wetland Functional Assessment

The criteria used for identifying wetlands of significance for these functions were taken from "Correlating Enhanced National Wetlands Inventory Data With Wetland Functions for Watershed Assessments: A Rationale for Northeastern U.S. Wetlands" (Tiner 2003b; http://www.fws.gov/nwi/pubs_reports/HGMReportOctober2003.pdf), but were modified for the Hackensack Meadowlands due to the predominance of common reed (Phragmites australis). The abundance of this species may reduce certain functions, especially for fish and shellfish and waterfowl and waterbird habitat (see below). A list of the wetland types designated as significant for each function is presented in Table 2.

Treatment of Common Reed Marshes

Common reed is the number one invasive plant threatening estuarine wetlands in the northeastern United States. It has replaced typical salt marsh plants such as smooth cordgrass (Spartina alterniflora), salt hay grass (Spartina patens), salt grass (Distichlis spicata), and black rush (Juncus gerardii) in areas where tidal flow has been significantly restricted and where fill has been deposited in wetlands. Common reed is a good disturbance indicator as it readily colonizes exposed soils in the coastal areas and even inland areas along highways (see Marks et al. 1994; Chambers et al. 1999). Although common reed is native to North America, the spread of this species since the 1950s has been attributed to a non-native variety (Saltonstall 2002). Natural stands were typically limited to the edges of estuarine wetlands (Orson et al. 1987). With the advance of common reed into the marsh interior and even along creekbanks, the basic structure of salt marshes has changed from a low-lying grassland to a veritable thicket of tall reeds often with a thick mat of decomposed plant material on the surface. Plant diversity usually declines with the invasion of Phragmites as this species commonly forms monotypic stands, especially in brackish waters (Meyerson et al. 2000). Given the extent of common reed in today's estuarine environments, there has been considerable recent attention given to the habitat function of this species in comparision to that of the pre-existing salt marsh (e.g., Meyerson et al. 2000). Changes in plant composition typically alter the habitat use by many species. A brief summary of the state-of-our-knowledge on the uses of common reed as habitat follow. For more detailed information, refer to the specific articles referenced.

Common reed is a productive plant and its biomass exceeds that of most marsh species it replaces. Recognizing that one of the major ecological functions of salt marshes is to produce material for the detrital food web of estuaries, the export and decomposition of plant materials is important. Common reed leaves decompose rapidly, but the stems take longer to decompose than the plants it replaces (Meyerson et al. 2000). Stem and stem litter remain on the marsh for years. This has given Phragmites an edge in carbon and other nutrient sequestration over other species. The presence of this species at sewage outfalls is testimony to its competitive advantage over other plants in occupying eutrophied sites (Freeman undated manuscript; Levine et al. 1998) and its high potential for nutrient transformation.

There is general agreement that pure Phragmites stands generally yield poorer quality wildlife habitat than the marshes they replace, while they may be important for some species (Roman et al. 1984; Kiviat 1987). The tall, dense reeds restrict wildlife movement and also adversely affect hydrology with negative impacts on aquatic species. Over 50 species of birds have been found in common reed marshes (Meyerson et al. 2000). Despite this usage, there are no birds that depend solely on these wetlands. Common birds in the east include marsh wren, red-winged blackbird, and swamp sparrow. Ringed-necked pheasant and American bittern have been observed (R. Tiner, personal observations). The average number of bird species may be lower in Phragmites wetlands than in salt marshes (Benoit and Askins 1999). Phragmites in mixed stands, common reed marshes along large pools, and the edges of reed marshes seem to be better bird habitats than the marsh interior (Buchsbaum 1997; Cross and Fleming 1999, Meyerson et al. 2000). Given this, regularly flooded mixed and pure stands dominated by Phragmites and irregularly flooded reed marshes that are contiguous with estuarine waters will be rated as moderate for the provision of waterfowl and waterbird habitat. Pure stands of irregularly flooded Phragmites separated from water ("interior marsh") will not be rated as significant for waterfowl and waterbirds, although their value to other birds is recognized under the "other wildlife habitat" function. (Note: Many reed marshes are adjacent to water and will therefore be rated as moderate; recognize, however, that the interior portions of these marshes are used less by waterfowl and waterbirds than the shoreline sections.)

Marsh flooding provides access for fish and nektonic invertebrate use and anything reducing this process will have a negative impact on its use by these organisms. Common reed is known to accelerate the buildup of the marsh surface and reduce drainage density by filling in small ditches and creeks (Weinsten and Balleto 1999), thereby restricting access to the marshes by fishes and transient shellfish. Reducing the frequency of tidal flooding has obvious negative consequences for aquatic species. Fish and shellfish density in Phragmites stands vary with hydrology and wetland geomorphology (Hanson et al. 2002). They noted that high stem density and litter accumulation may reduce tidal flow rates, leading to a reduction in the depth of tidal flooding. From the surface of a brackish Phragmites marsh along the Hudson River, they collected common mummichog (Fundulus heteroclitus), herrings (Alosa spp.), grass shrimp (Palaemonetes pugio), and blue crab (Callinectes sapidus). Most of the individuals were captured in the marsh near the creekbanks and only a few in the marsh interior. Depositional sites produced the most individuals and greatest biomass, but other studies have not yielded similar findings (Rozas 1992). Some studies have found a greater abundance of mummichog in Spartina marshes than in neighboring Phragmites marshes (Able and Hagan 2003, Hanson et al. 2002). Regularly flooded reed marshes will be ranked as having moderate potential for fish and shellfish; irregularly flooded Phragmites marshes contiguous with estuarine open water will be similarly rated as will nontidal, semipermanently flooded reed marshes contiguous to an open waterbody. Interior reed marshes (not bordering a waterbody) will not be viewed as potentially significant fish and shellfish habitat.

Table 2. List of wetlands of potential significance for ten functions for use in the Hackensack River Watershed. (Source: Adapted from Tiner 2003b). See Appendix A for LLWW coding. NWI codes: L2 = lacustrine littoral, P = palustrine, E2 = estuarine intertidal, AB = aquatic bed, EM = emergent, EM1 = persistent emergent, EM5 = Phragmites, SS = scrub-shrub, FO = forested, US = unconsolidated shore, RS = rocky shore, SB = streambed, H = permanently flooded, F = semipermanently flooded, E = seasonally flooded/saturated, C = seasonally flooded, A = temporarily flooded, B = saturated, L = subtidal, N = regularly flooded (tidal), P = irregularly flooded (tidal), R = seasonally flooded-tidal, T = semipermanently flooded-tidal, S = temporarily flooded-tidal.

Function	Level of Function	Wetland Types
Surface Water Detention	High	ESFR, ESBA, ESIL, LEBA, LEFR, LEFL (in reservoir and dammed areas only), LEIL, LSBA, LRBA, LSFP, LRFP, LSFR, LRFR, LRIL, MAFR, MAIL, PDTH, TEFRpdTH, TEBApdTH, PDBI, PDBT, TEBApdBT, TEBATH. TEBATI
	Moderate	LRFL, LSFL, LEFL, TEIF, TEBA (other than above), PD (other except PD2f), TE__pd (other), TEFP__
Coastal Storm Surge Detention	High	ESBA, ESFR, ESIL, LR5FR, LR5FP (=LR5BA and LR5FL), LR5IL, MAFR
Streamflow Maintenance	High	hw (not dr = not ditched)
	Moderate	hwdr, LR1FP, PDTH, TE__pdTH, PDOU, TE__pdOU, TEOU (not hw but associated with streams not rivers), LE wetlands associated with throughflow lakes (LK__TH)
Nutrient Transformation	High	P__(AB, EM, SS, FO and mixes)C, P__(AB, EM, SS, FO and mixes)E, P__(AB, EM, SS, FO and mixes)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, E2EM, E2SS, E2FO, P__(AB, EM, SS, FO and mixes)B (not on coastal plain or glaciolacustrine plain)
	Moderate	P__(AB, EM, SS, FO and mixes)B (on coastal plain or glaciolacustrine plain), P__(AB, EM, SS, FO)A, P__(AB, EM, SS, FO and mixes)S
Sediment and Other Particulate Retention	High	ES__(vegetated), LEBA, LEFR(vegetated), LEIL(veg), LSBA, LRBA, LSFP, LRFP, LRFR(veg), LSFR(veg), LRIL (veg), PDTH, TE__pdTH (including __pq), PDBI, TE__pdBI (including __pq), PDBT, TE__pdBT, TEBATH, TEBATI,

		TEIFbaTH, TEIFbaTI
	Moderate	E2__(US, SB, excluding RS), LSFL(not PSS_Ba or PFO_Ba), LRIL (nonveg), LRFR(nonveg), LSFR (nonveg), M2US, TEBA(not PSS_Ba or PFO_Ba), PD (not c, d, e, f, g, j types), TE__pd(not PSS_Ba or FO_Ba), TEFP__
Shoreline Stabilization	High	E2__(AB, EM, SS, FO and mixes), E2RS (not ESIL), M2RS(not MAIL), LR_(AB, EM, SS, FO and mixes; not LRIL), LS_(AB, EM, SS, FO and mixes), LE__(AB, EM, SS, FO and mixes; not LEIL)
	Moderate	TE__pd (AB, EM, SS, FO and mixes), TE__OUhw (AB, EM, SS, FO and mixes)
Fish and Shellfish Habitat	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, E2RF, E2AB, E2RS (vegetated with macroalga; may be classified as E2AB1), L2_F, L2AB, L2UB/__(AB, EM, SS, FO), LE__ (vegetated; AB, EM, SS, FO) and NWI water regime = H (permanently flooded), M2AB, M2RS, M2US, M2RF (vegetated with macroalga; may be classified as M2AB1), P__F and adjacent to PD, LK, RV (all except RV4), ST (all except ST4), or EY waters, PAB, PUB/__(AB, EM, SS, FO), P__(EM, SS, FO)H, PEM__(N,R,T, or L, except EM5), PD associated with P__(AB, EM, SS, FO)F, R1EM, R1US(except S)
	Moderate	LE__ and PEM1E, LR__ and PEM1E (and mixes), LS__ and PEM1E (and mixes), PEM5F and adjacent to LK, RV (except RV4), ST(except ST4) and EY, E2EM5N (and mixes), PEM5N (and mixes), 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), PD (except c, d, e, f, g, j types), EY; PD (except c, d, e, f, g, j types); TEFRpd (along these ponds)
	Stream Shading	LS (not LS4) and PFO, LS (not LS4) and PSS (not PSS_Ba)
Waterfowl and Waterbird Habitat	High	E2EM1 or E2EM2 (includes mixes where they predominate), 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, or C), L2_H (vegetated, AB, EM, SS, FO and mixes with nonvegetated), M2AB, M2RS, M2US, M2RF, P__F (excluding EM5-

		dominated wetlands) and adjacent to PD, LK, RV(not RV4) ST(not ST4), or EY waters; PAB, P__H (vegetated, EM, SS, FO including mixes with UB), P__Eh, P__Eb; LS__ and PEM1E (including mixes), LR__ and PEM1E (including mixes), TE__ hw and PEM1E;, PEM__N,R,T, or L (includes mixes, but excludes Phragmites-dominanted EM5), PD associated with P__(AB, EM, SS, FO)F, PEM1R (and mixes), PEM1T (and mixes), PUB__b, R1EM, R1US (except S water regime)
	Moderate	E2EM5N (and mixes), E2EM5P (and mixes) and contiguous with open water (not "interior" marshes), PEM5__E,F, R, or T and adjacent to PD, LK, RV(not RV4), ST(not ST4), or EY, other L2UB (not listed as high), Other PD (except c, d, e, f, g, j types), PEM1E__ (including mixes) and associated with PD, LK, RV(not RV4), or ST(not ST4)
	Wood Duck	LS(1,2, or 5)BA and P__ (FO or SS and mixes), LS(1,2, or 5)FR and P__ (FO or SS and mixes), LR(1,2, or 5)FPba and P__(FO or SS and mixes), LR(1,2, or 5)BA and P__(FO or SS and mixes), LRFPba and PFO/EM, 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
Other Wildlife Habitat	High	Any wetland complex $\geq$ 20 acres, wetlands 10-20 acres with 2 or more classes (excluding EM5), small isolated wetlands in dense cluster in a forest matrix (restrict to forest regions of U.S. with woodland vernal pools)
	Moderate	Other vegetated wetlands
Conservation of Biodiversity	Regional significant for Northeast U.S	E2EM1N, E2EM1P6, R1EM, R1US, PEM1N, PEM1R, PEM2N, PEM2R, PSS_R, PSS_T, PFO4__g (Atlantic white cedar), PEM__i (herbaceous fen), PSS__i (shrub fen), PFO__i (treed fen), PFO2__ (bald cypress), E1AB__ (eelgrass and SAV beds), LS__FR, LR__FR, PD1m (woodland vernal pool; small ponds surrounded by forest), forested wetlands within >7410-acre forest, very large wetland complexes ($\geq$ 100 acres)
	Locally significant in the Northeast	Beaver-influenced wetlands, Estuarine emergent wetlands (except Phragmites), contiguous wetlands within the Meadowlands District, headwater wetlands, Lentic fringe and basin wetlands (> 10 acres), Lotic River or Stream wetland complexes

Natural Habitat Integrity Assessment

For this assessment, a geospatial database covering the entire Hackensack River watershed was created. Wetland data were obtained from the updated NWI database. Land use and land cover data for upland areas in the watershed were created through photointerpretation of the 1994-1996 aerial photography. The Anderson et al. (1976) land use and land cover (LULC) classification system was used to classify upland areas. The following categories were among those identified: developed land, agricultural land, forests, wetlands (from NWI data), transitional land (moving toward some type of development or agricultural use, but future status unknown), and water. This update focused on changes between “natural” habitat and developed land and, therefore, does not represent a comprehensive revision of all LULC categories. Stream data came from USGS 1:24,000 digital hydrography data and many small streams (especially intermittent ones in hilly and mountainous terrain) are often not designated. These data were not improved since stream mapping was not part of the project and this method typically uses the best available recent data on land use/cover, streams, and wetlands for assessment.

We applied the remotely sensed indices of “natural habitat integrity” (Tiner 2004) to the geospatial dataset for the Hackensack watershed. These indices were designed to meet four of the following requirements: 1) derived from air photointerpretation and/or satellite image processing for contemporary data and from maps for historical data, 2) suitable for frequent updating and rapid assessment, 3) consist of metrics that could efficiently and cost effectively be updated for large geographic areas, 4) present a broad view of the condition of “natural habitat,” and 5) provide a historic perspective on the extent of wetlands and open waterbodies. Such indices represent coarse-filter variables for assessing the overall condition of watersheds. They were intended to augment, not supplant, other more rigorous, fine-filter approaches for describing the ecological condition of watersheds (e.g., Index of Biological Integrity for instream macroinvertebrates and fish, and the extent of invasive species) and for examining human impacts on natural resources.

Eleven indices were calculated for this assessment. Six indices address habitat extent (i.e., the amount of natural habitat occurring in the watershed and along wetlands and waterbodies) and four indices deal with habitat disturbances (emphasizing human alterations to streams, wetlands, and terrestrial habitats), whereas the remaining index is a composite index integrating results from the other ten indices and reflecting the overall natural condition of the watershed. The six “natural” habitat extent indices are “natural” cover, river-stream corridor integrity, vegetated wetland buffer integrity, pond and lake buffer integrity, wetland extent, and standing waterbody extent. The four “habitat disturbance indices” involve dammed stream flowage, channelized stream flowage, wetland disturbance, and habitat fragmentation by roads. The last index - “composite natural habitat integrity index” - is comprised of the weighted sum of all the other indices, with the disturbance indices subtracted from the habitat extent indices to yield an overall “natural habitat integrity” score for a watershed or subbasin. All indices have a maximum value of 1.0 and a minimum value of zero. For the habitat extent indices, the higher the value, the more habitat available. For the disturbance indices, the higher the score, the more disturbance.

For purposes of this study, “natural habitats” are defined as areas where significant human activity is limited to activities such as nature observation, hiking, hunting, fishing, or timber harvest, and where vegetation is allowed to grow for many years without annual harvesting of vegetation or fruits and berries for commercial purposes. While natural habitats are essentially plant communities represented by forests, meadows, shrub thickets, and wetlands where resident and migratory wildlife find food, shelter, and water, they are not restricted to pristine habitats and may include managed habitats (e.g., commercial forests and wildlife impoundments), and forests, fields, and thickets adjoining residential properties, plus wetlands now colonized by invasive species (e.g., Phragmites australis or Lythrum salicaria). "Natural vegetation" is the plant community growing in these habitats.

Natural habitat integrity is broadly defined as conditions where "natural habitat" is typically allowed to exist for many years, without great disturbance or alteration by humans. This is quite different from the concept of biological integrity proposed by Angermeier and Karr (1994) emphasizing conditions with little or no human influence. The indices do not include certain qualitative information on the condition of existing habitats as reflected by the presence, absence, or abundance of invasive species or the degree of forest fragmentation, or contaminant concentration and availability. The level of effort required to inject more qualititative data into the analysis may preclude their use in remotely-sensed ecological assessments. Weighting of natural woodlands versus commercial forests may be a practical option for this type of assessment, but it was not explored. Another consideration would be establishment of minimum size thresholds to determine what constitutes a viable "natural habitat" for analysis (e.g., 0.04 hectare/0.1 acre patch of forest or 0.4 hectare/1 acre minimum?). Other indices (e.g., index of ditching density for agricultural and silvicultural lands) may also be useful for water quality assessments.

Habitat Extent Indices

These indices provide an assessment of the amount of "natural vegetation" or "natural habitat" that occurs in a watershed, including strategic locations important for water quality and aquatic/wetland wildlife. Data for the indices come from analyses of the land use/cover and wetlands geospatial data for the watershed. The following areas are emphasized: the entire watershed, stream and river corridors, vegetated wetlands and their buffers, and pond and lake buffers. The extent of standing waterbodies is also included to provide information on the quantity of aquatic habitat in the watershed.

The *Natural Cover Index* (I_{NC}) is the proportion of a watershed that is wooded or "natural" open land (e.g., emergent wetlands, "old fields," or sand dunes, but not cropland, hayfields, lawns, turf, or pastures), excluding open water.

> $I_{NC} = A_{NV}/A_W$, where A_{NV} (area in "natural" vegetation) equals the area of the watershed's land surface in "natural" vegetation and A_W is the total land surface area of the watershed (excluding open water).
>
> Significance of index: provides information on how much of a watershed is not developed and may be serving as important wildlife habitat.

The *River-Stream Corridor Integrity Index* (I_{RSCI}) is derived by considering the condition of the land bordering perennial rivers and streams.

> $I_{RSCI} = A_{VC}/A_{TC}$, where A_{VC} (vegetated river-stream corridor area) is the area of the river-stream corridor that is colonized by "natural vegetation" and A_{TC} (total river-stream corridor area) is the total area of the river-stream corridor.
>
> Significance of index: provides information on the status of vegetated riparian corridors.

The width of the river-stream corridor may be varied to suit project goals, but a 200-meter corridor (100m on each bank of the river or stream) was used for this study due to interest in wildlife habitat. Note that these corridors include banks of impounded sections of rivers and streams, so that a continuous river or stream corridor is evaluated. The corridor area does not include the waterbody. For the Hackensack watershed, the index was applied to nontidal rivers and streams for assessing the composite natural habitat integrity index.

The *Wetland Buffer Integrity Index* (I_{WB}) measures the condition of wetland buffers within a specified distance (e.g., 100m) of mapped vegetated wetlands for a watershed.

> $I_{WB} = A_{VB}/A_{TB}$, where A_{VB} (area of vegetated buffer) is the area of the buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.
>
> Significance of index: provides information on vegetated buffers around wetlands that are important for wildlife and for reducing impacts to wetland water quality from surface runoff.

This buffer is drawn around existing vegetated wetlands and while the buffer zone may include open water, the buffer index focuses on land areas that are capable of supporting free-standing vegetation. For the Hackensack watershed, a 100m buffer was examined.

The *Pond and Lake Buffer Integrity Index* (I_{PLB}) addresses the status of buffers of a specified width around these standing waterbodies (excluding instream impoundments that are part of the river-stream corridor integrity index):

> $I_{PLB} = A_{VB}/A_{TB}$, where A_{VB} (area of vegetated buffer) is the area of the buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.
>
> Significance of index: documents the condition of vegetation in a zone surrounding these waterbodies which is important for both water quality and aquatic life (buffer from impacts associated with adjacent urban/suburban development, agriculture, and other human actions).

Vegetated ponds are mapped as a vegetated wetland type and their buffers are not included in this analysis, but instead are evaluated as wetland buffers. For the Hackensack River watershed analysis, a 100m buffer was examined.

The *Wetland Extent Index* (I_{WE}) compares the current extent of vegetated wetlands (excluding nonvegetated, open-water wetlands) to the estimated historic extent.

$I_{WE} = A_{CW}/A_{HW}$, where A_{CW} is the current area of vegetated wetland in a watershed and A_{HW} is the historic vegetated wetland area in the watershed.

Significance of index: gives historical perspective on wetland loss.

The I_{WE} is an approximation of the extent of the original wetland acreage remaining in a watershed. Farmed wetlands are included where cultivation is during droughts only, since they are likely to support "natural vegetation" during normal and wet years. Where farmed wetlands are cultivated more or less annually, they are not included in the area of vegetated wetland, since they lack "natural vegetation" in most years and only minimally function as wetland. Hydric soil data are used to generate the historic extent of wetlands. To calculate the wetland extent index for the watershed and subbasins hydric soils data were available for all counties portion of the watershed except Hudson; a historic map of the Hackensack Meadowlands from 1889 was used for this area (Tiner et al. 2002).

The *Standing Waterbody Extent Index* (I_{SWE}) addresses the current extent of standing fresh waterbodies (e.g., lakes, reservoirs, and open-water wetlands - ponds) in a watershed relative to the historic area of such features.

$I_{SWE} = A_{CSW}/A_{HSW}$, where A_{CSW} is the current standing waterbody area and A_{HSW} is the historic standing waterbody area in the watershed.

Significance of index: gives perspective on changes in waterbody area (historic vs. today).

From a practical standpoint, this index is estimated. For most areas, including the Hackensack watershed, a net gain in ponds and impoundments has occurred over time. Every national wetland trend study (Frayer et al. 1983, Tiner 1984, Dahl and Johnson 1991, Dahl 2000) has shown an increase in pond area as ponds are constructed for a multitude of purposes. For these situations, the I_{SWE} value is 1.0+ indicating a gain in this aquatic resource and no specific calculations necessary; a value of 1.0 is then used for determining the composite natural habitat integrity index for the study area. In geographic areas where significant loss of open water has occurred, an estimate will need to be derived from available sources (including historic maps).

Habitat Disturbance Indices

A set of four indices have been developed to address alterations to natural habitats. For these indices, a value of 1.0 is assigned when all of the streams or existing wetlands have been modified.

The *Dammed Stream Flowage Index* (I_{DSF}) highlights the direct impact of damming on rivers and streams in a watershed.

> $I_{DSF} = L_{DS}/L_{TS}$, where L_{DS} is the length of perennial streams impounded by dams (combined pool length) and L_{TS} is the total length of perennial streams in the watershed (including the length of instream pools).
>
> Significance of index: reveals how much of the stream system has been dammed.

Note that the total stream length used for this index will be greater than that used in the channelized stream length index, since the latter emphasizes existing streams and excludes dammed segments. For this project, this index was applied only to linear streams (not rivers); in the future, this index should be expanded to include the entire river-stream length (i.e., the Dammed River-Stream Flowage Index).

The *Channelized Stream Length Index* (I_{CSL}) is a measure of the extent of stream channelization within a watershed.

> $I_{CSL} = L_{CS}/L_{TS}$, where L_{CS} is the channelized stream length and L_{TS} is the total stream length for the watershed.
>
> Significance of index: documents the magnitude of stream channelization.

Since this index addresses channelization of existing streams, it focuses on the linear streams. The index will usually emphasize perennial streams as it does for the Hackensack study, but could be expanded to include intermittent streams, if desirable. The total stream length does not include the length of: 1) artificial ditches excavated in farm fields and forests, 2) dammed sections of streams, and 3) polygonal portions of rivers. Channelization of the latter may be represented by a separate index or combined with this index to form a Channelized River/Stream Length Index.

The *Wetland Disturbance Index* (I_{WD}) focuses on alterations within existing wetlands. As such, it is a measure of the extent of existing wetlands that are diked/impounded, ditched, excavated, or farmed.

> $I_{WD} = A_{DW}/A_{TW}$, where A_{DW} is the area of disturbed or altered wetlands and A_{TW} is the total wetland area in the watershed.
>
> Significance of index: identifies the degree to which existing wetlands have been altered by human actions.

Wetlands are represented by both vegetated and nonvegetated (e.g., shallow ponds) types including natural and created wetlands. Since the focus of analysis is on “natural habitat,” diking or excavating wetlands (or portions thereof) is viewed as an adverse action. It is recognized, however, that many such wetlands serve as valuable wildlife habitats (e.g., waterfowl impoundments), despite such alteration.

The *Habitat Fragmentation by Road Index* (I_{HF}) attempts to address habitat fragmentation by roads.

> $I_{HF} = A_R/A_W \times 16$, where A_R is the area of roads (interstates, state/county and other roads) and A_W is the total land area of the watershed.
>
> Significance of index: indicates habitat fragmentation by roads, but likely reflects degradation of water quality, and terrestrial and aquatic ecosystems from associated development.

Since road area will never equal 100 percent of a watershed, a multiplier was created to increase the index value to a level of relevance for the composite index (remotely-sensed index of natural habitat integrity). A multiplier of 16 was established based on examination of road density in a portion of Jersey City, NJ with extremely high road density (0.06 road area/city area); multiplying by 16 would yield an index value near 1.0 (the estimated maximum road area/unit area). If this multiplier yields an index value greater than 1.0, use 1.0 for the value when computing the composite index. (Note: This would only happen if an entire watershed or subbasin had higher road density than Jersey City, NJ which would be a rare situation.)

While limited to road fragmentation, this index serves a surrogate for habitat fragmentation and degradation. Two watersheds may have the same amount of natural habitat, but may differ in the extent of roads. Although not the only human action that causes habitat fragmentation, road density is closely correlated to degraded ecosystems (Miller et al. 1996, Quigley and Arbelbide 1997, Forman and Alexander 1998, Forman 2000, and Trombulak and Frissell 2000). Moreover, adverse impacts from other development (e.g., urban and suburban) are likely related to the extent of roads, especially paved roads. More detailed assessments of habitat fragmentation, including mean patch size, patch density, edge density, and total core area, could be performed, if necessary.

For the Hackensack watershed study, we used the same road widths used in prior studies (Tiner 2004) to calculate A_R: interstates (2 lanes/direction) - 12.1m, state roads (2 lanes; 1 lane/direction) - 12.1m, county/local roads (2 lanes; 1 lane/direction) - 11.5m, and dirt roads (2-lanes) - 6.7m. These widths tended to match well with similar roads in the Hackensack watershed. Road widths were applied to road lengths to calculate area of roads for the study area.

Composite Habitat Integrity Index for the Watershed

The *Composite Natural Habitat Integrity Index* (I_{CNHI}) is a combination of the preceding indices. It seeks to express the overall condition of a watershed in terms of its potential ecological integrity or the relative intactness of “natural” plant communities and waterbodies, without reference to specific qualitative differences among these communities and waters. Variations of I_{CNHI} may be derived by considering buffer zones of different widths around wetlands and other aquatic habitats (e.g., $I_{CNHI\ 100}$ or $I_{CNHI\ 200}$) and by applying different weights to individual indices or by separating or aggregating various indices (e.g., stream corridor integrity index, river corridor integrity index, or river-stream corridor integrity index). The weighting of the indices come from Tiner (2004) and although subjective, the results of this analysis are comparable among the subbasins examined. The same weighting scheme must be used whenever comparisons of this index are made between and within watersheds.

For the analysis of Hackensack River watershed, the following formula was used to determine this composite index:

> $I_{CNHI\ 100} = (0.5 \times I_{NC}) + (0.125 \times I_{RSCI200}) + (0.125 \times I_{WB100}) + (0.05 \times I_{PLB100}) + (0.1 \times I_{WE}),$ $+ (0.1 \times I_{SWE}) - (0.1 \times I_{DSF}) - (0.1 \times I_{CSL}) - (0.1 \times I_{WD}) - (0.1 \times I_{HF})$, where the condition of a 100m buffer is used throughout.
>
> Significance of index: gives an overview of the condition of the watershed relative to the existence of "natural" habitat and a measure that can be compared with other watersheds.

The indices were applied to the watershed as a whole and to individual subbasins.

Appropriate Use of this Report

The report provides a basic wetland characterization, a preliminary assessment of wetland functions, and a remotely-sensed assessment of “natural habitat” integrity for the Hackensack River watershed. Keeping in mind the limitations mentioned previously, the results are an initial screening of the watershed's wetlands to designate wetlands that may have a significant potential to perform different functions and to assess the general condition or state of “natural habitat” throughout the basin. The targeted wetlands have been predicted to perform a given function at a significant level presumably important to the 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 level above that of wetlands not designated.

While the results are useful for gaining an overall perspective of a watershed's wetlands and their relative importance in performing certain functions, the report does not identify differences among wetlands of similar type and function. The latter information is often critical for making decisions about wetland acquisition and designating certain wetlands as more important for preservation versus others with the same classification.

The report is useful for general natural resource planning, as a screening tool for prioritization of wetlands (for acquisition or strengthened protection), as an educational tool (e.g., helping the public and nonwetland specialists better understand the functions of wetlands and the relationships between wetland characteristics and performance of individual functions), and for characterizing the differences among wetlands in terms of both form and function within a watershed.

Results

The results are presented for the entire watershed and for each of its 19 subbasins. The watershed findings consist of a summary of wetland types, a preliminary assessment of functions for wetlands in the Hackensack watershed, and an assessment of the "natural habitat integrity" derived from remote sensing techniques. Data for corresponding subbasins are summarized in this section while the detailed results presented in tabular form in Appendix B.

Maps

Maps are presented in a separate folder and are hyperlinked to the report. A series of 16 maps was produced for the Hackensack River watershed with subbasin boundaries shown. All maps were produced at a scale of 1:75,000 for this report. A list of the 16 maps follows: Map 1 - Wetlands and Deepwater Habitats Classified by NWI Types, Map 2 - Wetlands Classified by Landscape Position, Map 3 - Wetlands Classified by Landform, Map 4 - Wetlands Classified by Landscape Position and Landform, Map 5 – Potential Wetlands of Significance for Surface Water Detention, Map 6 - Potential Wetlands of Significance for Streamflow Maintenance, Map 7 - Potential Wetlands of Significance for Nutrient Transformation, Map 8 - Potential Wetlands of Significance for Sediment and Other Particulate Retention, Map 9 – Potential Wetlands of Significance for Coastal Storm Surge Detention, Map 10 - Potential Wetlands of Significance for Shoreline Stabilization, Map 11 - Potential Wetlands of Significance for Fish and Shellfish Habitat, Map 12 - Potential Wetlands of Significance for Waterfowl/Waterbird Habitat, Map 13 - Potential Wetlands of Significance for Other Wildlife Habitat, Map 14 – Potential Wetlands of Significance for the Conservation of Biodiversity, Map 15 – Extent of "Natural Cover" in the Hackensack River Watershed, and Map 16 – Condition of River and Stream Corridors.

Watershed Findings

Wetland Characterization

Wetlands by NWI Types

According to the NWI, the Hackensack watershed had nearly 9,650 acres of wetlands (including ponds) (Table 3; Map 1). Estuarine emergent wetlands were the predominant wetland type comprising 42 percent of the watershed's wetlands. Palustrine forested wetlands were next ranked in abundance, accounting for 33 percent of all wetlands. Tidal flats (estuarine unconsolidated shore) associated with the Hackensack Meadowlands were third-ranked with about 13 percent of the acreage.

Wetlands by LLWW Types

The wetland acreage based on LLWW classification was 9,268 acres (excluding ponds) or 9,623.5 acres including ponds (Table 4). Some waterbodies in the 10-20 acre size range that were classified as palustrine unconsolidated bottoms on the NWI maps were reclassified as lakes since they are likely deeper than 6.6 feet at low water. This reduced the wetland acreage of the Hackensack watershed by about 27 acres (see Table 3).

Since the Hackensack Meadowlands is the most prominent wetland in the watershed, it was not surprising that most (56%) of the wetland acreage was associated with the estuary (estuarine landscape position; Map 2). This figure included tidal freshwater wetlands contiguous with salt and brackish marshes of the estuary. Nearly 25 percent ot the watershed's wetland acreage was associated with rivers and streams and almost 5 percent contiguous with lakes (lentic). Eleven percent of the wetland acreage was represented by terrene wetlands (headwater stream source and isolated types), with the remaining 4 percent being ponds.

From the landform perspective, basin wetlands were most extensive, accounting for 57 percent of the wetland acreage (excluding ponds; Map 3 and Map 4). Many of these wetlands were estuarine wetlands whose tidal sheet flow has been diminished somewhat due to road construction (causeways and bridges). Fringe wetlands were second-ranked comprising 26 percent of the acreage. Flats made up 12 percent of the landform acreage, while floodplains associated with rivers accounted for four percent and slopes comprised one percent.

Considering water flow path, 61 percent of the wetland acreage was bidirectional-tidal and 26 percent was throughflow. Outflow types accounted for only seven percent of the acreage and nearly five percent was isolated. Almost two percent of the acreage was classified as bidirectional (associated with lakes/reservoirs) while 276 acres of the throughflow ponds were associated with lake/reservoir basins.

For the 347 ponds identified (355.7 acres), nearly 70 percent of the acreage was either throughflow or isolated (31.7% throughflow-perennial, 2.8% throughflow-intermittent, and 34.5% isolated). About 16 percent of the pond acreage had bidirectional water flow and all but 0.2 acres of this was tidally influenced. Outflow ponds accounted for 14 percent of the pond acreage and only one percent of the pond acreage was subjected to inflow.

Table 3. Wetlands classified by NWI types for the Hackensack River watershed.

NWI Wetland Type	Acreage	% of Total Acreage
Estuarine Wetlands		
Emergent	4,019.9	
Emergent/Scrub-Shrub	13.8	
(subtotal Emergent)	*(4,033.7)*	41.8
Scrub-Shrub	1.6	<0.1
Unconsolidated Shore	1,212.1	12.6
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Estuarine Subtotal	5,247.4	54.4
Palustrine Wetlands		
Emergent	483.7	
Emergent/Scrub-Shrub	116.7	
(subtotal Emergent)	*(600.4)*	13.6
Forested, Broad-leaved Deciduous	3,033.5	
Forested, Mixed	2.6	
Forested, Needle-leaved Evergreen	2.6	
Forested, Dead	80.3	
Forested/Scrub-Shrub	49.0	
Forested/Emergent	29.6	
(subtotal Forested)	*(3,197.5)*	33.1
Scrub-Shrub, Deciduous	102.8	
Scrub-Shrub/Emergent	43.3	
Scrub-Shrub/Forested	75.2	
(subtotal Scrub-Shrub)	*(221.3)*	2.3
Unconsolidated Bottom	375.6	
Unconsolidated Shore	7.3	
(subtotal nonvegetated)	*(382.9)*	4.0
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Palustrine Subtotal	4,402.1	45.6
GRAND TOTAL (ALL WETLANDS)	9,649.5	

Table 4. Wetlands in the Hackensack River watershed classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Acreage**
Estuarine (ES)	Fringe (FR)	Bidirectional-tidal (BT)	2,185.7
	Basin (BA)	Bidirectional-tidal (BT)	3,193.9
	Island (IL)	Bidirectional-tidal (BT)	1.8
	Total Estuarine		*5,381.4*
Lentic (LE)	Basin (BA)	Bidirectional (BI)	55.5
		Throughflow (TH)	135.8
		(subtotal)	*(191.3)*
	Flat (FL)	Bidirectional (BI)	62.9
		Isolated (IS)	3.3
		Throughflow (TH)	75.4
		(subtotal)	*(141.6)*
	Fringe (FR)	Bidirectional (BI)	55.7
		Throughflow (TH)	61.1
		(subtotal)	*(116.8)*
	Total Lentic		*449.7*
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	382.7
	Fringe (FR)	Bidirectional-tidal (BT)	79.5
		Throughflow (TH)	6.9
	Total Lotic River		*469.1*
Lotic Stream (LS)	Basin (BA)	Bidirectional-tidal (BT)	126.7
		Throughflow (TH)	1,140.5
		(subtotal)	*(1,267.2)*
	Flat (FL)	Bidirectional-tidal (BT)	35.5
		Throughflow (TH)	592.1
		(subtotal)	*(627.6)*
	Fringe (FR)	Throughflow (TH)	5.1
	Slope (SL)	Throughflow (TH)	7.7
	Total Lotic Stream		*1,907.6*
Terrene (TE)	Basin (BA)	Isolated (IS)	270.1
		Outflow (OU)	368.9
		(subtotal)	*(639.0)*
	Flat (FL)	Isolated (IS)	107.8
		Outflow (OU)	229.9
		(subtotal)	*(337.7)*
	Slope (SL)	Isolated (IS)	42.4
		Outflow (OU)	40.9
		(subtotal)	*(83.3)*
	Total Terrene		*1,060.0*
TOTAL LLWW Types*			9,267.8

*Does not include 347 ponds that totaled 355.7 acres.

Preliminary Assessment of Wetland Functions

The results for each wetland function for the Hackensack River watershed are given in Table 5. Refer to the maps for locations of these wetlands.

Nearly all of the remaining wetland acreage (>95%) in the watershed was deemed potentially significant for surface water detention and sediment and other particulate retention. Three of the other functions were predicted to be performed by more than 80 percent of the acreage: nutrient transformation (84%), provision of other wildlife habitat (83%), and conservation of biodiversity (82%), with a fourth function – provision of fish and shellfish habitat – rated just below 80 percent (79.5%). Over half of the conservation of biodiversity function was attributed to the presence of the Hackensack Meadowlands – one of the largest remaining urban wetlands in the northeastern United States and one that is located in a key position along the Atlantic Flyway and therefore vitally important for migratory birds. Over 250 species of birds have been observed in these wetlands. Other wetlands recognized as important for biodiversity included large complexes greater than 100 acres, headwater wetlands, beaver-influenced wetlands, lakeside wetlands, wetlands in large complexes along rivers and streams, freshwater tidal wetlands, and potential woodland vernal pools. The Hackensack watershed wetlands also provided habitat for waterfowl and other waterbirds at significant levels (71%). An additional 1,744 acres along streams (18% of the acreage) were rated as important for fish and shellfish by providing shade over streams. Over 70 percent of the wetland acreage was predicted to be important for shoreline stabilization, while 58 percent was significant for coastal storm surge detention. Only 30 percent of the wetland acreage was located in headwater positions that serve to maintain streamflow.

Table 5. Predicted wetland functions for the Hackensack River watershed. Click on maps to view potential wetlands of significance for each function.

Function	**Predicted Level**	**Acreage**	**Percent of Wetlands**
Surface Water Detention (Map 5)	High	7740.1	80.4
	Moderate	1746.7	18.2
	Total	*9486.8*	*98.6*
Streamflow Maintenance (Map 6)	High	1118.4	11.6
	Moderate	1795.9	18.7
	Total	*2914.3*	*30.3*
Nutrient Transformation (Map 7)	High	6687.5	69.5
	Moderate	1367.0	14.2
	Total	*8054.5*	*83.7*
Sediment and Other Particulate Retention (Map 8)	High	6998.3	72.7
	Moderate	2204.4	22.9
	Total	*9202.7*	*95.6*
Coastal Storm Surge Detention (Map 9)	High	5623.1	58.4
Shoreline Stabilization (Map 10)	High	7034.6	73.1
	Moderate	38.1	0.4
	Total	*7072.7*	*73.5*
Fish and Shellfish Habitat (Map 11)	High	1751.8	18.2
	Moderate	4132.8	42.9
	Shading	1774.6	18.4
	Total	*7659.2*	*79.5*
Waterfowl and Waterbird Habitat (Map 12)	High	1907.5	19.8
	Moderate	3827.8	39.8
	Wood Duck	1122.5	11.7
	Total	*6857.8*	*71.3*
Other Wildlife Habitat (Map 13)	High (large complex)	5790.3	60.2
	High (small diverse wetland)	864.3	9.0
	Moderate	1401.7	14.6
	Total	*8056.3*	*83.8*

Table 5 (cont'd).

Conservation of Biodiversity (Map 14)	100-acre + wetland complex	721.7	7.5
	Beaver-influenced wetland	14.1	0.1
	Meadowlands wetlands	5238.5	54.4
	Estuarine emergent wetland (not Phragmites)	5.1	0.1
	Headwater wetland	1004.4	10.4
	Lentic Fringe or Basin wetland	220.7	2.3
	Lotic wetland complex	593.6	6.2
	Seasonally flooded-tidal wetland (not Phragmites)	85.3	0.9
	Possible vernal pool	2.5	<0.1
	Total	*7885.9*	*81.9*

Remotely-sensed Indices of "Natural Habitat Integrity"

The generally poor condition of the Hackensack watershed is reflected in the natural habitat integrity index scores (Table 6). The composite index score of 0.20 indicates a significantly modified watershed which is no surprise given that three-quarters of the watershed is urbanized (Map 15). The overall landscape is typically devoid of natural vegetation, with only 25 percent of the watershed in some kind of "natural cover" in 1995 (natural cover index score of 0.25). The remaining vegetated regions of the watershed are located in the Meadowlands, around Oradell Reservoir, around a number of streams (including Overpeck Creek), and in headwater positions in the northern portion of the watershed.

The predominant urban-suburban landscape generated low scores for the habitat extent indices (Table 6). About 35 percent of the 100m river-stream corridor was colonized by vegetation (Map 16), whereas 27 percent of the 100m buffer around mapped wetlands was in natural cover. The pond and lake buffer appeared to be in somewhat better condition with 44 percent vegetated. The watershed has lost an estimated 64 percent of its original wetlands and as of 1995, only 36 percent of pre-settlement wetland acreage remained (as reflected by the wetland extent index score of 0.36). In contrast, waterbodies have increased due to human activities (as reflected by a standing waterbody extent index score of 1.0). Numerous ponds, reservoirs (e.g., Oradell Reservoir), and dammed lakes have been built in the watershed since European settlement.

As expected, the aquatic resources within the watershed have been significantly disturbed and the high disturbance index scores for wetland disturbance and habitat fragmentation by roads bear this out. Fifty-nine percent of the wetlands altered to some degree. Road construction and accompanying urban and suburban development has left the Hackensack watershed a fragmented landscape with only remnants of its original natural habitat in place. In addition, 16 percent of the river/stream miles have been dammed and 33 percent of the stream miles have been channelized.

Table 6. Scores for remotely-sensed indices of “natural habitat integrity” for the Hackensack River watershed. *Note: The scores for these indices reflect the percent of the subject area that is in “natural vegetation.”

Index	**Score**
Habitat Extent Indices	
Natural Cover Index (Map 15)*	0.25
River/Stream Corridor Integrity Index (Map 16)*	0.35
Wetland Buffer Integrity Index*	0.27
Pond/Lake Buffer Integrity Index*	0.44
Wetland Extent Index	0.36
Standing Waterbody Extent Index	1.00
Habitat Disturbance Indices	
Dammed River/Stream Flowage Index (Map 16)	0.16
Channelized Stream Length Index	0.33
Wetland Disturbance Index	0.59
Habitat Fragmentation by Road Index	0.51
Composite Index	0.20

Subbasin Findings

The detailed findings for each subbasin are given in a series of tables in Appendix B. Subbasins are listed alphabetically. Highlights are given below and in Tables 7 through 11. (Note: Totals for each subbasin may differ from those reported in an earlier report on the Hackensack Meadowlands District wetlands because the subbasins may include an area slightly larger than that contained within the District).

Wetland Characterization

Wetlands by NWI Types

Three subbasins contained the majority of the watershed's wetland acreage due to the abundance of estuarine wetlands: Hackensack River Route 3 to Bellman's Creek, Hackensack River Amtrak Bridge to Route 3, and Berry's Creek below Paterson Avenue (Table 7). Combined these subbasins accounted for 40 percent of the total wetland acreage and 72 percent of the salt and brackish wetland acreage. Palustrine wetlands were best represented in three subbasins with each having more than 500 acres of these types: Hackensack-Nauranshaun Confluence, Hackensack River Oradell to Tappan Bridge, and De Forest Lake. Their freshwater wetland acreage comprised 37 percent of the watershed's palustrine acreage.

Wetlands by LLWW Types

The Hackensack-Nauranshaun Confluence subbasin had the most acreage of wetlands associated with reservoirs and lakes (lentic wetlands) and also ranked high in the extent of streamside wetlands (lotic stream) and terrene wetlands (Table 8). Lotic river wetlands were best represented in three subbasins: Hackensack River above Tappan Bridge, Pascack Brook above Westwood Gage, and Hackensack River Fort Lee to Oradell Gage. They accounted for 76 percent of the watershed's riverside wetlands. Four subbasins had more than 200 acres of streamside wetlands (lotic stream), with Berry's Creek above Paterson Avenue will just slightly fewer acres (196). Terrene wetlands were most extensive in Hackensack River Oradell to Tappan Bridge while three other subbasins had more than 100 acres of these types. Estuarine wetlands were most abundant in three subbasins (same as listed by NWI types).

Table 7. Wetland acreage summaries by NWI system for subbasins of the Hackensack River watershed. The percent of each subbasin occupied by wetlands is given along with the percent of the Hackensack's wetlands that these wetlands represent and a ranking of subbasins relative to wetland acreage.

Subbasin	**Estuarine Acreage**	**Palustrine Acreage**	**Total Acreage**	**Percent of Subbasin**	**Percent of Hackensack Wetland Area**	**Rank**
Berry's Creek above Paterson Avene	83.8	379.5	463.3	12.1	4.8	9
Berry's Creek below Paterson Avenue	909.3	42.1	951.4	24.8	9.9	3
Coles Brook/Van Saun Mill Brook	--	123.7	123.7	2.8	1.3	16
De Forest Lake	--	506.0	506.0	2.9	5.2	8
Dwars Kill	--	408.0	408.0	11.6	4.2	10
Hackensack-Nauranshaun Confluence	--	596.4	596.4	5.5	6.2	6
Hackensack R. – Amtrak Bridge to Rt. 3	1431.3	47.9	1479.2	23.2	15.3	1
Hackensack R. – Bellman's Creek to Fort Lee Road	651.7	55.6	707.3	11.3	7.3	4
Hackensack R. below Amtrak Bridge	563.1	89.9	653.0	9.6	6.8	5
Hackensack R. – Ft. Lee to Oradell Gage	--	118.0	118.0	3.0	1.2	17
Hackensack R. – Rt. 3 to Bellman's Creek	1445.6	9.6	1455.2	28.4	15.1	2
Hackensack R. above Tappan Bridge	--	397.4	397.4	5.3	4.1	11
Hackensack R. – Oradell to Tappan Bridge	--	510.6	510.6	6.5	5.3	7
Hirshfeld Brook	--	30.0	30.0	1.0	0.3	19
Overpeck Creek	162.6	149.5	312.1	2.8	3.2	13
Pascack Brook above Westwood Gage	--	301.7	301.7	3.3	3.1	14
Pascack Brook below Westwood Gage	--	337.6	337.6	6.2	3.5	12
Tenakill Brook	--	202.3	202.3	3.6	2.1	15
Upper Pascack Brook	--	96.4	96.4	2.1	1.0	18

Table 8. Wetlands by landscape position for subbasins of the Hackensack River watershed.

Subbasin	Estuarine Acreage	Lentic Acreage	Lotic River Acreage	Lotic Stream Acreage	Terrene Acreage	Total Acres
Berry's Creek above Paterson Avene	102.6	--	3.0	196.3	157.0	458.9
Berry's Creek below Paterson Avenue	922.9	--	--	--	1.7	924.6
Coles Brook/Van Saun Mill Brook	--	--	3.9	92.6	19.8	116.3
De Forest Lake	--	45.1	--	280.0	114.0	439.1
Dwars Kill	--	84.8	--	240.8	77.3	402.9
Hackensack-Nauranshaun Confluence	--	211.5	23.9	204.2	120.2	559.8
Hackensack R. – Amtrak Bridge to Rt. 3	1447.4	--	--	1.6	13.5	1462.5
Hackensack R. – Bellman's Creek to Fort Lee Road	675.9	--	--	16.7	5.6	698.2
Hackensack R. below Amtrak Bridge	609.1	--	--	--	9.1	618.2
Hackensack R. – Ft. Lee to Oradell Gage	1.0	--	79.8	13.5	15.4	109.7
Hackensack R. – Rt. 3 to Bellman's Creek	1453.7	--	--	--	--	1453.7
Hackensack R. above Tappan Bridge	--	5.8	148.2	145.2	71.0	370.2
Hackensack R. – Oradell to Tappan Bridge	--	3.3	31.4	248.3	205.8	488.8
Hirshfeld Brook	--	--	--	26.34	--	26.3
Overpeck Creek	168.8	1.3	0.5	82.0	30.2	282.8
Pascack Brook above Westwood Gage	--	27.6	36.7	132.7	80.4	277.4
Pascack Brook below Westwood Gage	--	41.8	129.6	123.4	26.2	321.0
Tenakill Brook	--	28.6	11.6	102.7	43.9	186.8
Upper Pascack Brook	--	--	0.6	1.3	68.9	70.8

Preliminary Assessment of Wetland Functions

It is no surprise that subbasins with the most wetland acreage tended to have the most acreage of wetlands significant for wetland functions, especially those comprising the bulk of wetlands in the Hackensack Meadowlands: Hackensack River Amtrak Bridge to Route 3, Hackensack River Route 3 to Bellman's Creek, and Berry's Creek below Paterson Avenue. Wetlands located in headwater positions are important for streamflow maintenance. These wetlands were most abundant in the Hackensack-Nauranshaun Confluence and De Forest Lake subbasins; they represented about 30 percent of the wetlands important for this function. Other subbasins with substantial acreage of headwater wetlands included Hackensack River 0radell to Tappan Bridge, Hackensack River above Tappan Bridge, Pascack Brook below Westwood Gage, and Dwars Kill which when combined accounted for 44 percent of the wetlands important for streamflow maintenance. Wetlands in the Hackensack River Ft. Lee to Oradell Gage subbasin represented 12 percent of the wetlands predicted as significant for sediment and other particulate retention.

Remotely-sensed Indices of "Natural Habitat Integrity"

Examining the composite index scores, five subbasins have more "natural habitat" relative to their size than the rest (Table 11): Dwars Kill, Hackensack River Oradell to Tappan Bridge, De Forest Lake, Hackensack-Nauranshaun Confluence, and Hackensack River above Tappan Bridge. All of these subbasins had composite score of 0.30 or more. Dwars Kill had the highest composite score (0.53) which was approaching twice the value of the next ranked subbasin (Hackensack River Oradell to Tappan Bridge). Six subbasins had more than 30 percent of their land area in natural vegetation (NC score $\geq$ 0.30). Hackensack River Amtrak Bridge to Route 3 and Dwars Kill had the highest scores. River and stream corridor integrity was best in Dwars Kill, but also was fairly good in six other subbasins having scores $\geq$ 0.40. Wetland buffers were in the best condition in six subbasins having scores near 0.50 and above. Hackensack River above Tappan Bridge had the highest rating (0.60) with 60 percent of its 100m buffer being vegetated. Four subbasins had pond and lake buffer scores above 0.50, with Dwars Kill ranked first. The wetland extent index scores were high for many subbasins, especially Tenakill Brook, Pascack Brook below Westwood Gage, and Coles Brook/Van Saun Mill Brook with scores above 0.80. Surprisingly, the Hackensack River Fort Lee to Oradell Gage subbasin appeared to have all of its historic wetlands (based on a comparison with the 1880s data). The standing waterbody extent index was assumed to be 1.0 for all subbasins.

For the disturbance indices, Hackensack River Fort Lee to Oradell Gage had the most dammed stream flowage with all of its streams dammed (Table 11). Three others had dammed stream flowage index scores above 0.24. Three subbasins had all their streams channelized: Berry's Creek above Paterson Avenue, Hackensack River Amtrak Bridge to Route 3, and Hackensack River below Amtrak Bridge. Numerous subbasins had more than 50 percent of their wetlands altered by ditching, impoundment, or excavation, with Berry's Creek below Paterson Avenue being most impacted (WD score of 0.87). The least wetland disturbance was noted in subbasins of the upper Hackensack watershed: Dwars Kill, Coles Brook/Van Saun Mill Brook and Hackensack River Fort Lee to Oradell Gage. Habitat fragmentation of the watershed by roads was extensive in most subbasins. Those with the lowest level of fragmentation included Dwars Kill and Hackensack River above Tappan Bridge.

Table 9. Acreage of wetlands identified as potentially significant for various functions within each subbasin. Numbers are rounded off to nearest acre. (See Appendix B for details)

Subbasin	**Acres of Wetlands Predicted as Significant for Specific Functions**									
	SWD	**SFM**	**NT**	**SPR**	**CSD**	**SS**	**FSH**	**WWH**	**OWH**	**CB**
Berry's Creek above Paterson Avenue	449	6	458	447	265	294	216	246	458	432
Berry's Creek below Paterson Avenue	951	--	924	951	923	924	911	920	924	873
Coles Brook/Van Saun Mill Brook	124	117	116	112	2	96	68	19	116	90
De Forest Lake	490	416	438	474	--	348	296	302	438	327
Dwars Kill	393	267	403	344	--	326	230	139	403	374
Hackensack-Nauranshaun Confluence	596	431	560	573	--	449	351	327	560	302
Hackensack R. – Amtrak Bridge to Rt. 3	1476	5	687	1476	1447	673	1451	1401	687	1438
Hackensack R. – Bellman's Creek to Ft.Lee Road	707	17	569	705	676	563	670	627	569	666
Hackensack R. below Amtrak Bridge	647	--	618	650	609	611	619	584	618	533
Hackensack R. – Ft. Lee to Oradell Gage	118	22	110	110	79	93	100	97	110	87
Hackensack R. – Rt. 3 to Bellman's Creek	1455	--	1163	1455	1454	1163	1450	1375	1163	1421
Hackensack R. above Tappan Bridge	394	350	370	354	--	309	297	217	370	332
Hackensack R. – Oradell to Tappan Bridge	445	353	489	380	--	324	203	62	489	282
Hirshfeld Brook	30	30	26	30	--	26	25	22	26	23
Overpeck Creek	312	113	269	307	169	237	249	121	269	135
Pascack Brook above Westwood Gage	298	241	277	265	--	200	132	107	278	134
Pascack Brook below Westwood Gage	338	304	321	325	--	293	227	214	321	279
Tenakill Brook	178	177	187	169	--	143	106	29	187	127
Upper Pascack Brook	86	65	71	74	--	2	16	50	71	30

Codes: **SWD**-surface water detention, **SFM**-streamflow maintenance, **NT**-nutrient transformation, **SPR**-sediment and other particulate retention, **CSD-**coastal storm surge detention, **SS**-shoreline stabilization, **FSH**-provision of fish and shellfish habitat, **WWH**-provision of waterfowl and waterbird habitat, **OWH**-provision of other wildlife habitat, and **CB**-conservation of biodiversity.

Table 10. Percent of watershed's wetlands identified as significant for various functions that are located in each subbasin.

Subbasin	**Percent of Hackensack Watershed's Significant Wetlands for Functions**									
	SWD	**SFM**	**NT**	**SPR**	**CSD**	**SS**	**FSH**	**WWH**	**OWH**	**CB**
Berry's Creek above Paterson Avenue	4.7	0.2	5.7	4.9	4.7	4.2	2.8	3.6	5.7	5.5
Berry's Creek below Paterson Avenue	10.0	--	11.5	10.3	16.4	13.1	11.9	13.4	11.5	11.1
Coles Brook/Van Saun Mill Brook	1.3	4.0	1.4	1.2	<0.1	1.4	0.9	0.3	1.4	1.1
De Forest Lake	5.2	14.3	5.4	5.2	--	4.9	3.9	4.4	5.4	4.1
Dwars Kill	4.1	9.2	5.0	3.7	--	4.6	3.0	2.0	5.0	4.7
Hackensack-Nauranshaun Confluence	6.3	14.8	7.0	6.2	--	6.3	4.6	4.8	6.9	3.8
Hackensack R. – Amtrak Bridge to Rt. 3	15.6	0.2	8.5	16.0	25.7	9.5	18.9	20.4	8.5	18.2
Hackensack R. – Bellman's Creek to Ft. Lee Road	7.5	0.6	7.1	7.7	12.0	8.0	8.7	9.1	7.1	8.4
Hackensack R. below Amtrak Bridge	6.8	--	7.7	7.1	10.8	8.6	8.1	8.5	7.7	6.8
Hackensack R. – Ft. Lee to Oradell Gage	1.2	0.8	1.4	12.0	1.4	1.3	1.3	1.4	1.4	1.1
Hackensack R. – Rt. 3 to Bellman's Creek	15.3	--	14.4	15.8	25.9	16.4	18.9	20.0	14.4	18.0
Hackensack R. above Tappan Bridge	4.2	12.0	4.6	3.8	--	4.4	3.9	3.2	4.6	4.2
Hackensack R. – Oradell to Tappan Bridge	4.7	12.1	6.1	4.1	--	4.6	2.6	0.9	6.1	3.6
Hirshfeld Brook	0.3	1.0	0.3	0.3	--	0.3	0.3	0.3	0.3	0.3
Overpeck Creek	3.3	3.9	3.3	3.3	3.0	3.4	3.3	1.8	3.3	1.7
Pascack Brook above Westwood Gage	3.1	8.2	3.4	2.9	--	2.8	1.7	1.6	3.4	1.7
Pascack Brook below Westwood Gage	3.6	10.4	4.0	3.5	--	4.1	3.0	3.1	4.0	3.5
Tenakill Brook	1.9	6.1	2.3	1.8	--	2.0	1.4	0.4	2.3	1.6
Upper Pascack Brook	0.9	2.2	0.9	0.8	--	--	0.2	0.7	0.8	0.4

Codes: **SWD**-surface water detention, **SFM**-streamflow maintenance, **NT**-nutrient transformation, **SPR**-sediment and other particulate retention, **CSD**-coastal storm surge detention, **SS**-shoreline stabilization, **FSH**-provision of fish and shellfish habitat, **WWH**-provision of waterfowl and waterbird habitat, **OWH**-provision of other wildlife habitat, and **CB**-conservation of biodiversity.

Table 11. Remotely-sensed indices of "natural habitat integrity" for subbbasins.

Subbasin	**Index Scores**										
	NC	**RSC**	**WB**	**PLB**	**WE**	**SWE**	**DSF**	**CSL**	**WD**	**HFR**	**COMP**
Berry's Creek above Paterson Avene	0.16	0.40	0.12	0.16	0.31	1.00	0.00	1.00	0.61	0.61	0.06
Berry's Creek below Paterson Avenue	0.31	0.00	0.14	0.10	0.35	1.00	0.00	0.00	0.87	0.72	0.15
Coles Brook/Van Saun Mill Brook	0.08	0.18	0.11	0.15	0.83	1.00	0.00	0.13	0.10	0.58	0.18
De Forest Lake	0.39	0.44	0.51	0.56	0.39	1.00	0.30	0.29	0.66	0.34	0.32
Dwars Kill	0.44	0.64	0.56	0.68	0.70	1.00	0.00	0.09	0.07	0.26	0.53
Hackensack-Nauranshaun Confluence	0.33	0.41	0.47	0.56	0.54	1.00	0.24	0.29	0.41	0.58	0.31
Hackensack R. – Amtrak Bridge to Rt. 3	0.45	0.03	0.04	0.22	0.16	1.00	0.00	1.00	0.55	0.56	0.15
Hackensack R. – Bellman's Creek to Fort Lee Road	0.13	0.10	0.07	0.28	0.45	1.00	0.00	0.88	0.72	0.77	0.01
Hackensack R. below Amtrak Bridge	0.16	0.10	0.33	0.41	0.27	1.00	0.00	1.00	0.77	0.82	0.02
Hackensack R. – Ft. Lee to Oradell Gage	0.07	0.33	0.11	0.07	1.00	1.00	1.00	0.03	0.10	0.54	0.13
Hackensack R. – Rt. 3 to Bellman's Creek	0.31	0.00	0.21	0.15	0.40	1.00	0.00	0.00	0.69	0.91	0.17
Hackensack R. above Tappan Bridge	0.24	0.45	0.61	0.45	0.74	1.00	0.33	0.19	0.72	0.26	0.30
Hackensack R. – Oradell to Tappan Bridge	0.27	0.47	0.50	0.54	0.73	1.00	0.06	0.24	0.63	0.31	0.33
Hirshfeld Brook	0.04	0.12	0.11	0.08	0.73	1.00	0.03	0.36	0.12	0.54	0.12
Overpeck Creek	0.12	0.22	0.34	0.27	0.36	1.00	0.09	0.56	0.36	0.69	0.11
Pascack Brook above Westwood Gage	0.23	0.41	0.26	0.39	0.59	1.00	0.09	0.09	0.41	0.41	0.27
Pascack Brook below Westwood Gage	0.16	0.35	0.19	0.27	0.84	1.00	0.05	0.45	0.18	0.36	0.24
Tenakill Brook	0.15	0.27	0.29	0.33	0.99	1.00	0.01	0.43	0.45	0.38	0.23
Upper Pascack Brook	0.20	0.08	0.49	0.36	0.24	1.00	0.08	0.67	0.34	0.40	0.17

Index Codes: **NC**-natural cover, **RSC**-river and stream corridor integrity, **WB**-wetland buffer integrity, **PLB**-pond and lake buffer integrity, **WE**-wetland extent, **SWE**-standing waterbody extent, **DSF**-dammed stream flowage, **CSL**-channelized stream length, **WD**-wetland disturbance, **HFR**-habitat fragmentation by road, and **COMP**-composite habitat integrity.

Conclusions

The Hackensack River watershed had nearly 9,650 acres of wetlands (including ponds), with over half (5,445 acres) located in the Hackensack Meadowlands. Estuarine emergent wetlands were the predominant wetland type comprising 42 percent of the watershed's wetlands. Palustrine forested wetlands were next ranked in abundance, accounting for a third of all wetlands.

From the landscape perspective, about 56 percent of the wetland acreage was associated with the estuary due to the prominence of the Hackensack Meadowlands. Nearly one-quarter of the wetland acreage was associated with rivers and streams (roughly 5% and 20%, respectively) and almost 5 percent contiguous with lakes. Eleven percent of the wetland acreage was represented by terrene wetlands (headwater stream source and isolated types), with the remaining four percent being ponds.

From the landform perspective, basin wetlands were most extensive, accounting for 57 percent of the wetland acreage (excluding ponds). Many of these wetlands were estuarine wetlands whose tidal sheet flow has been diminished somewhat due to road construction (causeways and bridges). Fringe wetlands were second-ranked comprising 26 percent of the acreage. Flats made up 12 percent of the acreage, while floodplains associated with rivers accounted for four percent and slopes comprised one percent.

Considering water flow path, 61 percent of the wetland acreage was bidirectional-tidal and 26 percent was throughflow. Outflow types (associated mostly with headwater wetlands in the upper watershed) accounted for only seven percent of the acreage. Nearly five percent of the wetland acreage was isolated and almost two percent of the acreage was classified as bidirectional (associated with lakes/reservoirs).

Functionally, nearly all of the remaining wetland acreage (>95%) in the watershed was rated as potentially significant for surface water detention (e.g., flood storage) and sediment and other particulate retention (e.g., water quality renovation). Four other functions were predicted to be performed by 80 percent or more of the acreage: provision of other wildlife habitat, nutrient transformation, conservation of biodiversity, and provision of fish and shellfish habitat. Over half of the conservation of biodiversity function was attributed to the presence of the Hackensack Meadowlands – one of the largest remaining urban wetlands in the northeastern United States. Other wetlands recognized as important for biodiversity included large complexes greater than 100 acres, headwater wetlands, beaver-influenced wetlands, lakeside wetlands, wetlands in large complexes along rivers and streams, freshwater tidal wetlands, and potential woodland vernal pools. About 70 percent of the Hackensack watershed wetlands also provided habitat for waterfowl and other waterbirds at significant levels and were rated as important for shoreline stabilization, while 58 percent was significant for coastal storm surge detention. Only 30 percent of the wetland acreage was located in headwater positions that serve to maintain streamflow.

Analysis of land use patterns in the watershed documented the generally poor condition of the Hackensack River watershed which is no surprise given that 75 percent of the watershed is urbanized. Over three centuries of population growth and land and water development in the watershed have taken their toll on the watershed's natural resources. The overall landscape is largely devoid of natural vegetation, with only 25 percent of the watershed in some kind of "natural cover" in 1995. As anticipated given the urban-suburban landscape, stream corridors and wetland buffers are generally devoid of vegetation: about 35 percent of the 100m river-stream corridor was colonized by vegetation, whereas 27 percent of the 100m buffer around mapped wetlands was in natural cover. By 1995, the watershed lost 64% of its original wetlands and the functions they provided. In contrast, waterbodies have increased due to construction of ponds, reservoirs, and dammed lakes. The aquatic resources within the watershed have been significantly altered: 16 percent of the river/stream miles have been dammed, 33 percent of the stream miles channelized, and 59 percent of the wetlands altered to some degree; pollution by runoff, discharge of municipal and industrial wastewaters, and other operations have further degraded the quality of the watershed's aquatic resources. Road construction and accompanying urban and suburban development have left the Hackensack watershed a fragmented landscape with only remnants of its original natural habitat in place.

Information from this study was used to help the Service prepare a conservation strategy for the Hackensack Meadowlands ecosystem (U.S. Fish and Wildlife Service 2007). Some key recommendations of this conservation plan were: 1) protect wetlands and their buffers in the upper Hackensack River watershed, 2) development of a comprehensive remediation and restoration plan is critical to address problems confronting the Meadowlands ecosystem, 3) increase the extent and connectivity of upland buffers, and 4) consider designating the Meadowlands as a marine/estuarine protected area.

Acknowledgments

The entire study was funded and conducted pursuant to Congressional directives to support restoration of the Hackensack Meadowlands (see H.R. 109-90). The initial classification and mapping, however, was funded by the Service's strategic mapping initiative of the National Wetlands Inventory (NWI) Program at the request of Cliff Day, Supervisor of the Service's New Jersey Field Office (NJFO). The analysis work and preparation of this report was funded by the New Jersey Field Office's Hackensack Meadowlands Initiative (HMI). Stan Hales was project officer for that portion of the work with Ralph Tiner serving as the principal investigator. We especially thank Congressman Steve Rothman for his support of the HMI.

All work was done by the Service's Regional NWI Program. Wetland classification and photointerpretation were performed by Meaghen Shaffer, Lauren McCubbin, and Lisa Reisner. Bobbi Jo McClain did LLWW classifications with quality control and final edits by Herb Bergquist. Mr. Bergquist was also responsible for land use/cover classification and mapping, GIS analysis, and providing data summaries and maps for this report. Ralph Tiner designed and coordinated the study, analyzed the results, and prepared the report.

Special thanks to Karen L. Siletti for the use of her figure showing the major waterbodies of the Hackensack River watershed (Figure 1).

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Appendices

Appendix A. Coding for LLWW descriptors from "Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors" (Tiner 2003a).

Section 4. Coding System for LLWW Descriptors

The following is the coding scheme for expanding classification of wetlands and waterbodies beyond typical NWI classifications. When enhancing NWI maps/digits, codes should be applied to all mapped wetlands and deepwater habitats (including linears). At a minimum, landscape position (including lotic gradient), landform, and water flow path should be applied to wetlands, and waterbody type and water flow path to water to waterbodies. Wetland and deepwater habitat data for specific estuaries, lakes, and river systems could be added to existing digital data through use of geographic information system (GIS) technology.

Codes for Wetlands

Wetlands are typically classified by landscape position, landform, and water flow path. Landforms are grouped according to Inland types and Coastal types with the latter referring to tidal wetlands associated with marine and estuarine waters. Use of other descriptors tends to be optional. They would be used for more detailed investigations and characterizations.

Landscape Position

ES	Estuarine
LE	Lentic
LR	Lotic river
LS	Lotic stream
MA	Marine
TE	Terrene

Lotic Gradient

1	Low	
2	Middle	
3	High	
4	Intermittent	
5	Tidal	
6	Dammed	
a		lock and dammed
b		run-of-river dam
c		beaver
d		other dammed
7	Artificial (ditch)	

Lentic Type

1	Natural deep lake (see also Pond codes for possible specific types)	
a		main body
b		open empbayment
c		semi-enclosed embayment
d		barrier beach lagoon
2	Dammed river valley lake	
a		reservoir
b		hydropower
c		other
3	Other dammed lake	
a		former natural
b		artificial
4	Excavated lake	
a		quarry lake
5	Other artificial lake	

Estuary Type

1	Drowned river valley estuary	
a		open bay (fully exposed)
b		semi-enclosed bay
c		river channel
2	Bar-built estuary	
a		coastal pond-open
b		coastal pond-seasonally closed
c		coastal pond-intermittently open
d		hypersaline lagoon
3	River-dominated estuary	
4	Rocky headland bay estuary	
a		island protected
5	Island protected estuary	
6	Shoreline bay estuary	
a		open (fully exposed)
b		semi-enclosed
7	Tectonic	
a		fault-formed
b		volcanic-formed
8	Fjord	
9	Other	

Inland Landform

SL	Slope	
SLpa		Slope, paludified
IL	Island*	
ILde		Island, delta
ILrs		Island, reservoir
ILpd		Island, pond
FR	Fringe*	
FRil		Fringe, island*
FRbl		Fringe, barrier island
FRbb		Fringe, barrier beach
FRpd		Fringe, pond
FRdm		Fringe, drowned river mouth
FP	Floodplain	
FPba		Floodplain, basin
FPox		Floodplain, oxbow
FPfl		Floodplain, flat
FPil		Floodplain, island
IF	Interfluve	
IFba		Interfluve, basin
IFfl		Interfluve, flat
BA	Basin	
BAcb		Basin, Carolina bay
BApo		Basin, pocosin
BAcd		Basin, cypress dome
BApp		Basin, prairie pothole
BApl		Basin, playa
BAwc		Basin, West Coast vernal pool
BAid		Basin, interdunal
BAwv		Basin, woodland vernal
BApg		Basin, polygonal
BAsh		Basin, sinkhole
BApd		Basin, pond
BAgp		Basin, grady pond
BAsa		Basin, salt flat
BAaq		Basin, aquaculture (created)
BAcr		Basin, cranberry bog (created)
BAwm		Basin, wildlife management (created)

BAip	Basin, impoundment (created)
BAfe	Basin, former estuarine wetland
BAff	Basin, former floodplain
BAfi	Basin, former interfluve
BAfo	Basin, former floodplain oxbow
BAdm	Basin, drowned river-mouth

FL Flat

FLsa	Flat, salt flat
FLff	Flat, former floodplain
FLfi	Flat, former interfluve

*Note: Inland slope wetlands and island wetlands associated with rivers, streams, and lakes are designated as such by the landscape position classification (e.g., lotic river, lotic stream, or lentic), therefore no additional terms are needed here to convey this association.

Coastal Landform

IL Island

ILdt	Island, delta
ILde	Island, ebb-delta
ILdf	Island, flood-delta
ILrv	Island, river
ILst	Island, stream
ILby	Island, bay

DE Delta

DEr	Delta, river-dominated
DEt	Delta, tide-dominated
DEw	Delta, wave-dominated

FR Fringe

FRal	Fringe, atoll lagoon
FRbl	Fringe, barrier island
FRbb	Fringe, barrier beach
FRby	Fringe, bay
FRbi	Fringe, bay island
FRcp	Fringe, coastal pond
FRci	Fringe, coastal pond island
FRhl	Fringe, headland
FRoi	Fringe, oceanic island
FRlg	Fringe, lagoon
FRrv	Fringe, river

FRri	Fringe, river island
FRst	Fringe, stream
FRsi	Fringe, stream island

BA Basin

BAaq	Basin, aquaculture (created)
BAid	Basin, interdunal (swale)
BAst	Basin, stream
BAsh	Basin, salt hay production (created)
BAtd	Basin, tidally restricted/road (not a management area)
BAtr	Basin, tidally restricted/railroad (not a management area)
BAwm	Basin, wildlife management (created)
BAip	Basin, impoundment (created)

Water Flow Path

PA	Paludified
IS	Isolated
IN	Inflow
OU	Outflow
OA	Outflow-artificial*
OP	Outflow-perennial
OI	Outflow-intermittent
TH	Throughflow
TA	Throughflow - artificial*
TN	Throughflow - entrenched
TI	Throughflow - intermittent
BI	Bidirectional Flow - nontidal
BT	Bidirectional Flow - tidal

*Note: To be used with wetlands connected to streams by ditches.

Other Modifiers (apply at the end of the code as appropriate)

br	barren
bv	beaver
ch	channelized flow
cl	coastal island (wetland on an island in an estuary or ocean including barrier islands)
cr	cranberry bog
dd	drainage divide
dr	partly drained
ed	freshwater wetland discharging directly into an estuary
fe	former estuarine wetland
fg	fragmented
fm	floating mat

gd groundwater-dominated (apply to Water Flow Path only)
hi severely human-induced
hw headwater
li lake island (wetland associated with a lake island)
md freshwater wetland discharging directly into marine waters
ow overwash
pi pond island border
ri river island (wetland associated with a river island)
sd surface water-dominated (apply to Water Flow Path only)
sf spring-fed
ss subsurface flow
td tidally restricted/road
tr tidally restricted/railroad

(Note: "ho" was formerly used to indicate human-induced outflow brought about by ditch construction; now this is addressed by the water flow path "OA" Outflow-Artificial.)

Codes for Waterbodies

Besides Waterbody Type, waterbodies can be classified by water flow path (for lakes and ponds), estuary hydrologic type (for estuaries), and tidal range types (for estuaries and oceans).

Waterbody Type

RV River
- 1 low gradient
  - a connecting channel
  - b canal
- 2 middle gradient
  - a connecting channel
- 3 high gradient
  - a waterfall
  - b riffle
  - c pool
- 4 intermittent gradient
- 5 tidal gradient
- 6 dammed gradient
  - a lock and dammed
  - b run-of-river dammed
  - c other dammed

ST Stream
- 1 low gradient
  - a connecting channel
- 2 middle gradient

a		connecting channel
3	high gradient	
a		waterfall
b		riffle
c		pool
4	intermittent gradient	
5	tidal gradient	
6	dammed	
a		lock and dammed
b		run-of-river dammed
c		beaver dammed
d		other dammed
7	artificial	
a		connecting channel
b		ditch

LK Lake

1	natural lake (*see also Pond codes for possible specific types*)	
a		main body
b		open empbayment
c		semi-enclosed embayment
d		barrier beach lagoon
2	dammed river valley lake	
a		reservoir
b		hydropower
c		other
3	other dammed lake	
a		former natural
b		artificial
4	other artificial lake	

(Consider using a modifier to highlight specific lakes as needed, especially the Great Lakes, e.g., LK1E for Lake Erie or LK2O for Lake Ontario, and Lake Champlain, LK1C)

EY Estuary

1	drowned river valley estuary	
a		open bay (fully exposed)
b		semi-enclosed bay
c		river channel
2	bar-built estuary	
a		coastal pond-open
b		coastal pond-seasonally closed
c		coastal pond-intermittently open
d		hypersaline lagoon
3	river-dominated estuary	

4	rocky headland bay estuary	
a		island protected
5	island protected estuary	
6	shoreline bay estuary	
a		open (fully exposed)
b		semi-enclosed
7	tectonic	
a		fault-formed
b		volcanic-formed
8	fjord	
9	other	

Note: If desired, you can also designate river channel (rc), stream channel (sc),and inlet channel (ic) by modifiers. *Examples*: EY1rc = Drowned River Valley Estuary river channel; EY2ic= Bar-built estuary inlet channel. If not, simply classify all estuarine water as a single type, e.g., EY1 for Drowned River Valley or EY2 for Bar-built Estuary.

OB	Ocean or Bay	
	1	open (fully exposed)
	2	semi-protected oceanic bay
	3	atoll lagoon
	4	other reef-protected waters
	5	fjord

PD	Pond		
	1	natural	
	a		bog
	b		woodland-wetland
	c		woodland-dryland
	d		prairie-wetland (pothole)
	e		prairie-dryland (pothole)
	f		playa
	g		polygonal
	h		sinkhole-woodland
	i		sinkhole-prairie
	j		Carolina bay
	k		pocosin
	l		cypress dome
	m		vernal-woodland
	n		vernal-West Coast
	o		interdunal
	p		grady
	q		floodplain
	r		other
	2	dammed/impounded	
	a		agriculture

a1		cropland
a2		livestock
a3		cranberry
b		aquaculture
b1		catfish
b2		crayfish
c		commercial
c1		commercial-stormwater
d		industrial
d1		industrial-stormwater
d2		industrial-wastewater
e		residential
e1		residential-stormwater
f		sewage treatment
g		golf
h		wildlife management
i		other recreational
o		other
q		floodplain
3	excavated	
a		agriculture
a1		cropland
a2		livestock
a3		cranberry
b		aquaculture
b1		catfish
b2		crayfish
c		commercial
c1		commercial-stormwater
d		industrial
d1		industrial-stormwater
d2		industrial-wastewater
e		residential
e1		residential-stormwater
f		sewage treatment
g		golf
h		wildlife management
i		other recreational
j		mining
j1		sand/gravel
j2		coal
o		other
q		floodplain
4	beaver	
5	other artificial	

Water Flow Path

IN	Inflow
OU	Outflow
OA	Outflow-artificial*
OP	Outflow-perennial
OI	Outflow-intermittent
TH	Throughflow
TA	Throughflow-artificial*
TI	Throughflow-intermittent*
TN	Throughflow-entrenched
BI	Bidirectional-nontidal
IS	Isolated
MI	Microtidal
ME	Mesotidal
MC	Macrotidal

*Note: OA and TA are human-caused by ditches; TI is to be used along intermittent streams.

Estuarine Hydrologic Circulation Type

SW	Salt-wedge/river-dominated type
PM	Partially mixed type
HO	Homogeneous/high energy type

Other Modifiers (apply at end of code)

ch	Channelized or Dredged
dv	Diverted
ed	freshwater stream flowing directly into an estuary
fv	Floating vegetation (on the surface)
lv	Leveed
md	freshwater stream flowing directly into marine waters
sv	Submerged vegetation

Appendix B. Study findings for individual subbasins. Subbasins are listed alphabetically. A series of tables of four tables are given for each subbasin: 1) wetland acreage summary by NWI types, 2) wetland acreage summary by LLWW types, 3) preliminary assessment of wetland functions, and 4) natural habitat integrity indices.

Subbasin: Berry's Creek above Paterson Avenue

Table 1. Wetlands classified by NWI types for the Berry's Creek above Paterson Avenue subbasin.

NWI Wetland Type	Acreage
Estuarine Wetlands	
Emergent	78.03
Emergent/Scrub-Shrub	3.15
(subtotal Emergent)	*81.18*
Scrub-Shrub	1.63
Unconsolidated Shore	0.97
--	---------
Estuarine Subtotal	*83.78*
Palustrine Wetlands	
Emergent	182.45
Emergent/Scrub-Shrub	8.66
(subtotal Emergent)	*191.11*
Forested, Broad-leaved Deciduous	102.35
Scrub-Shrub, Deciduous	13.14
Scrub-Shrub/Emergent	4.73
Scrub-Shrub/Forested	63.87
(subtotal Scrub-Shrub)	*81.74*
Unconsolidated Bottom	4.33
---	------------
Palustrine Subtotal	*379.53*
Riverine Wetlands	3.40
GRAND TOTAL (ALL WETLANDS)	*466.71*

Table 2. Wetlands in the Berry's Creek above Paterson Avenue subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands*	Acreage
Estuarine (ES)	Basin	Bidirectional-tidal (BT)	--	102.63
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	2	2.96
Lotic Stream (LS)	Basin (BA)	Bidirectional-tidal (BT)	4	126.69
		Throughflow (TH)	4	20.83
		(subtotal)	*(8)*	*(147.52)*
	Flat (FL)	Bidirectional-tidal (BT)	4	35.51
		Throughflow (TH)	2	13.27
		(subtotal)	*(6)*	*(48.8)*
	Subtotal Lotic Stream		14	196.30
Terrene (TE)				
	Basin (BA)	Isolated (IS)	6	14.44
		Outflow (OU)	5	126.43
		(subtotal)	*(11)*	*(140.87)*
	Flat (FL)	Isolated (IS)	3	1.91
		Outflow (OU)	2	1.46
		(subtotal)	*(5)*	*(3.37)*
	Slope (SL)	Outflow (OU)	1	12.84
	Subtotal Terrene		17	157.08
TOTAL LLWW Types*			33+	458.97

*Does not include 4 ponds that totaled 4.33 acres. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages in database due to computer round-off procedures.

Table 3. Predicted wetland functions for the Berry's Creek above Paterson Avenue subbasin.

Function	Level	Acreage
Surface Water Detention	High	255.20
	Moderate	193.47
	Total	*448.67*
Streamflow Maintenance	High	5.85
	Moderate	--
	Total	*5.85*
Nutrient Transformation	High	393.01
	Moderate	65.00
	Total	*458.01*
Sediment and Other Particulate Retention	High	421.62
	Moderate	25.47
	Total	*447.09*
Coastal Storm Surge Detention	High	264.83
Shoreline Stabilization	High	294.18
	Moderate	--
	Total	*294.18*
Fish and Shellfish Habitat	High	17.93
	Moderate	168.99
	Shading	28.84
	Total	*215.76*
Waterfowl and Waterbird Habitat	High	30.42
	Moderate	186.40
	Wood Duck	29.04
	Total	*245.86*
Other Wildlife Habitat	High	389.19 (large complexes)
	High	26.61 (small diverse wetlands)
	Moderate	42.66
	Total	*458.46*
Conservation of Biodiversity	100acre+ complexes	164.00
	Meadowlands	265.37
	Headwater wetlands	2.96
	Total	*432.33*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Berry’s Creek above Paterson Avenue subbasin.

Index	Score
Natural Cover Index	0.16
River/Stream Corridor Integrity Index	0.40
Wetland Buffer Integrity Index	0.12
Pond/Lake Buffer Integrity Index	0.16
Wetland Extent Index	0.31
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	1.00
Wetland Disturbance Index	0.61
Habitat Fragmentation by Road Index	0.61
Composite Index	0.06

Subbasin: Berry's Creek below Paterson Avenue

Table 1. Wetlands classified by NWI types for the Berry's Creek below Paterson Avenue subbasin.

NWI Wetland Type	**Acreage**
Estuarine Wetlands	
Emergent	904.13
Emergent/Scrub-Shrub	4.13
Unconsolidated Shore	1.07
Estuarine Subtotal	909.33
Palustrine Wetlands	
Emergent	2.87
Emergent/Scrub-Shrub	5.85
Forested, Broad-leaved Deciduous	1.85
Scrub-Shrub/Forested	4.69
Unconsolidated Bottom	26.84
Palustrine Subtotal	42.10
Riverine Wetlands	0.49
GRAND TOTAL (ALL WETLANDS)	951.92

Table 2. Wetlands in the Berry's Creek below Paterson Avenue subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	18.58
	Basin	Bidirectional-tidal (BT)	--	904.33
	(Subtotal Estuarine)			*922.91*
Terrene (TE)	Basin (BA)	Isolated (IS)	1	1.66
TOTAL LLWW Types*			1+	924.57

*Does not include 11 ponds that totaled 26.83 acres. Number of estuarine wetlands not determined.

<u>Note</u>: Subtotals may be slightly different than the sum of acreages in the database due to computer round-off procedures.

Table 3. Predicted wetland functions for the Berry's Creek below Paterson Avenue subbasin. Click on maps to view potential wetlands of significance for each function.

Function	**Level**	**Acreage**
Surface Water Detention	High	943.97
	Moderate	7.47
	Total	*951.41*
Streamflow Maintenance	High	--
	Moderate	--
	Total	--
Nutrient Transformation	High	919.07
	Moderate	4.43
	Total	*923.50*
Sediment and Other Particulate Retention	High	942.90
	Moderate	8.52
	Total	*951.42*
Coastal Storm Surge Detention	High	922.91
Shoreline Stabilization	High	921.84
	Moderate	1.66
	Total	*923.50*
Fish and Shellfish Habitat	High	7.63
	Moderate	903.45
	Shading	--
	Total	*911.08*
Waterfowl and Waterbird Habitat	High	7.63
	Moderate	908.04
	Wood Duck	4.41
	Total	*920.08*
Other Wildlife Habitat	High	873.20
	Moderate	50.30
	Total	*923.50*
Conservation of Biodiversity	Meadowlands	872.77

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Berry's Creek below Paterson Avenue subbasin.

Index	Score
Natural Cover Index	0.31
River/Stream Corridor Integrity Index	0.00
Wetland Buffer Integrity Index	0.14
Pond/Lake Buffer Integrity Index	0.10
Wetland Extent Index	0.35
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.00
Wetland Disturbance Index	0.87
Habitat Fragmentation by Road Index	0.72
Composite Index	0.15

Subbasin: Coles Brook/Van Saun Mill Brook

Table 1. Wetlands classified by NWI types for the Coles Brook/Van Saun Mill Brook subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	2.10
Emergent/Scrub-Shrub	4.67
Forested, Broad-leaved Deciduous	109.42
Unconsolidated Bottom	7.55
Palustrine Subtotal	123.74
Riverine Wetlands	3.73
GRAND TOTAL (ALL WETLANDS)	127.47

Table 2. Wetlands in the Coles Brook/Van Saun Mill Brook subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	1	2.15
	Fringe (FR)	Bidirectional-tidal (BT)	2	1.65
	(Subtotal Lotic River)		*3*	*3.80*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	4	30.84
	Flat (FL)	Throughflow (TH)	11	61.75
	(Subtotal Lotic Stream)		*15*	*92.59*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	1	0.53
		Outflow (OU)	1	7.83
		(subtotal)	*(2)*	*(8.36)*
	Flat (FL)	Isolated (IS)	3	2.99
		Outflow (OU)	2	6.91
		(subtotal)	*(5)*	*(9.90)*
	Slope (SL)	Isolated (IS)	1	1.55
	(Subtotal Terrene)		*8*	*19.81*
TOTAL LLWW Types*			26	116.20

*Does not include 4 ponds that totaled 7.55 acres.
Note: Subtotals may be slightly different than the sum of acreages in the database due to computer round-off procedures.

Table 3. Predicted wetland functions for the Coles Brook/Van Saun Mill Brook subbasin.

Function	Level	Acreage
Surface Water Detention	High	38.64
	Moderate	85.09
	Total	*123.73*
Streamflow Maintenance	High	89.50
	Moderate	27.21
	Total	*116.71*
Nutrient Transformation	High	40.84
	Moderate	75.34
	Total	*116.18*
Sediment and Other Particulate Retention	High	90.49
	Moderate	21.80
	Total	*112.29*
Coastal Storm Surge Detention	High	1.65
Shoreline Stabilization	High	96.39
	Moderate	--
	Total	*96.39*
Fish and Shellfish Habitat	High	1.65
	Moderate	7.55
	Shading	58.90
	Total	*68.10*
Waterfowl and Waterbird Habitat	High	1.65
	Moderate	7.55
	Wood Duck	9.60
	Total	*18.81*
Other Wildlife Habitat	High	59.29
	Moderate	56.89
	Total	*116.19*
Conservation of Biodiversity	Headwater wetlands	88.12
	Tidal fresh wetlands	1.65
	Total	*89.77*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Coles Brook/Van Saun Mill Brook subbasin.

Index	Score
Natural Cover Index	0.08
River/Stream Corridor Integrity Index	0.18
Wetland Buffer Integrity Index	0.11
Pond/Lake Buffer Integrity Index	0.15
Wetland Extent Index	0.83
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.13
Wetland Disturbance Index	0.10
Habitat Fragmentation by Road Index	0.58
Composite Index	0.18

Subbasin: De Forest Lake

Table 1. Wetlands classified by NWI types for the De Forest Lake subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	56.92
Emergent/Scrub-Shrub	10.92
(subtotal Emergent)	*67.84*
Forested, Broad-leaved Deciduous	330.14
Forested, Needle-leaved Evergreen	2.59
Forested/Scrub-Shrub	7.98
Forested/Emergent	6.68
(subtotal Forested)	*347.39*
Scrub-Shrub, Deciduous	20.78
Scrub-Shrub/Emergent	1.99
(subtotal Scrub-Shrub)	*22.77*
Unconsolidated Bottom	66.84
Unconsolidated Shore	1.12
Palustrine Subtotal	505.96
Riverine Wetlands	6.83
GRAND TOTAL (ALL WETLANDS)	512.79

Table 2 Wetlands in the De Forest Lake subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands	Acreage
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	7	10.45
		Throughflow (TH)	3	23.83
		(subtotal)	*10*	*34.28*
	Flat (FL)	Bidirectional (BI)	4	6.50
		Isolated (IS)	1	3.27
		(subtotal)	*5*	*9.77*
	Fringe (FR)	Bidirectional (BI)	1	1.08
	(Subtotal Lentic)		*16*	*45.13*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	28	264.09
	Flat (FL)	Throughflow (TH)	7	15.69
	Fringe (FR)	Throughflow (TH)	1	0.19
	(Subtotal Lotic Stream)		*36*	*279.97*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	34	35.01
		Outflow (OU)	9	63.67
		(subtotal)	*43*	*98.68*
	Flat (FL)	Isolated (IS)	3	2.95
		Outflow (OU)	5	12.38
		(subtotal)	*8*	*15.33*
	(Subtotal Terrene)		*51*	*114.01*
TOTAL LLWW Types*			103	439.11

*Does not include 73 ponds that totaled 50.80 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the De Forest Lake subbasin.

Function	Level	Acreage
Surface Water Detention	High	325.23
	Moderate	164.35
	Total	*489.58*
Streamflow Maintenance	High	142.61
	Moderate	273.60
	Total	*416.21*
Nutrient Transformation	High	397.21
	Moderate	40.79
	Total	*438.00*
Sediment and Other Particulate Retention	High	322.38
	Moderate	151.88
	Total	*474.26*
Shoreline Stabilization	High	334.38
	Moderate	13.10
	Total	*347.75*
Fish and Shellfish Habitat	High	2.18
	Moderate	51.91
	Shading	241.66
	Total	*295.75*
Waterfowl and Waterbird Habitat	High	17.96
	Moderate	59.73
	Wood Duck	223.97
	Total	*301.66*
Other Wildlife Habitat	High	207.33 (large complexes)
	High	118.52 (small diverse wetlands)
	Moderate	112.16
	Total	*438.01*
Conservation of Biodiversity	100acre+ complexes	171.50
	Headwater wetlands	143.88
	Lentic basins/fringes	11.29
	Possible vernal pool	0.39
	Total	*327.06*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the DeForest Lake subbasin.

Index	Score
Natural Cover Index	0.39
River/Stream Corridor Integrity Index	0.44
Wetland Buffer Integrity Index	0.51
Pond/Lake Buffer Integrity Index	0.56
Wetland Extent Index	0.39
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.30
Channelized Stream Length Index	0.29
Wetland Disturbance Index	0.66
Habitat Fragmentation by Road Index	0.34
Composite Index	0.32

Subbasin: Dwars Kill

Table 1. Wetlands classified by NWI types for the Dwars Kill subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	3.19
Forested, Broad-leaved Deciduous	374.40
Forested/Scrub-Shrub	2.36
Forested/Emergent	5.23
(subtotal Forested)	*381.99*
Scrub-Shrub, Deciduous	6.16
Scrub-Shrub/Emergent	8.48
Scrub-Shrub/Forested	3.13
(subtotal Scrub-Shrub)	*17.77*
Unconsolidated Bottom	5.08
Palustrine Subtotal	408.03
Riverine Wetlands	6.94
GRAND TOTAL (ALL WETLANDS)	414.97

Table 2. Wetlands in the Dwars Kill subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands	Acreage
Lentic (LE)				
	Basin (BA)	Throughflow (TH)	6	31.46
	Flat (FL)	Bidirectional (BI)	4	8.92
		Throughflow (TH)	6	44.41
		(subtotal)	*10*	*53.33*
	(Subtotal Lentic)		*16*	*84.79*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	10	135.25
	Flat (FL)	Throughflow (TH)	12	105.58
	(Subtotal Lotic Stream)		*22*	*240.83*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	5	12.60
		Outflow (OU)	2	0.70
		(subtotal)	*7*	*13.30*
	Flat (FL)	Isolated (IS)	6	36.33
		Outflow Intermittent (OI)		
		Outflow (OU)	6	27.42
		(subtotal)	*12*	*63.75*
	Slope (SL)	Isolated (IS)	1	0.28
	(Subtotal Terrene)		*19*	*77.33*
TOTAL LLWW Types*			57	402.83

*Does not include 5 ponds that totaled 5.07 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Dwars Kill subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	224.47
	Moderate	168.14
	Total	*392.61*
Streamflow Maintenance	High	33.67
	Moderate	233.01
	Total	*266.68*
Nutrient Transformation	High	180.02
	Moderate	222.93
	Total	*402.95*
Sediment and Other Particulate Retention	High	263.75
	Moderate	80.25
	Total	*344.00*
Shoreline Stabilization	High	325.84
	Moderate	--
	Total	*325.84*
Fish and Shellfish Habitat	High	--
	Moderate	5.08
	Shading	225.13
	Total	*230.21*
Waterfowl and Waterbird Habitat	High	0.13
	Moderate	5.08
	Wood Duck	133.32
	Total	*138.53*
Other Wildlife Habitat	High	306.09 (large complexes)
	High	23.04 (small diverse wetlands)
	Moderate	73.81
	Total	*402.94*
Conservation of Biodiversity	100 acre+ wetlands	346.68
	Headwater wetlands	26.83
	Total	*373.51*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Dwars Kill subbasin.

Index	**Score**
Natural Cover Index	0.44
River/Stream Corridor Integrity Index	0.64
Wetland Buffer Integrity Index	0.56
Pond/Lake Buffer Integrity Index	0.68
Wetland Extent Index	0.70
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.09
Wetland Disturbance Index	0.07
Habitat Fragmentation by Road Index	0.26
Composite Index	0.53

Subbasin: Hackensack River - Amtrak Bridge to Route 3

Table 1. Wetlands classified by NWI types for the Hackensack River - Amtrak Bridge to Rt. 3 subbasin.

NWI Wetland Type	**Acreage**
Estuarine Wetlands	
Emergent	655.62
Unconsolidated Shore	775.72
Estuarine Subtotal	1431.33
Palustrine Wetlands	
Emergent	21.40
Forested, Broad-leaved Deciduous	2.00
Scrub-Shrub, Deciduous	7.84
Unconsolidated Bottom	13.21
Unconsolidated Shore	3.46
Palustrine Subtotal	47.91
Riverine Wetlands	2.39
GRAND TOTAL (ALL WETLANDS)	1,481.63

Table 2. Wetlands in the Hackensack River - Amtrak Bridge to Rt. 3 subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	962.33
	Basin	Bidirectional-tidal (BT)	--	484.36
	Island	Bidirectinal-tidal (BT)	--	0.75
	(Subtotal Estuarine)			*1447.44*
Lotic Stream (LS)				
	Flat (FL)	Throughflow (TH)	1	1.63
	(Subtotal Lotic Stream)			*1.63*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	3	2.36
		Outflow (OU)	4	8.01
		(subtotal)	*7*	*10.37*
	Flat (FL)	Outflow (OU)	1	3.14
	(Subtotal Terrene)		*8*	*13.51*
TOTAL LLWW Types*			9+	1462.58

*Does not include 14 ponds that totaled 16.67 acres. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River - Amtrak Bridge to Rt. 3 subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	1453.45
	Moderate	22.34
	Total	*1475.79*
Streamflow Maintenance	High	1.63
	Moderate	3.69
	Total	*5.32*
Nutrient Transformation	High	682.09
	Moderate	4.77
	Total	*686.86*
Sediment and Other Particulate Retention	High	682.30
	Moderate	793.80
	Total	*1476.10*
Coastal Storm Surge Detention	High	1447.44
Shoreline Stabilization	High	673.36
	Moderate	--
	Total	*673.36*
Fish and Shellfish Habitat	High	1030.90
	Moderate	418.69
	Shading	1.63
	Total	*1451.22*
Waterfowl and Waterbird Habitat	High	1023.32
	Moderate	377.28
	Wood Duck	0.39
	Total	*1400.99*
Other Wildlife Habitat	High	622.59 (large complexes)
	High	3.23 (small diverse wetlands)
	Moderate	61.04
	Total	*686.86*
Conservation of Biodiversity	Meadowlands	1436.29
	Headwater wetlands	1.63
	Tidal fresh wetlands	0.39
	Total	*1438.31*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River - Amtrak Bridge to Rt. 3 subbasin.

Index	**Score**
Natural Cover Index	0.45
River/Stream Corridor Integrity Index	0.03
Wetland Buffer Integrity Index	0.04
Pond/Lake Buffer Integrity Index	0.22
Wetland Extent Index	0.16
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	1.00
Wetland Disturbance Index	0.55
Habitat Fragmentation by Road Index	0.56
Composite Index	0.15

Subbasin: Hackensack River above Tappan Bridge

Table 1. Wetlands classified by NWI types for the Hackensack River above Tappan Bridge subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	6.68
Emergent/Scrub-Shrub	4.38
(subtotal Emergent)	*11.06*
Forested, Broad-leaved Deciduous	345.59
Forested/Scrub-Shrub	12.63
(subtotal Forested)	*358.22*
Scrub-Shrub, Deciduous	0.87
Unconsolidated Bottom	27.27
Palustrine Subtotal	397.42
Riverine Wetlands	4.20
GRAND TOTAL (ALL WETLANDS)	401.62

Table 2. Wetlands in the Hackensack River above Tappan Bridge subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	3	2.09
		Throughflow (TH)	2	3.31
		(subtotal)		
	Fringe (FR)	Bidirectional (BI)	1	0.38
	(Subtotal Lentic)		*6*	*5.78*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	8	148.15
	(Subtotal Lotic River)			*148.15*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	19	107.37
	Flat (FL)	Throughflow (TH)	15	37.83
	(Subtotal Lotic Stream)		*34*	*145.20*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	12	10.73
		Outflow (OU)	6	19.78
		(subtotal)	*18*	*30.51*
	Flat (FL)	Isolated (IS)	4	3.54
		Outflow (OU)	3	6.40
		(subtotal)	*7*	*9.94*
	Slope (SL)	Isolated (IS)	1	13.80
		Outflow (OU)	5	16.76
		(subtotal)	*6*	*30.56*
	(Subtotal Terrene)		*31*	*71.01*
TOTAL LLWW Types*			79	370.14

*Does not include 33 ponds that totaled 27.26 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River above Tappan Bridge subbasin.

Function	Level	Acreage
Surface Water Detention	High	277.05
	Moderate	117.13
	Total	*394.19*
Streamflow Maintenance	High	155.33
	Moderate	195.15
	Total	*350.48*
Nutrient Transformation	High	235.35
	Moderate	134.80
	Total	*370.15*
Sediment and Other Particulate Retention	High	296.96
	Moderate	56.72
	Total	*353.68*
Shoreline Stabilization	High	299.14
	Moderate	10.27
	Total	*309.41*
Fish and Shellfish Habitat	High	0.38
	Moderate	27.45
	Shading	269.03
	Total	*296.86*
Waterfowl and Waterbird Habitat	High	2.80
	Moderate	29.88
	Wood Duck	184.66
	Total	*217.34*
Other Wildlife Habitat	High	173.79 (large complexes)
	High	90.06 (small diverse wetlands)
	Moderate	106.30
	Total	*370.15*
Conservation of Biodiversity	Headwater wetlands	147.65
	Lotic complexes	184.73
	Total	*332.38*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River above Tappan Bridge subbasin.

Index	**Score**
Natural Cover Index	0.24
River/Stream Corridor Integrity Index	0.45
Wetland Buffer Integrity Index	0.61
Pond/Lake Buffer Integrity Index	0.45
Wetland Extent Index	0.74
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.33
Channelized Stream Length Index	0.19
Wetland Disturbance Index	0.72
Habitat Fragmentation by Road Index	0.26
Composite Index	0.30

Subbasin: Hackensack River – Bellman’s Creek to Fort Lee Road

Table 1. Wetlands classified by NWI types for the Hackensack River – Bellman’s Creek to Ft. Lee Road subbasin.

NWI Wetland Type	**Acreage**
Estuarine Wetlands	
Emergent	516.01
Emergent/Scrub-Shrub	6.47
(Subtotal Emergent)	522.48
Unconsolidated Shore	129.18
Estuarine Subtotal	651.66
Palustrine Wetlands	
Emergent	10.06
Emergent/Scrub-Shrub	5.64
(subtotal Emergent)	*15.70*
Forested, Broad-leaved Deciduous	27.87
Scrub-Shrub/Emergent	2.85
Unconsolidated Bottom	9.19
Palustrine Subtotal	55.61
Riverine Wetlands	1.76
GRAND TOTAL (ALL WETLANDS)	709.03

Table 2. Wetlands in the Hackensack River – Bellman's Creek to Ft. Lee Road subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	324.30
	Basin	Bidirectional-tidal (BT)	--	351.55
	(Subtotal Estuarine)			*675.85*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	3	16.11
	Flat (FL)	Throughflow (TH)	1	0.56
	(Subtotal Lotic Stream)		*4*	*16.67*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	2	3.60
	Flat (FL)	Isolated (IS)	2	1.96
	(Subtotal Terrene)		4	5.56
TOTAL LLWW Types*			8+	698.08

*Does not include 5 ponds that totaled 9.19 acres. Number of estuarine wetlands not determined.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River – Bellman's Creek to Ft. Lee Road subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	692.05
	Moderate	15.23
	Total	*707.28*
Streamflow Maintenance	High	16.67
	Moderate	--
	Total	*16.67*
Nutrient Transformation	High	566.38
	Moderate	2.52
	Total	*568.90*
Sediment and Other Particulate Retention	High	588.44
	Moderate	116.87
	Total	*705.31*
Coastal Storm Surge Detention	High	675.86
Shoreline Stabilization	High	563.34
	Moderate	--
	Total	*563.34*
Fish and Shellfish Habitat	High	138.44
	Moderate	525.46
	Shading	6.13
	Total	*670.03*
Waterfowl and Waterbird Habitat	High	148.50
	Moderate	456.83
	Wood Duck	21.84
	Total	*627.17*
Other Wildlife Habitat	High	523.95 (large complexes)
	High	20.72 (small diverse wetlands)
	Moderate	24.22
	Total	*568.89*
Conservation of Biodiversity	Meadowlands	649.31
	Headwater wetlands	16.67
	Total	*665.98*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Hackensack River – Bellman's Creek to Ft. Lee Road subbasin.

Index	**Score**
Natural Cover Index	0.13
River/Stream Corridor Integrity Index	0.10
Wetland Buffer Integrity Index	0.07
Pond/Lake Buffer Integrity Index	0.28
Wetland Extent Index	0.45
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.88
Wetland Disturbance Index	0.72
Habitat Fragmentation by Road Index	0.77
Composite Index	0.01

Subbasin: Hackensack River below Amtrak Bridge

Table 1. Wetlands classified by NWI types for the Hackensack River below Amtrak Bridge subbasin.

NWI Wetland Type	Acreage
Estuarine Wetlands	
Emergent	562.70
Unconsolidated Shore	0.39
Estuarine Subtotal	563.09
Palustrine Wetlands	
Emergent	47.23
Emergent/Scrub-Shrub	7.08
(subtotal Emergent)	*54.31*
Forested, Broad-leaved Deciduous	0.21
Scrub-Shrub, Deciduous	0.53
Unconsolidated Bottom	32.12
Unconsolidated Shore	2.75
Palustrine Subtotal	89.92
Riverine Wetlands	0.17
GRAND TOTAL (ALL WETLANDS)	653.18

Table 2. Wetlands in the Hackensack River below Amtrak Bridge subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands*	Acreage
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	99.45
	Basin	Bidirectional-tidal (BT)	--	509.62
	(Subtotal Estuarine)			*609.07*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	7	3.47
	Flat (FL)	Isolated (IS)	3	5.60
	(Subtotal Terrene)		10	9.07
TOTAL LLWW Types*			10+	618.14

*Does not include 35 ponds that totaled 34.87 acres; estuarine wetlands are not included in the number of wetlands. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River below Amtrak Bridge subbasin.

Function	Level	Acreage
Surface Water Detention	High	626.18
	Moderate	21.17
	Total	*647.35*
Streamflow Maintenance	High	--
	Moderate	--
	Total	--
Nutrient Transformation	High	605.08
	Moderate	12.67
	Total	*617.75*
Sediment and Other Particulate Retention	High	628.54
	Moderate	21.78
	Total	*650.32*
Coastal Storm Surge Detention	High	609.07
Shoreline Stabilization	High	608.47
	Moderate	2.91
	Total	*611.38*
Fish and Shellfish Habitat	High	8.64
	Moderate	610.38
	Shading	--
	Total	*619.02*
Waterfowl and Waterbird Habitat	High	17.26
	Moderate	565.68
	Wood Duck	0.74
	Total	*583.68*
Other Wildlife Habitat	High	549.80 (large complexes)
	High	0.74 (small diverse wetlands)
	Moderate	67.60
	Total	*618.14*
Conservation of Biodiversity	Estuarine emergent (not Phragmites)	4.98
	Meadowlands	527.24
	Tidal fresh wetlands	0.74
	Total	*532.96*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River below Amtrak Bridge subbasin.

Index	**Score**
Natural Cover Index	0.16
River/Stream Corridor Integrity Index	0.10
Wetland Buffer Integrity Index	0.33
Pond/Lake Buffer Integrity Index	0.41
Wetland Extent Index	0.27
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	1.00
Wetland Disturbance Index	0.77
Habitat Fragmentation by Road Index	0.82
Composite Index	0.02

Subbasin: Hackensack River – Fort Lee to Oradell Gage

Table 1. Wetlands classified by NWI types for the Hackensack River – Ft. Lee to Oradell Gage subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	22.59
Emergent/Scrub-Shrub	17.67
Forested, Broad-leaved Deciduous	69.35
Unconsolidated Bottom	8.42
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Palustrine Subtotal	118.02
GRAND TOTAL (ALL WETLANDS)	118.02

Table 2. Wetlands in the Hackensack River – Ft. Lee to Oradell Gage subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Basin	Bidirectional-tidal (BT)	--	0.97
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	1	1.97
	Fringe (FR)	Bidirectional-tidal (BT)	23	77.83
	(Subtotal Lotic River)		*24*	*79.80*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	1	9.32
	Flat (FL)	Throughflow (TH)	2	4.14
	(Subtotal Lotic Stream)		*3*	*13.46*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	3	7.71
	Flat (FL)	Isolated (IS)	2	1.02
		Outflow (OU)	2	6.64
		(subtotal)	*4*	*7.66*
	(Subtotal Terrene)			*15.37*
TOTAL LLWW Types*			7+	109.60

*Does not include 5 ponds that totaled 8.42 acres; estuarine wetlands are not included in the number of wetlands. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River – Ft. Lee to Oradell Gage subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	90.70
	Moderate	27.32
	Total	*118.02*
Streamflow Maintenance	High	10.05
	Moderate	12.01
	Total	*22.06*
Nutrient Transformation	High	94.35
	Moderate	15.25
	Total	*109.60*
Sediment and Other Particulate Retention	High	94.84
	Moderate	15.52
	Total	*110.36*
Coastal Storm Surge Detention	High	78.8
Shoreline Stabilization	High	93.26
	Moderate	--
	Total	*93.26*
Fish and Shellfish Habitat	High	38.57
	Moderate	8.42
	Shading	49.55
	Total	*96.54*
Waterfowl and Waterbird Habitat	High	38.57
	Moderate	8.42
	Wood Duck	49.55
	Total	*96.54*
Other Wildlife Habitat	High	45.37 (small diverse wetlands)
	Moderate	64.23
	Total	*109.60*
Conservation of Biodiversity	Headwater wetlands	10.05
	Tidal fresh wetlands	77.31
	Total	*87.36*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Hackensack River – Ft. Lee to Oradell Gage subbasin.

Index	**Score**
Natural Cover Index	0.07
River/Stream Corridor Integrity Index	0.33
Wetland Buffer Integrity Index	0.11
Pond/Lake Buffer Integrity Index	0.07
Wetland Extent Index	1.00
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	1.00
Channelized Stream Length Index	0.03
Wetland Disturbance Index	0.10
Habitat Fragmentation by Road Index	0.54
Composite Index	0.13

Subbasin: Hackensack River-Nauranshaun Confluence

Table 1. Wetlands classified by NWI types for the Hackensack River-Nauranshaun Confluence subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	61.09
Emergent/Scrub-Shrub	21.26
(subtotal Emergent)	*82.35*
Forested, Broad-leaved Deciduous	361.64
Forested, Dead	80.30
Forested/Scrub-Shrub	6.05
Forested/Emergent	15.96
(subtotal Forested)	*463.95*
Scrub-Shrub, Deciduous	12.44
Scrub-Shrub/Emergent	1.14
(subtotal Scrub-Shrub)	*13.57*
Unconsolidated Bottom	36.50
Palustrine Subtotal	596.38
Riverine Wetlands	9.19
GRAND TOTAL (ALL WETLANDS)	605.57

Table 2. Wetlands in the Hackensack River-Nauranshaun Confluence subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	10	32.53
		Throughflow (TH)	4	49.53
		(subtotal)	*14*	*82.06*
	Flat (FL)	Bidirectional (BI)	3	6.01
		Throughflow (TH)	1	8.08
		(subtotal)	*4*	*14.09*
	Fringe (FR)	Bidirectional (BI)	5	54.23
		Throughflow (TH)	3	61.10
		(subtotal)	*8*	*115.33*
	(Subtotal Lentic)		*26*	*211.48*
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	5	17.05
	Fringe (FR)	Throughflow (TH)	1	6.88
	(Subtotal Lotic River)		*6*	*23.93*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	24	151.30
	Flat (FL)	Throughflow (TH)	13	50.79
	Fringe (FR)	Throughflow (TH)	1	2.15
	(Subtotal Lotic Stream)		*38*	*204.24*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	49	69.32
		Outflow (OU)	14	23.29
		(subtotal)	*63*	*92.61*
	Flat (FL)	Isolated (IS)	12	12.26
		Outflow Intermittent (OI)		
		Outflow (OU)	4	7.67
		(subtotal)	*16*	*19.93*
	Slope (SL)	Isolated (IS)	7	4.49
		Outflow (OU)	1	3.19
		(subtotal)	*8*	*7.68*
	(Subtotal Terrene)		*87*	*120.22*
TOTAL LLWW Types*			157	559.87

*Does not include 44 ponds that totaled 36.51 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River-Nauranshaun Confluence subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	405.68
	Moderate	190.30
	Total	*595.98*
Streamflow Maintenance	High	98.96
	Moderate	331.65
	Total	*430.61*
Nutrient Transformation	High	451.11
	Moderate	108.76
	Total	*559.87*
Sediment and Other Particulate Retention	High	438.56
	Moderate	134.15
	Total	*572.71*
Shoreline Stabilization	High	439.65
	Moderate	9.27
	Total	*448.92*
Fish and Shellfish Habitat	High	124.22
	Moderate	43.48
	Shading	183.24
	Total	*350.94*
Waterfowl and Waterbird Habitat	High	155.68
	Moderate	49.07
	Wood Duck	122.29
	Total	*327.04*
Other Wildlife Habitat	High	292.39 (large complexes)
	High	132.64 (small diverse wetlands)
	Moderate	134.84
	Total	*559.87*
Conservation of Biodiversity	Beaver wetlands	11.33
	Headwater wetlands	93.47
	Lentic basins/fringes	195.22
	Possible vernal pool	1.59
	Total	*301.61*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River-Nauranshaun Confluence subbasin.

Index	**Score**
Natural Cover Index	0.33
River/Stream Corridor Integrity Index	0.41
Wetland Buffer Integrity Index	0.47
Pond/Lake Buffer Integrity Index	0.56
Wetland Extent Index	0.54
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.24
Channelized Stream Length Index	0.29
Wetland Disturbance Index	0.41
Habitat Fragmentation by Road Index	0.58
Composite Index	0.31

Subbasin: Hackensack River – Oradell to Tappan Bridge

Table 1. Wetlands classified by NWI types for the Hackensack River – Oradell to Tappan Bridge subbasin.

NWI Wetland Type	**Acreage**
Palustrine Wetlands	
Emergent	9.37
Forested, Broad-leaved Deciduous	452.21
Forested/Scrub-Shrub	10.68
Forested, Deciduous and Evergreen Mixed	0.58
(subtotal Forested)	*463.47*
Scrub-Shrub, Deciduous	15.48
Scrub-Shrub/Emergent	0.51
(subtotal Scrub-Shrub)	*15.99*
Unconsolidated Bottom	21.81
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Palustrine Subtotal	510.64
Riverine Wetlands	4.40
GRAND TOTAL (ALL WETLANDS)	515.04

Table 2. Wetlands in Hackensack River – Oradell to Tappan Bridge subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	1	0.27
	Flat (FL)	Bidirectional (BI)	4	3.05
	(Subtotal Lentic)		*5*	*3.32*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	9	31.40
	(Subtotal Lotic River)		*9*	*31.40*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	15	119.62
	Flat (FL)	Throughflow (TH)	15	128.66
	(Subtotal Lotic Stream)		*30*	*248.28*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	22	40.04
		Outflow (OU)	21	34.31
		(subtotal)	*43*	*74.35*
	Flat (FL)	Isolated (IS)	10	14.48
		Outflow (OU)	6	116.88
		(subtotal)	*16*	*131.36*
	Slope (SL)	Isolated (IS)	1	0.12
	(Subtotal Terrene)		*60*	*205.81*
TOTAL LLWW Types*			104	488.81

*Does not include 28 ponds that totaled 21.81 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River – Oradell to Tappan Bridge subbasin.

Function	Level	Acreage
Surface Water Detention	High	168.23
	Moderate	277.112
	Total	*445.35*
Streamflow Maintenance	High	138.13
	Moderate	215.25
	Total	*353.38*
Nutrient Transformation	High	198.60
	Moderate	290.23
	Total	*488.83*
Sediment and Other Particulate Retention	High	202.97
	Moderate	176.89
	Total	*379.86*
Shoreline Stabilization	High	322.66
	Moderate	0.69
	Total	*324.35*
Fish and Shellfish Habitat	High	--
	Moderate	21.81
	Shading	181.07
	Total	*202.88*
Waterfowl and Waterbird Habitat	High	1.13
	Moderate	21.12
	Wood Duck	39.53
	Total	*61.78*
Other Wildlife Habitat	High	276.67 (large complexes)
	High	80.71 (small diverse wetlands)
	Moderate	131.45
	Total	*488.83*
Conservation of Biodiversity	100-acre + wetlands	10.90
	Headwater wetlands	157.85
	Lotic complexes	112.97
	Total	*281.72*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River – Oradell to Tappan Bridge subbasin.

Index	**Score**
Natural Cover Index	0.27
River/Stream Corridor Integrity Index	0.47
Wetland Buffer Integrity Index	0.50
Pond/Lake Buffer Integrity Index	0.54
Wetland Extent Index	0.73
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.06
Channelized Stream Length Index	0.24
Wetland Disturbance Index	0.63
Habitat Fragmentation by Road Index	0.31
Composite Index	0.33

Subbasin: Hackensack River – Route 3 to Bellman's Creek

Table 1. Wetlands classified by NWI types for the Hackensack River – Rt. 3 to Bellman's Creek subbasin.

NWI Wetland Type	**Acreage**
Estuarine Wetlands	
Emergent	1154.76
Unconsolidated Shore	290.83
Estuarine Subtotal	1445.59
Palustrine Wetlands	
Emergent	4.17
Forested, Broad-leaved Deciduous	3.93
Unconsolidated Bottom	1.48
Palustrine Subtotal	9.58
Riverine Wetlands	0.14
GRAND TOTAL (ALL WETLANDS)	1455.31

Table 2. Wetlands in the Hackensack River – Rt. 3 to Bellman's Creek subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	758.64
	Basin	Bidirectional-tidal (BT)	--	694.00
	Island (IL)	Bidirectional-tidal (BT)	--	1.04
	(Subtotal Estuarine)			*1453.68*
TOTAL LLWW Types*				1453.68

*Does not include 4 ponds that totaled 1.49 acres. Number of estuarine wetlands not determined.

Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hackensack River – Rt. 3 to Bellman's Creek subbasin.

Function	Level	Acreage
Surface Water Detention	High	1454.16
	Moderate	1.01
	Total	*1455.17*
Streamflow Maintenance	High	--
	Moderate	0.23
	Total	*0.23*
Nutrient Transformation	High	1162.85
	Moderate	--
	Total	*1162.85*
Sediment and Other Particulate Retention	High	1163.33
	Moderate	291.84
	Total	*1455.17*
Coastal Storm Surge Detention	High	1453.68
Shoreline Stabilization	High	1162.85
	Moderate	--
	Total	*1162.85*
Fish and Shellfish Habitat	High	376.18
	Moderate	1074.05
	Shading	--
	Total	*1450.23*
Waterfowl and Waterbird Habitat	High	376.18
	Moderate	994.60
	Wood Duck	3.93
	Total	*1374.71*
Other Wildlife Habitat	High	1117.47 (large complexes)
	Moderate	45.99
	Total	*1163.46*
Conservation of Biodiversity	Meadowlands	1417.55
	Tidal fresh wetlands	3.93
	Total	*1421.48*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Hackensack River – Rt. 3 to Bellman’s Creek subbasin.

Index	**Score**
Natural Cover Index	0.31
River/Stream Corridor Integrity Index	0.00
Wetland Buffer Integrity Index	0.21
Pond/Lake Buffer Integrity Index	0.15
Wetland Extent Index	0.40
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.00
Channelized Stream Length Index	0.00
Wetland Disturbance Index	0.69
Habitat Fragmentation by Road Index	0.91
Composite Index	0.17

Subbasin: Hirshfeld Brook

Table 1. Wetlands classified by NWI types for the Hirshfeld Brook subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	5.14
Forested, Broad-leaved Deciduous	21.13
Unconsolidated Bottom	3.72
Palustrine Subtotal	29.98
GRAND TOTAL (ALL WETLANDS)	29.98

Table 2. Wetlands in the Hirshfeld Brook subbasin classified by LLWW types.

Landscape Position	Landform	Water Flow	Number of Wetlands	Acreage
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	4	20.01
	Flat (FL)	Throughflow (TH)	3	6.25
	(Subtotal Lotic Stream)		*7*	*26.26*
TOTAL LLWW Types*			7	26.26

*Does not include 1 pond that totaled 3.72 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Hirshfeld Brook subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	23.72
	Moderate	6.25
	Total	*29.97*
Streamflow Maintenance	High	26.44
	Moderate	3.53
	Total	*29.97*
Nutrient Transformation	High	20.01
	Moderate	6.25
	Total	*26.26*
Sediment and Other Particulate Retention	High	29.98
	Moderate	--
	Total	*29.98*
Shoreline Stabilization	High	26.26
	Moderate	--
	Total	*26.26*
Fish and Shellfish Habitat	High	--
	Moderate	3.72
	Shading	21.01
	Total	*24.73*
Waterfowl and Waterbird Habitat	High	3.53
	Moderate	3.72
	Wood Duck	14.76
	Total	*22.01*
Other Wildlife Habitat	High	14.87 (small diverse wetlands)
	Moderate	11.39
	Total	*26.26*
Conservation of Biodiversity	Headwater wetlands	22.73

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Hirshfeld Brook subbasin.

Index	Score
Natural Cover Index	0.04
River/Stream Corridor Integrity Index	0.12
Wetland Buffer Integrity Index	0.11
Pond/Lake Buffer Integrity Index	0.08
Wetland Extent Index	0.73
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.03
Channelized Stream Length Index	0.36
Wetland Disturbance Index	0.12
Habitat Fragmentation by Road Index	0.54
Composite Index	0.12

Subbasin: Overpeck Creek

Table 1. Wetlands classified by NWI types for the Overpeck Creek subbasin.

NWI Wetland Type	Acreage
Estuarine Wetlands	
Emergent	148.64
Unconsolidated Shore	13.98
--	----------
Estuarine Subtotal	162.63
Palustrine Wetlands	
Emergent	8.29
Emergent/Scrub-Shrub	0.37
(subtotal Emergent)	*8.67*
Forested, Broad-leaved Deciduous	102.45
Scrub-Shrub, Deciduous	9.07
Unconsolidated Bottom	29.30
--	------------
Palustrine Subtotal	149.49
Riverine Wetlands	7.99
GRAND TOTAL (ALL WETLANDS)	320.11

Table 2. Wetlands in the Overpeck Creek subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands***	**Acreage**
Estuarine (ES)	Fringe	Bidirectional-tidal (BT)	--	22.32
	Basin	Bidirectional-tidal (BT)	--	146.51
	(Subtotal Estuarine)			*168.83*
Lentic (LE)	Flat (FL)	Bidirectional (BI)	1	1.25
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	1	0.47
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	5	28.36
	Flat (FL)	Throughflow (TH)	8	53.68
	(Subtotal Lotic Stream)		*13*	*82.04*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	5	3.11
		Outflow (OU)	5	22.20
		(subtotal)		*25.31*
	Flat (FL)	Outflow (OU)	4	4.91
	(Subtotal Terrene)		*14*	*30.22*
TOTAL LLWW Types*			29+	282.81

*Does not include 16 ponds that totaled 29.30 acres; estuarine wetlands are not included in the number of wetlands. Number of estuarine wetlands not determined.

<u>Note</u>: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Overpeck Creek subbasin.

Function	Level	Acreage
Surface Water Detention	High	210.43
	Moderate	101.51
	Total	*311.94*
Streamflow Maintenance	High	52.57
	Moderate	60.06
	Total	*112.63*
Nutrient Transformation	High	208.51
	Moderate	60.31
	Total	*268.82*
Sediment and Other Particulate Retention	High	250.40
	Moderate	56.63
	Total	*307.03*
Coastal Storm Surge Detention	High	168.83
Shoreline Stabilization	High	237.29
	Moderate	--
	Total	*237.29*
Fish and Shellfish Habitat	High	15.88
	Moderate	164.36
	Shading	68.80
	Total	*249.04*
Waterfowl and Waterbird Habitat	High	16.31
	Moderate	80.12
	Wood Duck	25.04
	Total	*121.47*
Other Wildlife Habitat	High	90.98 (large complexes)
	High	40.48 (small diverse wetlands)
	Moderate	137.37
	Total	*268.83*
Conservation of Biodiversity	Estuarine emergent (not Phragmites)	0.15
	Meadowlands	69.96
	Headwater wetlands	63.74
	Tidal fresh wetlands	1.32
	Total	*135.17*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Overpeck Creek subbasin.

Index	Score
Natural Cover Index	0.12
River/Stream Corridor Integrity Index	0.22
Wetland Buffer Integrity Index	0.34
Pond/Lake Buffer Integrity Index	0.27
Wetland Extent Index	0.36
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.09
Channelized Stream Length Index	0.56
Wetland Disturbance Index	0.36
Habitat Fragmentation by Road Index	0.69
Composite Index	0.11

Subbasin: Pascack Brook above Westwood Gage

Table 1. Wetlands classified by NWI types for the Pascack Brook above Westwood Gage subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	2.38
Forested, Broad-leaved Deciduous	259.54
Forested/Scrub-Shrub	6.92
Forested, Deciduous and Evergreen Mixed	2.03
(subtotal Forested)	*268.49*
Scrub-Shrub, Deciduous	4.18
Scrub-Shrub/Emergent	0.93
Scrub-Shrub/Forested	1.36
(subtotal Scrub-Shrub)	*6.47*
Unconsolidated Bottom	24.40
--	------------
Palustrine Subtotal	301.74
Riverine Wetlands	2.50
GRAND TOTAL (ALL WETLANDS)	304.24

Table 2. Wetlands in the Pascack Brook above Westwood Gage subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Bidirectional (BI)	2	10.11
		Throughflow (TH)	2	3.92
		(subtotal)		*14.03*
	Flat (FL)	Bidirectional (BI)	3	13.53
	(Subtotal Lentic)		*7*	*27.56*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	18	36.73
	(Subtotal Lotic River)		*18*	*36.73*
Lotic Stream (LS)				
	Basin (BA)	Throughflow (TH)	1	110.24
	Flat (FL)	Throughflow (TH)	10	19.69
	Fringe (FR)	Throughflow (TH)	1	2.75
	(Subtotal Lotic Stream)		*12*	*132.68*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	13	21.04
		Outflow (OU)	9	26.17
		(subtotal)	*22*	*47.21*
	Flat (FL)	Isolated (IS)	2	12.37
		Outflow (OU)	2	1.67
		(subtotal)	*4*	*14.04*
	Slope (SL)	Isolated (IS)	16	15.69
		Outflow (OU)	3	3.44
		(subtotal)	*19*	*19.13*
	(Subtotal Terrene)		*45*	*80.38*
TOTAL LLWW Types*			82	277.35

*Does not include 30 ponds that totaled 24.40 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Pascack Brook above Westwood Gage subbasin.

Function	Level	Acreage
Surface Water Detention	High	194.26
	Moderate	103.89
	Total	*298.15*
Streamflow Maintenance	High	133.47
	Moderate	107.52
	Total	*240.99*
Nutrient Transformation	High	198.22
	Moderate	79.13
	Total	*277.35*
Sediment and Other Particulate Retention	High	194.34
	Moderate	70.64
	Total	*264.98*
Shoreline Stabilization	High	196.97
	Moderate	--
	Total	*196.97*
Fish and Shellfish Habitat	High	--
	Moderate	24.40
	Shading	107.18
	Total	*131.58*
Waterfowl and Waterbird Habitat	High	3.39
	Moderate	24.40
	Wood Duck	79.07
	Total	*106.86*
Other Wildlife Habitat	High	33.01 (large complexes)
	High	82.30 (small diverse wetlands)
	Moderate	162.25
	Total	*277.56*
Conservation of Biodiversity	Beaver wetlands	2.75
	Headwater wetlands	131.07
	Possible vernal pool	0.55
	Total	*134.37*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Pascack Brook above Westwood Gage subbasin.

Index	**Score**
Natural Cover Index	0.23
River/Stream Corridor Integrity Index	0.41
Wetland Buffer Integrity Index	0.26
Pond/Lake Buffer Integrity Index	0.39
Wetland Extent Index	0.59
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.09
Channelized Stream Length Index	0.09
Wetland Disturbance Index	0.41
Habitat Fragmentation by Road Index	0.41
Composite Index	0.27

Subbasin: Pascack Brook below Westwood Gage

Table 1. Wetlands classified by NWI types for the Pascack Brook below Westwood Gage subbasin.

NWI Wetland Type	**Acreage**
Palustrine Wetlands	
Emergent	32.45
Emergent/Scrub-Shrub	1.60
(subtotal Emergent)	*34.05*
Forested, Broad-leaved Deciduous	275.19
Forested/Scrub-Shrub	2.35
Forested/Emergent	1.68
(subtotal Forested)	*279.22*
Scrub-Shrub, Deciduous	1.43
Scrub-Shrub/Emergent	6.29
(subtotal Scrub-Shrub)	*7.72*
Unconsolidated Bottom	16.56
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Palustrine Subtotal	337.55
Riverine Wetlands	1.70
GRAND TOTAL (ALL WETLANDS)	339.25

Table 2. Wetlands in the Pascack Brook below Westwood Gage subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)	Basin (BA)	Throughflow (TH)	5	14.23
	Flat (FL)	Bidirectional (BI)	4	27.52
	(Subtotal Lentic)		*9*	*41.75*
Lotic River (LR)				
	Floodplain (FP)	Throughflow (TH)	49	129.64
Lotic Stream (LS)	Basin (BA)	Throughflow (TH)	18	114.58
	Flat (FL)	Throughflow (TH)	5	8.80
	(Subtotal Lotic Stream)		*23*	*123.38*
Terrene (TE)				
	Basin (BA)	Isolated (IS)	7	11.27
		Outflow (OU)	2	2.79
		(subtotal)	*9*	*14.06*
	Flat (FL)	Isolated (IS)	1	2.05
	Slope (SL)	Isolated (IS)	4	6.48
		Outflow (OU)	1	3.63
		(subtotal)	*5*	*10.11*
	(Subtotal Terrene)		*15*	*26.22*
TOTAL LLWW Types*			96	320.99

*Does not include 16 ponds that totaled 16.56 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Pascack Brook below Westwood Gage subbasin.

Function	Level	Acreage
Surface Water Detention	High	292.56
	Moderate	45.00
	Total	*337.56*
Streamflow Maintenance	High	118.83
	Moderate	185.47
	Total	*304.30*
Nutrient Transformation	High	237.50
	Moderate	83.50
	Total	*321.00*
Sediment and Other Particulate Retention	High	266.72
	Moderate	58.68
	Total	*325.40*
Shoreline Stabilization	High	292.53
	Moderate	--
	Total	*292.53*
Fish and Shellfish Habitat	High	--
	Moderate	19.44
	Shading	207.46
	Total	*226.90*
Waterfowl and Waterbird Habitat	High	26.18
	Moderate	19.44
	Wood Duck	168.57
	Total	*214.19*
Other Wildlife Habitat	High	182.23 (large complexes)
	High	93.45 (small diverse wetlands)
	Moderate	45.32
	Total	*321.00*
Conservation of Biodiversity	Headwater wetlands	34.97
	Lentic basins/fringes	14.23
	Lotic complexes	230.12
	Total	*279.32*

Table 4. Remotely-sensed indices of “natural habitat integrity” for the Pascack Brook below Westwood Gage subbasin.

Index	**Score**
Natural Cover Index	0.16
River/Stream Corridor Integrity Index	0.35
Wetland Buffer Integrity Index	0.19
Pond/Lake Buffer Integrity Index	0.27
Wetland Extent Index	0.84
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.05
Channelized Stream Length Index	0.45
Wetland Disturbance Index	0.18
Habitat Fragmentation by Road Index	0.36
Composite Index	0.24

Subbasin: Tenakill Brook

Table 1. Wetlands classified by NWI types for the Tenakill Brook subbasin.

NWI Wetland Type	Acreage
Palustrine Wetlands	
Emergent	0.31
Forested, Broad-leaved Deciduous	160.92
Scrub-Shrub, Deciduous	7.03
Scrub-Shrub/Emergent	16.44
Scrub-Shrub/Forested	2.15
(subtotal Scrub-Shrub)	*25.62*
Unconsolidated Bottom	15.40
Palustrine Subtotal	202.26
Riverine Wetlands	8.18
GRAND TOTAL (ALL WETLANDS)	210.44

Table 2. Wetlands in the Tenakill Brook subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lentic (LE)				
	Basin (BA)	Throughflow (TH)	1	9.55
	Flat (FL)	Throughflow (TH)	3	19.06
	(Subtotal Lentic)		*4*	*28.61*
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	6	11.60
Lotic Stream (LS)	Basin (BA)	Throughflow (TH)	6	11.21
	Flat (FL)	Throughflow (TH)	7	91.53
	(Subtotal Lotic Stream)		*13*	*102.74*
Terrene (TE)	Basin (BA)	Isolated (IS)	4	6.10
		Outflow (OU)	2	4.07
		(subtotal)	*6*	*10.17*
	Flat (FL)	Isolated (IS)	3	5.92
		Outflow (OU)	3	26.78
		(subtotal)	*6*	*32.70*
	Slope (SL)	Outflow (OU)	1	1.05
	(Subtotal Terrene)		*13*	*43.92*
TOTAL LLWW Types*			36	186.87

*Does not include 17 ponds that totaled 15.40 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Tenakill Brook subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	56.78
	Moderate	120.98
	Total	*177.76*
Streamflow Maintenance	High	43.73
	Moderate	133.45
	Total	*177.18*
Nutrient Transformation	High	38.60
	Moderate	148.26
	Total	*186.86*
Sediment and Other Particulate Retention	High	112.48
	Moderate	56.03
	Total	*168.51*
Shoreline Stabilization	High	142.94
	Moderate	--
	Total	*142.94*
Fish and Shellfish Habitat	High	--
	Moderate	15.40
	Shading	90.44
	Total	*105.84*
Waterfowl and Waterbird Habitat	High	2.03
	Moderate	14.91
	Wood Duck	11.76
	Total	*28.70*
Other Wildlife Habitat	High	122.97 (large complexes)
	High	6.72 (small diverse wetlands)
	Moderate	57.17
	Total	*186.86*
Conservation of Biodiversity	100-acre + wetlands	28.61
	Headwater wetlands	32.51
	Lotic complexes	65.79
	Total	*126.91*

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Tenakill Brook subbasin.

Index	**Score**
Natural Cover Index	0.15
River/Stream Corridor Integrity Index	0.27
Wetland Buffer Integrity Index	0.29
Pond/Lake Buffer Integrity Index	0.33
Wetland Extent Index	0.99
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.01
Channelized Stream Length Index	0.43
Wetland Disturbance Index	0.45
Habitat Fragmentation by Road Index	0.38
Composite Index	0.23

Subbasin: Upper Pascack Brook

Table 1. Wetlands classified by NWI types for the Upper Pascack Brook subbasin.

NWI Wetland Type	**Acreage**
Palustrine Wetlands	
Emergent	5.08
Emergent/Scrub-Shrub	28.60
(subtotal Emergent)	*33.68*
Forested, Broad-leaved Deciduous	33.25
Scrub-Shrub, Deciduous	3.86
Unconsolidated Bottom	25.60
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Palustrine Subtotal	96.39
Riverine Wetlands	0.95
GRAND TOTAL (ALL WETLANDS)	97.34

Table 2. Wetlands in the Upper Pascack Brook subbasin classified by LLWW types.

Landscape Position	**Landform**	**Water Flow**	**Number of Wetlands**	**Acreage**
Lotic River (LR)	Floodplain (FP)	Throughflow (TH)	2	0.60
Lotic Stream (LS)	Basin (BA)	Throughflow (TH)	1	1.34
Terrene (TE)				
	Basin (BA)	Isolated (IS)	16	27.14
		Outflow (OU)	3	29.65
		(subtotal)	*19*	*56.79*
	Flat (FL)	Isolated (IS)	6	4.37
		Outflow (OU)	1	7.69
		(subtotal)	*7*	*12.06*
	(Subtotal Terrene)		*26*	*68.85*
TOTAL LLWW Types*			29	70.79

*Does not include 9 ponds that totaled 15.53 acres.
Note: Subtotals may be slightly different than the sum of acreages shown due to computer round-off procedures.

Table 3. Predicted wetland functions for the Upper Pascack Brook subbasin.

Function	**Level**	**Acreage**
Surface Water Detention	High	7.32
	Moderate	78.99
	Total	*86.31*
Streamflow Maintenance	High	50.96
	Moderate	14.06
	Total	*65.02*
Nutrient Transformation	High	58.73
	Moderate	12.06
	Total	*70.79*
Sediment and Other Particulate Retention	High	7.32
	Moderate	66.93
	Total	*74.25*
Shoreline Stabilization	High	1.94
	Moderate	0.20
	Total	*2.14*
Fish and Shellfish Habitat	High	--
	Moderate	15.52
	Shading	--
	Total	*15.52*
Waterfowl and Waterbird Habitat	High	34.84
	Moderate	15.52
	Wood Duck	--
	Total	*50.36*
Other Wildlife Habitat	High	28.60 (large complexes)
	High	25.54 (small diverse wetlands)
	Moderate	16.65
	Total	*70.79*
Conservation of Biodiversity	Headwater wetlands	30.26

Table 4. Remotely-sensed indices of "natural habitat integrity" for the Upper Pascack Brook subbasin.

Index	Score
Natural Cover Index	0.20
River/Stream Corridor Integrity Index	0.08
Wetland Buffer Integrity Index	0.49
Pond/Lake Buffer Integrity Index	0.36
Wetland Extent Index	0.24
Standing Waterbody Extent Index	1.00
Dammed Stream Flowage Index	0.08
Channelized Stream Length Index	0.67
Wetland Disturbance Index	0.34
Habitat Fragmentation by Road Index	0.40
Composite Index	0.17