INVENTORY, CLASSIFICATION, AND DESCRIPTION OF RIPARIAN NATURAL COMMUNITY REFERENCE TYPES FOR WEST KILL WATERSHED, NEW YORK

REVISED FINAL TECHNICAL REPORT NOVEMBER 2009

Prepared for
Greene County Soil and Water Conservation District and
NYC DEP Stream Management Program

New York Natural Heritage Program

A Partnership between The Nature Conservancy and the NYS Department of Environmental Conservation

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Cover photo: Cobble Shore Community *Carex torta - Apocynum cannabinum - Cyperus* spp. herbaceous vegetation (CEGL006536) (Plot WK19A) along West Kill main stem

Photograph by: Frederick C. Sechler, NYNHP

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The New York Natural Heritage Program is a partnership between NYS Department of Environmental Conservation and The Nature Conservancy. The program's mission is to facilitate the conservation of New York's biodiversity by providing comprehensive information and scientific expertise on rare species and natural ecosystems to resource managers and other conservation partners.

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EXECUTIVE SUMMARY

The New York Natural Heritage Program, in partnership with New York City Department of Environmental Protection and the Greene County Soil and Water Conservation District, conducted natural community inventories and ecological quality rank assessments along the West Kill main stem in the Catskill Mountains with the goal of classifying, mapping, and describing a set of reference riparian habitat types within the West Kill Watershed. These reference community descriptions will then be used to guide stream corridor restoration projects within the watershed.

In summary, 76 plots and observation points were sampled across approximately 16 natural community types, including plots from the following natural communities: beech-maple mesic forest, hemlock-northern hardwood forest, pine-northern hardwood forest, floodplain forest, cobble shore, shallow emergent marsh, shrub swamp, maple-basswood rich mesic forest/calcareous talus slope woodland, and vernal pool. Successional communities found along the West Kill main stem include successional northern hardwoods/pine plantation, successional southern hardwoods, successional old field, and successional red cedar woodland.

A cluster analysis was performed using 67 plots, excluding those from successional communities and vernal pools. In addition, an ecological indicator analysis was conducted between beech-maple mesic forest and floodplain forest to determine if certain species were good indicators of each of these community types.

The approximate 9-mile stretch of riparian habitat along the West Kill main stem offered opportunities for good reference "expressions" of many of the major natural riparian community types encountered. Beech-maple mesic forests and hemlock-northern hardwood/pine-northern hardwood forests all contain excellent "expressions" and several plots could be used as "references" for those types. Floodplain forests were small in size, were in poorer landscape condition, and contained some exotic species, but several plots could still qualify as excellent "expressions" and could be used as "references" for this natural community. Shrub swamps, cobble shores, and shallow emergent marshes all contained abundant exotic plants that lowered their Plot Quality Rank System (PQRS) and Plant Stewardship Index (PSI) scores. Shrub swamps, however, were in good landscape position, and at least one plot may be used as a "reference" for this natural community type. Cobble shores were very common along the West Kill, but were generally small and contained abundant exotic plants. However, at least one plot may be a fair example of a "reference" for this natural community. Shallow emergent marshes, on the other hand, were rarely encountered along the West Kill, and the examples were small and contained exotic plants. We do not recommend that these examples be used as "references" for this natural community type.

ACKNOWLEDGEMENTS

We thank the following people for their time and assistance with this project. Mark Vian and Jenn Grieser with NYC DEP, and Abbe Martin of GCSWC provided invaluable expertise on logistics, access, and local information for the West Kill main stem, and provided incredible edits to all documents.

Timothy Howard, Greg Edinger (NY Natural Heritage), and Mark Vian (NYC DEP) initiated this fruitful collaboration between NY Natural Heritage and NYC DEP/GCSWC. Greg Edinger, DJ Evans and Shereen Brock provided valuable comments and edits in reviewing the document.

Introduction

A riparian area is defined as the transitional zone between a river or stream and the adjoining terrestrial upland ecosystem, including both the stream channel itself and the surrounding land that is influenced by fluctuating water levels (Colwell & Hix 2008). These areas support high biodiversity, provide water quality protection, naturally control floods, stabilize stream banks, provide wildlife habitat, and allow for direct human benefits such as recreation and aesthetics (Rheinhardt *et al.* 2007). Riparian ecosystems provide important ecological services, but they are among the most threatened ecosystems in the world (Colwell & Hix 2008).

Riparian areas are highly interconnected ecosystems such that stresses or alterations occurring in one part of a stream network affect other parts of the network (Rheinhardt *et al.* 2007). Thus, it is important to include all riparian ecosystems in the network in assessments, from intermittent headwater reaches to perennial mainstem reaches. Headwater riparian ecosystems can include both channels and adjacent riparian areas, which collectively constitute an interconnected ecological unit. Therefore, both narrow floodplain wetlands and adjacent non-wetlands (uplands) are critical components of stream ecosystems. Stresses such as excessive clearing or removal of vegetation in the adjacent upland will directly affect the main stem of the riparian zone (Rheinhardt *et al.* 2007).

In 1996, the West Kill Watershed experienced catastrophic floods that caused severe bank erosion and instability, and rapidly increased turbidity within the watershed, prompting landowners, fishing anglers, and resource agencies to act (Greene County Soil and Water Conservation District Stewardship Program 2005). The agencies determined that the West Kill Watershed had an insufficient riparian buffer to protect from such floods. Subsequently, an action plan was generated to identify these insufficiencies. The Greene County Soil and Water Conservation District (GCSWCD), in partnership with the New York City Department of Environmental Protection Stream Management Program (NYCDEP-SMP), completed a comprehensive stream management plan for the West Kill Watershed in 2002. One major goal of the management plan included creating recovery plans for multiple management units along the West Kill main stem in cooperation with streamside landowners. One portion of the plan was to document current conditions and to outline a plan that would protect and enhance the integrity of the stream and floodplain ecosystems. The problem areas along the West Kill that contribute most to the erosion and instability of the riparian zone were identified, and the stewardship program developed goals to restore the ecological integrity of these locations (Greene County Soil and Water Conservation District Stewardship Program 2005).

A vegetation mapping project was also initiated to provide the planning team a baseline document about riparian natural communities within the watershed. This included a description of the condition of the vegetation in the riparian area and recommendations related to the management of riparian vegetation along the stream (Greene County Soil and Water Conservation District Stewardship Program 2005). Although forested land covers a large portion of the watershed's riparian area, those areas under herbaceous cover offer poor stream bank protection. While herbaceous cover ranks better than no cover at all, it is better to contain plants with a variety of rooting depths (herbs, shrubs, and trees) provide more extensive stream bank protection. Approximately 136 acres, or 18% of the land cover is considered to have inadequate vegetative cover; this includes areas of herbaceous vegetation, cobble and cobble/herbaceous areas, and exposed banks (Greene County Soil and Water Conservation District Stewardship Program 2005). The amount of streamside area with inadequate vegetation cover based on the results of this vegetation mapping project provided a need for a streamside planting program.

Reference sites can be defined as natural communities meeting criteria such as "natural" species composition, landscape quality, and chemical, physical, and biological characteristics (Whittier *et al.* 2007). Metrics and indices are developed from those characteristics and are used as a basis against which other sites over large areas can be compared to evaluate their ecological condition. Ideally, reference sites should have minimal evidence of human disturbance. However, such sites do not always exist because of widespread, long-term human use of the land. In those regions, the best sites can only be considered least disturbed (Whittier *et al.* 2007).

Known relationships between biota and physical parameters can be used as a reference for refining objectives and the methods adopted to achieve them.A "reference" can be expressed as specific natural community species composition and associated abiotic data in areas where conditions are favorable for a specific natural community type. Determining what successional stage to restore to is challenging, especially if land-use has been historically intense in the area. Capturing of abiotic data such as soil characteristics, slope, aspect, and hydrologic regime, is important along with species composition in order to provide scientific clues to what natural community type a specific area naturally supports.

In the spring of 2008, the NY Natural Heritage Program (NYNHP) was contracted by the GCSWCD and NYCDEP-SMP to inventory, classify, and describe a set of riparian natural community reference types for the West Kill Watershed. We used our field data to classify and then describe a local 'West Kill' expression of each of the major natural riparian community types encountered. NYNHP provided final descriptions and locations within the watershed where the best examples of each community type may be found. Descriptions included lists of common plant species and their relative abundance, a complete list of plant species found in each community type, characteristic and indicator species, and other physical characteristics for the community. Most importantly, reference community descriptions included recommendations for restoration and management, such as the most appropriate species to plant and the most appropriate mix of size classes to strive for when restoring each community type. These reference community descriptions can then be used as a guide for stream corridor revegetation projects within the watershed.

Methods

Study area description

The West Kill Watershed is located in Greene County within the town of Lexington in the northeastern portion of Catskill Park (Figure 1). This watershed is located in the High Allegheny Plateau ecoregion (Bailey 1997). The West Kill main stem originates in the Spruceton Hollow area of the town of Lexington, and stretches 9.5 miles to its confluence with the Schoharie Creek, just west of the hamlet of Lexington (Greene County Soil and Water Conservation District Stewardship Program 2005). Evergreen, Rusk, WestKill, Balsam, Mt. Sherrill, and North Dome mountains ring the upper watershed. The lower portion of the watershed is bound by the east slopes of Halcott, Vinegar Hill, and Vly Mountains. The headwaters of this watershed are located on the northernmost peaks and highest elevations in the Catskill chain. The total watershed area is 31.2 square miles, with an average watershed slope of nearly 29%, the highest of any Schoharie tributary (Greene County Soil and Water Conservation District Stewardship Program 2005) (Figure 2).

Topography and Geology of West Kill Watershed

The bedrock geology consists mainly of Walton Formations that comprise sandstones, shales, and mudstones. These formations comprise most of the West Kill Watershed bedrock from the valley floor to the mountain top (Greene County Soil and Water Conservation District Stewardship Program 2005). The Oneonta Formation forms the valley floor within the lower half of the watershed. This rock sequence consists of alternating layers of red shales and mudstones, gray sandstones, and small amounts of gray shale.

The West Kill valley's complex glacial history is reflected by the variable character of the West Kill valley streams (Greene County Soil and Water Conservation District Stewardship Program 2005). This glacially modified landscape with its varying deposits of clay-rich or bouldery till and silts, sands, gravels, and cobbles of meltwater streams and ice-contract deposits can be tracked in the significant variation of floodplain topography, sediment supply, channel boundary resistance, and rate of vegetative recovery of streambanks and hillslopes following catastrophic disturbances. In this way the size, shape, and bed form of the stream channel is influenced to a large extent by the glacially and post-glacially deposited soils through which the stream runs (as well as in the adjacent hilltops) (Greene County Soil and Water Conservation District Stewardship Program 2005).

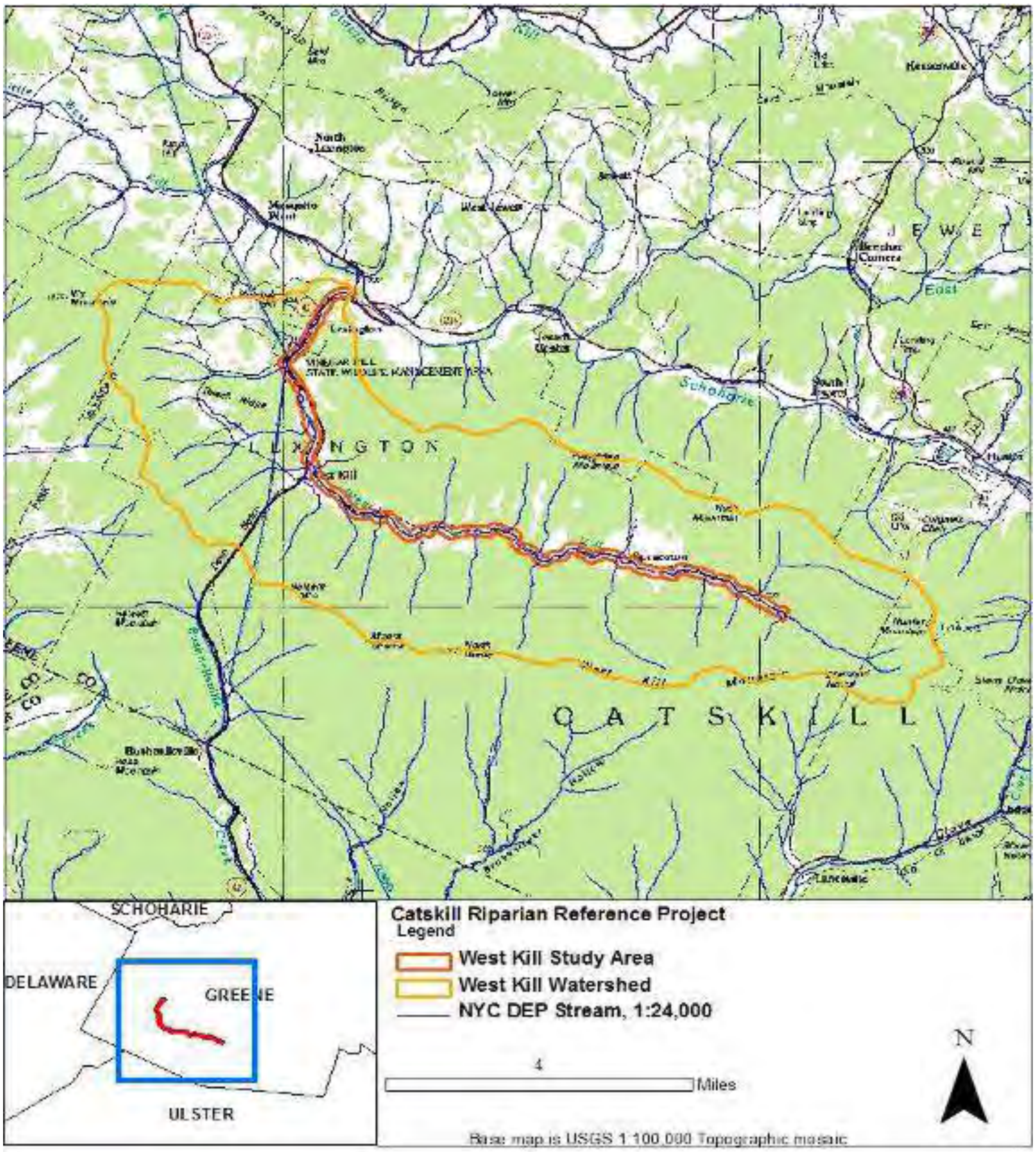

Figure 1. West Kill Valley Study Area

Field methodology

All preliminary NY Natural Communities (Edinger *et al.* 2002) identified during preliminary work were sampled using standardized releve plot collection techniques. Our goal was 3-5 plots per type. Each plot within these vegetation types was randomly located within each targeted community delineation (e.g., polygon) using a variety of methods. All vegetation plot sampling followed the USGS/NPS Vegetation Mapping Program protocols (The Nature Conservancy & Environmental Systems Research Institute 1994a). Within each polygon selected for sampling, a plot was established in an area that most represents the existing vegetation association (Mueller-Dumbois 1974). All vegetation data were collected following NatureServe's accepted natural heritage sampling protocols (The Nature Conservancy & Environmental Systems Research Institute 1994b,The Nature Conservancy & Environmental Systems Research Institute 1994c, Edinger *et al.* 2000), with 20 m × 20 m plots in forests and woodlands, and 10 m × 10 m plots in shrublands and herbaceous vegetation. The vegetation was visually divided into eight strata: emergent trees (variable height), tree canopy (variable height), tree subcanopy (>5 m), tall shrub (2–5 m), short shrub (<2 m), herbaceous, non-vascular, and vines. Specimens of species that were not identifiable in the field were collected for later identification. The diameter at breast height (1.3 m) was measured with a Biltmore stick for all trees larger than 10 cm in diameter that were rooted in the plot. The diameters were recorded according to species and strata.

In addition to floristic information, we also recorded the following environmental variables at each plot: slope, aspect, topographic position, hydrologic regime, soil stoniness or coarseness, average soil texture, and soil drainage. Any unvegetated area of the plot was characterized by the exposed substrate. Notes were taken on the plot representativeness of the surrounding vegetation and any other significant environmental information, such as landscape context, herbivory, stand health, recent disturbance, or evidence of historic disturbance. Plot data and reference observation point data were collected digitally in the field using an iPAQ hand-held computer with software (Hand-Held Database – HHDB) and imported to the Field Form Database (FFDB) developed by NY Natural Heritage. Prior to the development of the HHDB and FFDB plot data were collected on paper forms. A sample plot form and screen shots from the HHDB used for this project are included in Appendix 2.

We collected a digital photograph at most of the plot sampling locations and recorded the location of each plot with a Garmin 60CX GPS unit. The datum on the GPS unit was set to North American 1983 (Conus) and the coordinate system was set to Universal Trans-Mercator (UTM) zone 18.

Plot sampling was conducted by Bud Sechler of NY Natural Heritage from May 29 to September 13, 2008. In total, we sampled 73 plots and 3 observation points throughout the West Kill riparian area. We completed 20 days of fieldwork for this project between the months of June and September. This time period generally captured the highest species richness within each natural community. Using aerial photography and an existing vegetation map provided by GCSWCS, our preliminary mapping of NYNHP ecological communities resulted in 16 community types. Based on an average of three plot collections per day, we expected to sample about 60 plots, resulting in about three to five plots for each natural community type. We assumed that cultural or highly disturbed communities do not need to be sampled and that natural community types occupying less than 3 polygons would have one plot placed in each polygon.

Plot Quality Ranking System

During and following field surveys and preliminary classification of the data, we ranked each plot and observation point based on several biotic, abiotic, and landscape variables. We used this ranking system for both forests and non-forests and included factors that would be used to determine the overall "quality" of the plot (NatureServe 2006, Colwell & Hix 2008, Tierney *et al.* 2006, Tierney *et al.* 2008). Table 1 describes each factor used for this Plot Quality Rank System Analysis. We evaluated forested plots with two additional factors. See Appendix 4 for detailed descriptions for each plot quality rank factor. The assessment of each factor occurred either in the field or remotely using aerial photography and other GIS layers.

Table 1: Plot Quality Rank System Factors (additional details in **Appendix 4**)

Factor	**Type**	**Application to Forest/Nonforest**	**Field/Remote**
Disturbances present in plot and within 50 meters of plot location	Abiotic Factors	Forest/Non-forest	Field and Remote
Hydrology regime within plot and surrounding natural community	Abiotic factors	Forested Wetlands/Non-forested Wetlands	Field
Distance of plot to the edge of non-natural habitat (Adjacent land use)	Landscape factors	Forest/Non-forest	Remote
Percentage of natural habitat within 1 km radius circle of plot location	Landscape factors	Forest/Non-forest	Remote using 2001 National Land Cover data (NLCD) (**Appendix 4**)
Distance to nearest paved road	Landscape factors	Forest/Non-forest	Remote
Percent cover of native plant species	Biotic factors	Forest/Non-forest	Field and remote
Species Condition within plot location	Biotic factors	Forest/Non-forest	Field
Size of natural community where plot is located	Size factor	Forest/Non-factor	Remote
Size structure of forest	Biotic factor	Forested plots only	Remote calculations based on field measurements
Amount of coarse woody debris within plot	Biotic factor	Forested plots only	Field measurements

Plant Stewardship Index

The Plant Stewardship Index (PSI) is a tool developed by Bowman's Hill Wildflower Preserve for conducting an ecological assessment of particular sites and is designed to answer questions regarding 1) the overall naturalness of the site, and 2) how land management practices or absences have affected the naturalness of the site (Bowman's Hill Wildflower Preserve 2006) (See Appendix 6). This index is based on the observation that some plants may act as generalists and can grow within a wide variety of different habitats and withstand a wide range of conditions. These plants are given a low coefficient of conservation. In contrast, plant species that live within a very specific set of habitat conditions and a low disturbance regime are given a high coefficient of conservation (Bowman's Hill Wildflower Preserve 2006). The Plant Stewardship Index summarizes all coefficient conservation values for all plant species at a given site (see Appendix 6).

We calculated PSIs for all plots conducted along the West Kill riparian area (Appendix 6). However, several caveats were encountered while using this Plant Stewardship Index. First, this index was developed in the Piedmont region of Pennsylvania and in New Jersey. The plants found in Pennsylvania and New Jersey may have different habitat specifications compared to New York. For example, yellow birch (*Betula alleghaniensis*) occupies only ravines, basin swamps, and riparian areas in the piedmont of Pennsylvania and in northern New Jersey, but occurs as a component of a beech-maple mesic forest in certain ecoregions in New York. The final PSI of a plot in New York may be skewed based on these coefficients of certain plant species. However, using this index still provides a consistent analysis of floral composition. Other caveats of this index include 1) the abundance of species within a measured plot are not taken into consideration, which loses quantitative species composition and quality, 2) the original coefficient of conservation for each species is a subjective assignment based on expert knowledge for the New Jersey/Pennsylvania region, and 3) species diversity appears to be weighted, indicating a plot that is high quality with low plant species diversity will score lower than a high quality, high diversity plot.

Statistical analysis

We performed a cluster analysis of 67 plots in PC-ORD 5.10 with the goal of clustering plots that contained similar vegetation from the tree, shrub, and herbaceous layers (McCune 2007, Figure 3). This is consistent with other studies that attempt to illustrate the application of cluster analysis to determine reference communities for landforms within a stream corridor (Harris 1999). The purpose of cluster analysis is to define groups based on their similarities. Omitted plots for analysis purposes included all cultural communities and specific natural communities successional southern hardwoods, successional old fields (references only), vernal pool (references only), successional red cedar woodland, and spruce/fir plantations. These types were omitted due to either low frequency and/or being classified as cultural community types. For data consistency purposes, and to negate outlying species within each plot, all species in each strata (T2 and T3 canopy layers, S1 and S2 shrub layers, vine, herbaceous and non-vascular plants) occurring in less than 2 percent of the total layer were deleted.

We used ecological indicator analysis to further explore the relationships between beech-maple mesic forest and floodplain forest community types. Our goal was to separate out vegetation differences and to look for indicators for each natural community type (McCune 2007). The indicator values ranged from zero (no indication) to 100 (perfect indication). Perfect indication means that presence of a species points to a particular group without error, at least within the data set in hand (McCune 2007).

Based on the cluster analysis results, assigned groups used for the ecological indicator analysis did not differentiate floodplain forests and beech-maple mesic forests. Consequently, the results would show species that are indicative of a certain group, but the groups would contain plots labeled beech-maple mesic and floodplain forests. Therefore, we created new groups to the data analysis within PC-ORD, and assigned group 1 to beech-maple mesic forest and group 2 to floodplain forest. This statistical analysis is useful if the goal is to determine if particular plant species may serve as indicators for beech-maple mesic forests and floodplain forests (Table 3).

RESULTS

Between late May and mid-September, we conducted natural community plot surveys and plot quality rank assessments along the West Kill main stem in the town of Lexington. Table 2 shows a summary of total plots and natural community types sampled. Overall, 76 plots were sampled across approximately 16 natural community types.

Several natural communities predicted along the West Kill main stem during the beginning of this project were not found during the actual plot sampling in 2008. For example, we did not document any red maple-hardwood swamps within the survey area. The steep overall topography of the West Kill was probably the largest contributor to the lack of this community type. Given the low drainage density, combined with steep side slopes, short tributaries and high precipitation, the West Kill stream system is relatively flashy, that is, stream levels rise and fall quickly in response to storm events (Greene County Soil and Water Conservation District Stewardship Program 2005). This flashy character prevents basin swamps from forming and consequently, red maple-hardwood, red maple-blackgum, and hemlock-hardwood swamps were not documented during plot surveys of 2008. In addition, herbaceous dominated marshes and wet meadows were scarce along the West Kill. Sedge meadow, a natural community that is potentially found along streams within the Catskills, was not documented during plot surveys of 2008. This is also likely due to the flashy nature of the West Kill main stem which prevents the development of a peatland natural community. Also, several predicted upland community types were not found within the West Kill riparian area. These include Appalachian oak-hickory and Appalachian oak-pine forests. Although present in very low numbers, the lack of oak (*Quercus* spp.) along the West Kill is particularly interesting and no associated natural communities dominated by oaks were found.

In addition, several natural communities were found that were not predicted in the preliminary assessment. We documented maple-basswood rich mesic forest at one site along the West Kill main stem during plot surveys. This natural community is difficult to distinguish on an aerial photograph from a beech-maple mesic forest, which was abundant along the West Kill. It is possible that other small pockets of maple-basswood rich mesic forest occur within the deciduous matrix uplands in close proximity to the West Kill riparian area. In addition, one plot best fit the classification for calcareous talus slope woodland. This natural community was small and the species were similar in composition to a maple-basswood rich mesic forest. However, calcareous talus slope woodlands occur on an extremely stony substrate and a fairly steep slope. This pocket of calcareous talus slope woodland was nestled within a hemlock-northern hardwood forest, and other small pockets may occur in addition to the documented example. Other NY natural community types found along the West Kill but not initially predicted included vernal pool, successional old field (noted but no plot collected), successional southern hardwoods, successional red cedar woodland, and spruce/fir plantation. We omitted these plots from the analyses due to either low frequency or being classified as cultural community types.

Table 2: Summary of NY Natural Community Plots sampled. Community types follow Edinger et al. (2002).

NY Natural Community type	# plots
Beech-maple mesic forest*	16
Floodplain forest*	14
Cobble shore*	9
Hemlock-northern hardwood forest*	9
Shrub swamp*	7
Pine-northern hardwood forest*	5
Shallow emergent marsh*	4
Successional old field	2
Maple-basswood rich mesic forest/Calcareous talus slope woodland	2
Vernal pool	2
Pine plantation/Pine-northern hardwood Forest	1
Successional northern hardwoods/Pine plantation	1
Successional southern hardwoods	1
Successional red cedar woodland	1
Spruce-fir plantation	1
Intermittent stream/Beech-maple mesic forest	1

*** The West Kill local "expression" of these natural communities will be described in the section "Natural Community Description and Composition". A sufficient number of plots (3) were labeled with these natural community types in this study area to capture enough variation to be described, classified, and ranked along the West Kill main stem. The remaining natural community/cultural types will not be described due to their infrequent occurrence and/or being irrelevant to this restoration guiding project.**

Statistical Analysis Results

Five distinct clustering groups emerged from the cluster analysis, and are labeled as groups 1 through 5 in Figure 3. Clustering groups 1 and 2 consisted mainly of beech-maple mesic forests and floodplain forests. The two plots labeled as maple-basswood rich mesic forest and calcareous talus slope woodland also clustered closely with beech-maple mesic forest plots, and this was expected due to similar canopy species within the types. Several pine-northern hardwood forests also clustered within group 2 but were also closely clustered with group 3 that included mostly pine-northern hardwood forests and hemlock-northern hardwood forest. Groups 4 and 5 consisted primarily of a combination of cobble shore, shallow emergent marsh, and shrub swamps. Group 4 also consisted of a few plots that did not cluster well with others (i.e., Appalachian oak-hickory forest, intermittent stream, and successional shrubland). These plots were not included in the final descriptions due to their rarity along the West Kill main stem. Within groups 4 and 5, shrub swamps, shallow emergent marshes, and cobble shores had fairly similar species composition, and differences between the three are discussed under Natural Community Descriptions later in this report. The most revealing and unexpected result of this cluster analysis was the very close clustering of floodplain forests and beech-maple mesic forests. Due to the overlap clustering of these two community types, further review of plot data was needed to determine the reason these two natural community types clustered closely. Similarities among the canopy and subcanopy species seemed to be driving this pattern of clustering. The canopy species associated with both floodplain forests and beech-maple mesic forests include sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), and to a lesser degree, yellow birch (*Betula alleghaniensis*). To see all species associated with these two natural communities, see full the descriptions later in this report.

Results from the ecological indicator analysis showed that several plant species emerged as ecological indicators for the beech-maple mesic forest and floodplain forest community types. Table 3 lists the most abundant species within each growth form of these two communities, the percent indication of each natural community, and the statistical significance. Species with a high percentage of indication to floodplain forests being statistically significant at the 0.05 level include musclewood (*Carpinus caroliniana*), Virginia waterleaf (*Hydrophyllum virginiana*), garlic mustard (*Alliaria petiolata*), jack-in-the-pulpit (*Arisaema triphyllum*), and Virginia creeper (*Parthenocissus quinquefoli*a) (Table 3). American basswood (*Tilia americana*) was a fair indicator of floodplain forests, but was not statistically significant (p=0.07), likely due to small sample size (Table 3). Species with a high percentage of indication to beech-maple mesic forests being statistically significant at the 0.05 level include Canada mayflower (*Maianthemum canadense*), striped maple (*Acer pensylvanicum*), American beech (*Fagus grandifolia*), intermediate fern (*Dryopteris intermedia*), spinulose wood fern (*Dryopteris carthusiana*), wild sarsaparilla (*Aralia nudicaulis*), and marginal wood fern (*Dryopteris marginalis*). Two species infrequently occurring in the beech-maple mesic forest herbaceous layer not shown in Table 3 also had statistically significant values for indication to this natural community type. These species include solomon's seals (*Polygonatum biflorum*) and partridgeberry (*Mitchella repens*). Yellow birch (*Betula alleghaniensis*), was a fair indicator of beech-maple mesic forests, but this was not significant at a statistical level ($p=0.09$) (Table 3).

The results also showed that species such as sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), and black cherry (*Prunus serotina*) were not good indicators of beech-maple mesic forests and floodplain forests, since they occurred frequently in both groups (Table 3). The ecological indicator analysis shows that there are species that can be used to distinguish clearly between the more upland beech-maple mesic forest and the more riparian floodplain forest (Table 3). These distinguishing features, in turn, may help inform restoration and planting efforts (see also floodplain forest and beech-maple mesic forest discussion/recommendations sections).

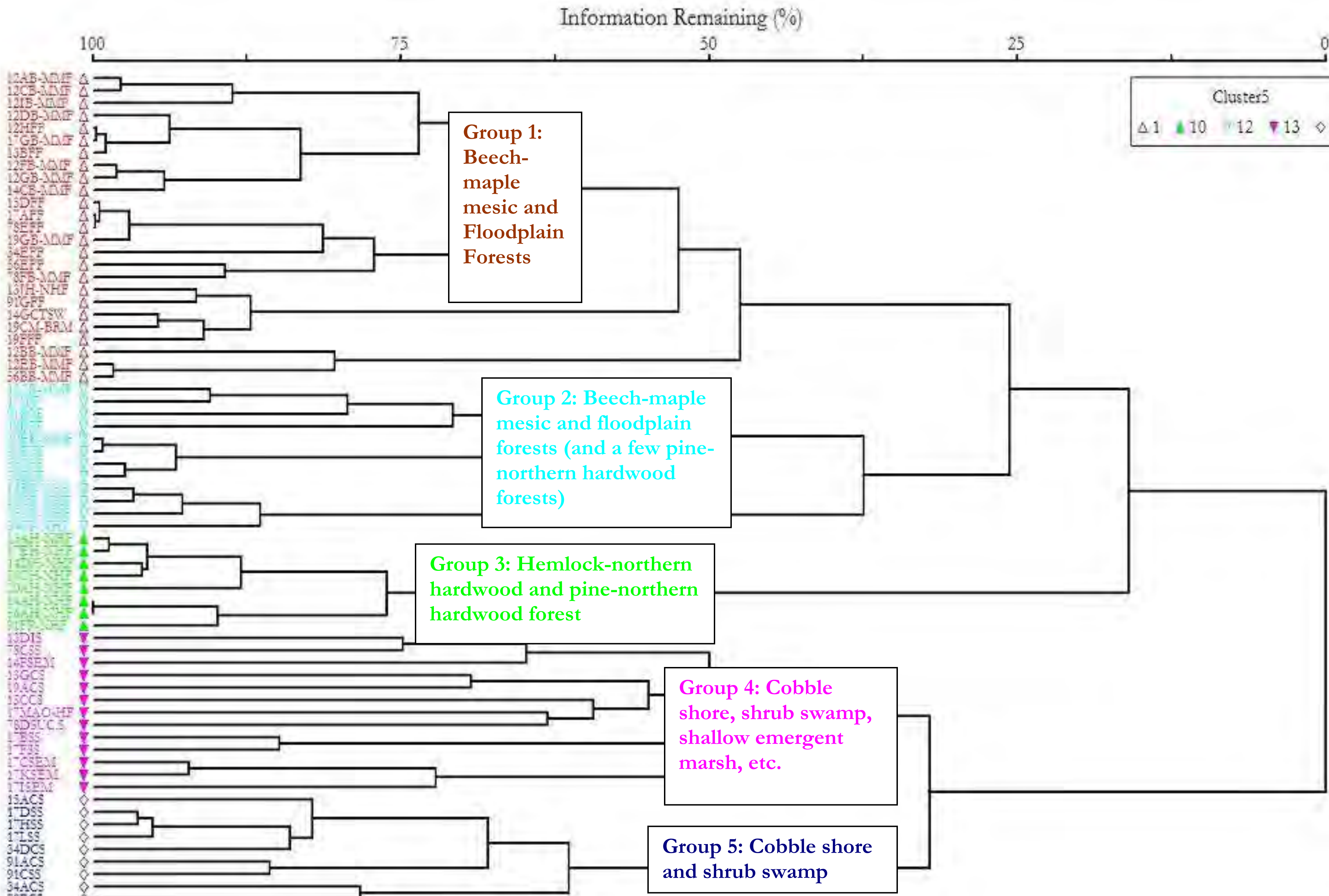

Figure 2: Cluster analysis results Tree Graph (color-coded)

Table 3: Ecological Indicator Analysis results for beech-maple mesic forest and floodplain forest. Shown are the more abundant species for each growth form, the % of indication for each community type (average abundance of a given species in a given group of natural communities over the average abundance of that species in both natural communities expressed as a %), and the significance of each species as an indicator for one or the other natural community (P-value).

Species	Growth form	% Indication **Beech-Maple Mesic Forest**	% Indication **Floodplain Forest**	P value
Acer saccharum	Tree, shrub	53	47	0.5610
Fraxinus americana	Tree, shrub	38	62	0.1410
Prunus serotina	Tree, shrub	66	34	0.2330
Pinus strobus	Tree	4	96	0.2420
Tilia americana	Tree, shrub	3	97	0.0720
Quercus rubra	Tree, shrub	28	72	0.4920
Betula alleghaniensis	Tree, shrub	70	30	0.0960
Acer rubrum	Tree, shrub	49	51	0.5150
Acer pensylvanicum	Tall shrub	81	19	0.0130*
Fagus grandifolia	Tree, shrub	90	10	0.0004***
Rubus allegheniensis	Shrub	0	100	0.2220
Carpinus caroliniana	Shrub	27	73	0.0070
Parthenocissus quinquefolia	Vine	0	100	0.0001***
Toxicodendron radicans	Vine	0	100	0.4750
Alliaria petiolata	Herbaceous	0	100	0.0240*
Hydrophyllum virginianum	Herbaceous	0	100	0.0010**
Arisaema triphyllum	Herbaceous	20	80	0.0010**
Laportea canadensis	Herbaceous	0	100	0.1120
Athyrium filix-femina	Herbaceous	43	57	0.6100
Heracleum maximum	Herbaceous	0	100	0.4730
Maianthemum canadense	Herbaceous	87	13	0.0110*
Dennstaedtia punctilobula	Herbaceous	100	0	0.1000
Dryopteris intermedia	Herbaceous	100	0	0.0140*
Dryopteris carthusiana	Herbaceous	91	9	0.2260
Leersia virginica	Herbaceous	41	59	0.8100
Ageratina altissima	Herbaceous	63	37	0.8260
Dryopteris marginalis	Herbaceous	91	9	0.0490*

*** p<0.05; ** p<0.01, *** p<0.001**

NATURAL COMMUNITY DESCRIPTIONS AND COMPOSITION

We provide a detailed description of each community as it occurred in the West Kill riparian area followed by species composition determined by averaging all plot data for that type. A sufficient number of plots (3) were labeled with these natural community types in this study area to capture enough variation to be described along the West Kill main stem. For each natural community, we also provide summary tables of the Plot Quality Rank System and Plant Stewardship Index results, classification, and pictures, location maps, and recommendations of specific plots that may serve as "references" for the type. Natural community types encountered along the West Kill main stem not meeting the sufficient criteria of three plots per type are omitted from this section.

This report also describes the Catskill riparian zone vegetation in the context of a national and regional vegetation classification (Grossman *et al.* 1998). The Nature Conservancy, in conjunction with NatureServe, the Federal Geographic Data Committee, and the Ecological Society of America Vegetation Subcommittee, developed the National Vegetation Classification System (NVCS) in order to standardize vegetation classification and facilitate the comparison of vegetation types throughout the United States and internationally. The NVCS is a systematic approach to classifying existing natural vegetation using physiognomics and floristics (Grossman *et al.* 1998).

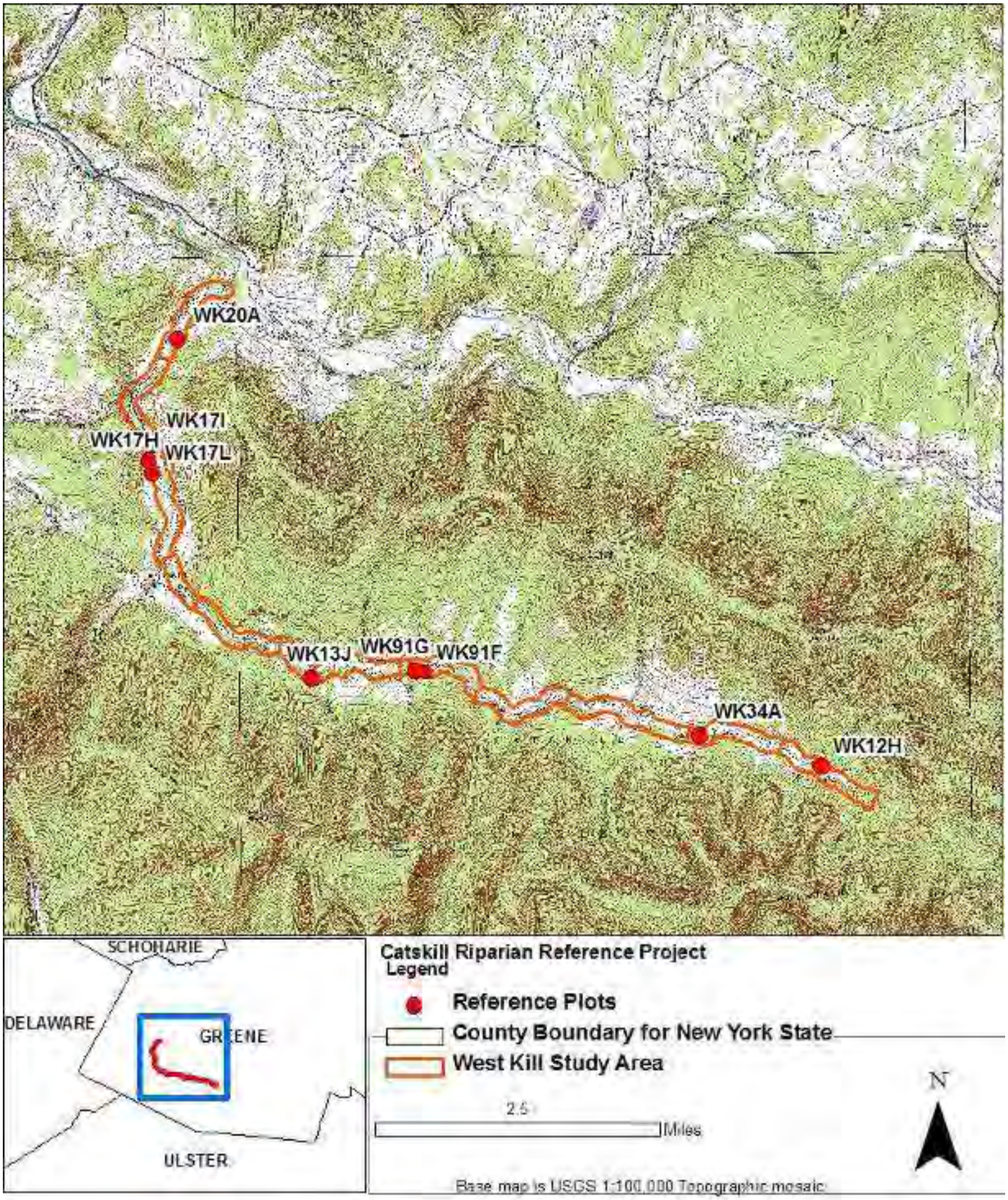

Figure 3. Natural Community Reference Plots along West Kill

Hemlock-Northern Hardwood Forest Description

This forest type typically occurs along fairly steep and mostly north facing slopes along the West Kill main stem and is dominated by eastern hemlock (*Tsuga canadensis*) with yellow birch (*Betula alleghaniensis)* as a common canopy associate. Other typical canopy associates include sugar maple (*Acer saccharum*) and white ash (*Fraxinus americana*), and in some cases, red oak (*Quercus rubra*) American beech (*Fagus grandifolia),* red maple (*Acer rubrum*), black birch (*Betula lenta*), and white pine (*Pinus strobus*) occurs in small numbers. The shrub layer is generally sparse, with hop-hornbeam (*Ostrya virginiana*), striped maple (*Acer pensylvanicum*), and American beech (*Fagus grandifolia*) occurring most frequently. The herbaceous layer can be typically sparse or surprisingly diverse, such as especially within the more mesic examples. Ferns are common, including spinulose wood fern (*Dryopteris carthusiana*), New York fern (*Thelypteris noveboracensis*), common oak fern (*Gymnocarpium dryopteris*), broad beech fern (*Phegopteris hexagonoptera*), and Christmas fern (*Polystichum acrostichoides*). Other herbaceous plants common in these hemlock-northern hardwood forests include partridgeberry (*Mitchella repens)*, wood-sorrel (*Oxalis montana)*, white wood aster (*Eurybia divaricata)*, etc. This forest occurs as a large-patch natural community for the High Allegheny ecoregion, and occurs in fairly large examples along the West Kill main stem. The largest sections of the hemlock-northern hardwood forest occur in various elevations upslope from the West Kill, but in one instance, a *Tsuga canadensis* dominant forest was within the riparian buffer zone.

Occurrences of this forest type within the West Kill riparian area are situated on topographic positions ranging from basin floor to low slopes of 4 º to 25 º. The aspects of these slopes ranged from 124 º to 352 º, with most aspects around 300 º. Stoniness of hemlock-northern hardwood forest plots ranged anywhere from stony (1-15% stones) to exceedingly stony (50-90% stony). Most plots were around 15-20% stoniness, and included both small and large rocks. The soils were fairly consistently of sandy loam type, but one plot had sandy clay loam as the dominant soil type.

Nine 20 m x 20 m releve plots, classified as hemlock-northern hardwood forests, were surveyed within the riparian buffer zone. The overall floral quality of these forests is excellent with very little to no evidence of exotic plants. The results of the plot quality ranking system show that all nine examples of this natural community type are in excellent biotic and abiotic condition, and also in good landscape condition. One plot, WK19B, an excellent quality example, was preliminarily classified as a floodplain forest, however, after further investigation, the vegetation of this plot is much more indicative of hemlock-northern hardwood forest.

Hemlock-Northern Hardwood Forest Species Composition (average from all plots sampled)

The tree canopy layer (29.9 m) has 72.8% cover with *Tsuga canadensis* (41.3%), *Acer saccharum* (8.1%), *Pinus strobus* (7.2%), *Fraxinus americana* (4.4%), *Tilia americana* (3.9%), *Populus tremuloides* (2.8%), and *Quercus rubra* (2.6%), as the most abundant species. *Betula alleghaniensis Acer rubrum* and *Prunus serotina* comprise less than two percent of the overall T2 layer.

The tree subcanopy layer (21.9 m) has 55% cover with *Tsuga canadensis* (17.7%), *Betula alleghaniensis* (16.3%), *Fraxinus americana* (6.8%), *Ostrya virginiana* (5.1%), and *Acer saccharum* (4.4%) as the most abundant species. *Betula lenta*, *Pinus strobus*, *Betula papyrifera*, *Carpinus caroliniana*, *Acer pensylvanicum*, *Acer rubrum*, *Fagus grandifolia*, and *Tilia americana* comprise less than two percent of the overall T3 layer.

The tall shrub layer (7 m) has 31% cover with *Ostrya virginiana* (5.0%), *Betula alleghaniensis* (4.9%), *Tsuga canadensis* (4.4%), *Fagus grandifolia* (3.0%), *Carpinus caroliniana* (2.7%), *Acer saccharum* (2.6%), *Acer pensylvanicum* (2.2%), *Fraxinus americana* (2.2%) as the most abundant species. *Acer spicatum* and *Hamamelis virginiana* comprise less than one percent of the overall S1 layer.

The short shrub layer (0.4 m) has 15.7% cover with *Acer pensylvanicum* (4.3%), and *Fagus grandifolia* (2.9%) as the most abundant species. *Ostrya virginiana*, *Carpinus caroliniana*, and *Fraxinus american*a, *Betula alleghaniensis*, *Tsuga canadensis*, *Rubus pubescens*, *Acer spicatum*, *Acer saccharum*, *Populus tremuloides, Hamamelis virginiana, Rubus allegheniensis*, *Prunus serotina*, *Rubus occidentalis*, *Pinus strobus*, *Quercus rubra,* and *Acer rubrum* comprise less than one percent of the overall S2 layer.

The vine layer (0.2 m) has 0.1% cover of *Solanum dulcamara*.

The herbaceous layer (0.3 m) has 27.9% cover with *Maianthemum canadense* (5.6%), *Dryopteris carthusiana* (5.1%), *Mitchella repens* (3.7%), *Huperzia* sp. (3.3%), *Polystichum acrostichoides* (1.6%), *Thelypteris noveboracensis* (1.3%), *Onoclea sensibilis* (1.0%), and *Osmunda claytoniana* (1.0%) as the most abundant species. *Gymnocarpium dryopteris, Athyrium filix-femina, Leersia virginica, Monotropa uniflora, Arisaema triphyllum, Eurybia divaricata, Carex debilis, Phegopteris hexagonoptera, Chrysosplenium americanum, Dryopteris intermedia, Polygonatum biflorum, Trientalis borealis, Epipactis helleborine, Alliaria petiolata, Carex trisperma, Thelypteris simulata, Dryopteris marginalis, Impatiens capensis, Hydrocotyle americana, Geranium maculatum, Galium asprellum, Oxalis montana, Polypodium virginianum, Geranium robertianum, Carex swanii, Lysimachia quadrifolia, Carex lurida, Satureja hortensis, Circaea alpina, Hepatica nobilis, Trillium erectum* comprise less than one percent of the overall herbaceous layer.

Plots and Ranking of Factors

Table 4: Hemlock-Northern Hardwood Forest Plot Quality Rank Summary Table:

Plot	**% Native Species**	**Size structure**	**Species condition**	**Coarse Woody Debris**	**Disturbances**	**Size of natural community**	**Estimated size of surrounding natural landscape**	**% of natural habitat (within 1km)**	**Distance to nearest paved road**	**TOTAL RANK SUM**	**RANK SCORE QUALITY**
WK20C	1	2	1	3	1	2	1	2	1	14	Excellent
WK20A	1	2	1	3	1	2	2	2	1	15	Excellent
WK13J	1	2	2	2	1	3	3	2	2	16	Excellent
WK14A	1	3	1	3	1	2	2	2	2	17	Excellent
WK13A	1	2	2	3	2	2	2	2	2	18	Excellent
WK56A	1	2	1	2	2	4	3	2	1	18	Excellent
WK19B	1	2	1	3	1	3	2	2	2	18	Excellent
WK17E	1	3	1	3	2	3	3	2	1	19	Excellent
WK14D	1	3	1	4	2	2	3	2	3	21	Good

Table 5: Hemlock-Northern Hardwood Forest Plot Quality Rank System/Plant Stewardship Index Quality (Conservation Coefficient) Summary Table

PLOT	+PQRS Rank	*PSI (adjusted)	**PSI Mean Coefficient of Conservation	***Difference between PSI and PQRS
WK20A	15	32.46	5.49	17.46
WK13J	16	29.19	5.50	13.19
WK20C	14	25.92	5.95	11.92
WK14D	21	31.92	6.38	10.92
WK19B	18	27.50	6.00	10.8
WK13A	18	26.15	6.00	8.15
WK14A	17	24.94	6.24	7.94
WK56A	18	21.41	6.45	3.41
WK17E	19	18.54	6.56	-.46

+ Plot Quality Rank System final rank of biotic, abiotic, and landscape factors (lower score constitutes higher quality ranking plot).
* Plant Stewardship Index (adjusted) (higher score indicates higher diversity and quality)
** Plant Stewardship Index mean-average of all scores of plants found in plot (higher score indicates more species with higher ranks).
******* Difference between PSI and PQRS (since low score of PQRS indicates high quality, and high score of PSI indicates high quality, the difference between these two could indicate a final "quality" ranking between biotic, abiotic, landscape, and floral rank factors).

Plots selected as reference examples are highlighted in yellow

Hemlock-Northern Hardwood Forest Discussion/Recommendations

According to the results of the PQRS and PSI, plots WK13J and WK20A appear to be the best overall candidates for a natural community reference for hemlock-northern hardwood forests along the West Kill main stem. These two plots are attributed to National Vegetation Classification NVC type "CEGL006109– *Tsuga canadensis - Betula alleghaniensis* lower new england /northern piedmont Forest"(Grossman *et al.* 1998). This NVC type fits fairly well with nearly all other hemlock-northern hardwood forest plots. Only one hemlock-northern hardwood forest plot was attributed with the NVC type CEGL006088 *Tsuga canadensis - Fagus grandifolia - Quercus rubra* forest (Grossman *et al.* 1998). The difference between NVC types CEGL006109 and CEGL006088 is attributed to the different associated canopy species of *Tsuga canadensis*. CEGL006109 is described as mostly northern hardwoods such as *Acer saccharum* and *Betula alleghaniensis* being associated with *Tsuga canadensis*. According to the results of this study, this type is by far the most common NVC type of hemlock-northern hardwood forest along the West Kill. CEGL006088 has oak (*Quercus* sp.) and black birch (*Betula lenta*) as common associates, and these species were not frequently encountered along the West Kill. Only one plot, WK19B, was classified as this type.

The results of the PSI show that many species documented in plots WK13J and WK20A have conservation coefficients of 7 or higher (Tables 6 and 7). Examples of these species include *Acer pensylvanicum*, *Acer spicatum*, *Betula alleghaniensis*, *Circaea alpina*, *Dryopteris marginalis*, *Fagus grandifolia*, *Gymnocarpium dryopteris*, *Phegopteris hexagonoptera, Tiarella cordifolia*, *Trientalis borealis*, and *Trillium erectum*. These species associated with hemlock-northern hardwood forests exhibit a poor range of ecological tolerances and/or have a high degree of fidelity to a narrow range of habitats (Tables 6 and 7). The overall PSI's of 32.46 (WK20A) and 29.19 (WK13J) indicate that these plots and surrounding area are comprised of high quality plant species, which indicate a well-functioning natural community (Table 5).

The overall PQRS rank sum of 15 for Plot WK20A is the highest quality for any hemlock-northern hardwood forest plot. This score is slightly higher than the sum of 16, which is the PQRS rank sum for WK13J (Table 4). The high quality of these plots is attributed to the lack of exotic plant species, good size structure within the community strata layers, a fair amount of coarse woody debris with decaying matter, no disturbances within and surrounding the plot, is embedded in 90-100% natural habitat within 1 kilometer, and distance to nearest paved road is greater than 100 meters. Below is a summary of the floral PSI, life form/strata, and abiotic characteristics of this plot.The summary tables and floral composition are recommendations in the final "expression" of this type (Tables 6-11).

Given an existing set of biotic and abiotic conditions along the West Kill, hemlock-northern hardwood forests will continue to mature and thrive as a natural community on fairly steep slopes in this valley. However, the devestating exotic insect hemlock woolly adelgid (*Adelges tsugae*) poses a future threat to this natural community. This insect will destroy eastern hemlock trees, but apparently does not attack eastern white pine (*Pinus strobus*), a major component of some hemlock-northern hardwood forests along the West Kill. It does appear that eastern hemlock (*Tsuga canadensis*), given the current set of biotic and abioitic conditions, may out live eastern white pine as well as other tree species (Godman and Lancaster 1990). However, given the threat of this insect to hemlock, preferences for planting white pine over hemlock may be an option since both occupy areas that have very similar biotic and abiotic conditions along the West Kill.

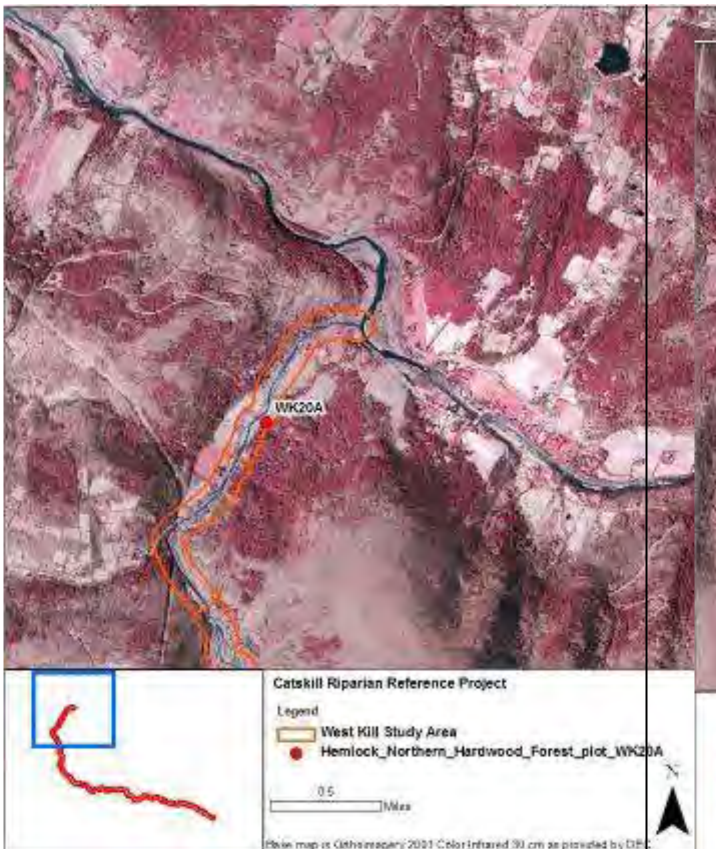

Figure 4. Location of Hemlock-northern hardwood forest **Plot WK20A**

Figure 5. Location of Hemlock-northern hardwood forest **Plot WK13J**

Figure 6. Hemlock-northern hardwood forest **Plot WK20A**

Figure 7. Hemlock-northern hardwood forest **Plot WK13J**

Table 6: Hemlock-northern hardwood forest **Plot WK20A** species and PSI Conservation Coefficient (as developed for New Jersey)

Species	**Common name**	**PSI Coefficient**
Acer pensylvanicum	Striped maple	N 7
Acer rubrum var. rubrum	Red maple	N 3
Arisaema triphyllum ssp. triphyllum	Jack-in-the-pulpit	N 5
Athyrium filix-femina var. *angustum*	lady fern	N 7
Betula alleghaniensis	yellow birch	N 10
Betula lenta	Black birch	N 6
Carex lurida	Sallow sedge	N 4
Carex swanii	Swan's sedge	N 6
Carex trisperma	Three-fruited sedge	N 10
Chrysoplenium americanum	Golden saxifrage	N 10
Circaea alpina	Enchanter's nightshade	N 10
Dryopteris carthusiana	spinulose wood fern	N 5
Eurybia divaricata	White wood aster	N 4
Fraxinus americana var. *americana*	White ash	N 7
Geranium maculatum	Wood geranium	N 4
Gymnocarpium dryopteris	Common oak fern	N 10
Hepatica nobilis var. obtusa	Hepatica	N 9
Huperzia lucidula	Shining firmoss/clubmoss	N 10
Leersia virginica	Cutgrass/White grass	N 3
Lysimachia quadrifolia	Whorled loosestrife	N 3
Maianthemum canadense	Canada mayflower	N 4
Mitchella repens	partridge-berry	N 5
Onoclea sensibilis	Sensitive fern	N 2
Oxalis montana	Mountain wood-sorrel	N ?
Phegopteris hexagonoptera	Broad beech fern	N 8
Pinus strobus	eastern white pine	N 3
Polystichum acrostichoides	Christmas fern	N 7
Prunus serotina	wild black cherry	N 1
Quercus rubra	Northern red oak	N 7
Rubus alleghaniensis	Common blackberry	N 3
Rubus occidentalis	Black raspberry	N 1
Satureja hortenis	Summer savory	I 0
Solanum dulcamara	Bittersweet nightshade	I 0
Trientalis borealis	star-flower	N 7
Trillium erectum	Wake-robin	N 8
Tsuga canadensis	Eastern hemlock	N 8

*** N=Native, I=Introduced**

Table 7: Hemlock-northern hardwood forest **Plot WK13J** species and PSI Conservation Coefficient (as developed for New Jersey)

Species	Common name	PSI Coefficient
Acer pensylvanicum	moosewood/striped maple	N 7
Acer saccharum var. saccharum	sugar maple	N 5
Acer spicatum	mountain maple	N 8
Alliaria petiolata	Garlic mustard	I 0
Arisaema triphyllum var. triphyllum	Jack-in-the-pulpit	N 5
Betula alleghaniensis	yellow birch	N 10
Carpinus caroliniana	musclewood	N 7
Dryopteris carthusiana	spinulose wood fern	N 5
Epipactis helleborine	Bastard helleborine	I 0
Eurybia divaricata	White wood aster	N 4
Fagus grandifolia	American beech	N 8
Geranium robertianum	Herb-robert	N 4
Hydrocotyle americana	Marsh pennywort	N 5
Mitchella repens	partridge-berry	N 5
Osmunda claytoniana	Interrupted fern	N 7
Ostrya virginiana	hop-hornbeam	N 7
Pinus strobus	eastern white pine	N 3
Polystichum acrostichoides	Christmas fern	N 7
Populus tremuloides	Quaking aspen	N 2
Quercus rubra	Red oak	N 7
Rubus pubescens	Dwarf blackberry	N 9
Thelypteris noveboracensis	New York fern	N 3
Tilia americana	American basswood	N 7
Trientalis borealis	star-flower	N 7
Tsuga canadensis	Eastern hemlock	N 8

*** N=Native, I=Introduced**

Table 8: Hemlock-northern hardwood forest **Plot WK13J** growth life form summary

Growth life form	% Cover	average height (meters)
T2 (Tree canopy >5m)	75%	30 m
T3 (Tree sub-canopy >5m)	65%	23 m
S1 (Tall shrub 2-5m, tree saplings)	35%	5 m
S2 short shrub (<2m) include tree seedlings	20%	0.3 m
H (Herbaceous)	25%	0.3 m

Table 9: Hemlock-northern hardwood forest **Plot WK20A** growth life form summary

Growth life form	% Cover	average height (meters)

T2 (Tree canopy >5m)	55%	29 m
T3 (Tree sub-canopy >5m)	45%	23 m
S1 (Tall shrub 2-5m, tree saplings)	15%	4 m
S2 short shrub (<2m) include tree seedlings	20%	1 m
V Vine/liana	1%	0.2 m
H (Herbaceous)	65%	0.3 m

Table 10: Hemlock-northern hardwood forest **Plot WK13J** abiotic characteristics summary

Unvegetated surface	2% large rocks, 15% small rocks, 5% wood >1cm
Soil drainage	Well drained
Soil type	Sandy loam
Slope	8 degrees
Slope aspect	340 degrees
Hydrologic regime	Never inundated
Topographic position	Low slope
Soil moisture regime	Dry

Table 11: Hemlock-northern hardwood forest **Plot WK20A** abiotic characteristics summary

Unvegetated surface	1% large rocks, 10% small rocks, 10% litter, duff, 3% wood >1cm, 6% water
Soil drainage	Somewhat well drained/Somewhat poorly drained
Soil type	Sandy loam
Slope	12 degrees
Slope aspect	260 degrees
Hydrologic regime	unknown
Topographic position	Low slope
Soil moisture regime	Moist to dry

Pine-Northern Hardwood Forest Description

This forest type typically occurs along fairly steep slopes along the West Kill main stem and is dominated by *Pinus strobus* with common canopy associates red maple (*Acer rubrum*), black cherry (*Prunus serotina*), sugar maple (*Acer saccharum*) and white ash (*Fraxinus americana*). Less common canopy associates include yellow birch (*Betula alleghaniensis*) and eastern hemlock (*Tsuga canadensis*). The shrub cover is generally fairly sparse but can have moderate cover. Species indicative of the shrub layer include musclewood (*Carpinus caroliniana*), witch-hazel (*Hamamelis virginiana*), striped maple (*Acer pensylvanicum*), hop-hornbeam (*Ostrya virginiana*), mountain maple (*Acer spicatum*), fly honeysuckle (*Lonicera canadensis*), and American beech (*Fagus grandifolia*). Black raspberry (*Rubus occidentalis*) occurs in one area where succession from a natural disturbance has occurred. The herbaceous layer is also relatively sparse, but can be surprisingly moderately dense and diverse in more mesic and rich locations. Herbaceous plants typical of this natural community type include common oak fern (*Gymnocarpium dryopteris*), starflower (*Trientalis borealis*), Christmas fern (*Polystichum acrostichoides*), lady fern (*Athyrium filix-femina*), sensitive fern (*Onoclea sensibilis*), sedge (*Carex debilis*), helleborine (*Epipactis helleborine*), wood-sorrel (*Oxalis montana*), spinulose wood fern (*Dryopteris carthusiana*), jack-in-the-pulpit (*Arisaema triphyllum*), wild sarsaparilla (*Aralia nudicaulis*), New York fern (*Thelypteris noveboracensis*), partridgeberry (*Mitchella repens*), and Canada mayflower (*Maianthemum canadense*).

Within this riparian corridor, pine-northern hardwood forests are closely related to hemlock-northern hardwood forests and may occur as a *Pinus strobus* expression of a hemlock-northern hardwood forest. However, for the purposes of recognizing these two community types for "references", this report will differentiate these two types based on dominant canopy cover. Pine- and hemlock-northern hardwood forests occur adjacent to one another and typically on the same topographic position. In addition, several pine-northern hardwood forest plots have significant amounts of *Tsuga canadensis*. Indeed, plots WK34C, WK91F, and WK14B contained *Tsuga canadensis* within the subcanopy and/or shrub layer. This *Pinus strobus/Tsuga canadensis* co-dominated type is not significantly different than the types with *Pinus strobus* and *Tsuga canadensis* as sole dominants. If both pine- and hemlock-northern hardwood forests types are similar in vegetation composition and topographic position, one would assume that the plot quality rank system results would be very similar as well. Indeed, both types averaged good to excellent overall with regard to the results of the PSI and PQRS.

Pine-northern hardwood forest tend to occur on fairly steep slopes along the West Kill, with *Pinus strobus* occasionally occurring in floodplain forests closer to the stream. As in hemlock-northern hardwood forest, intermittent mountain streams tend to influence vegetation composition within the natural community, producing a more diverse and mesic overall flora. Both of these forest types are typically in excellent condition, with little to no exotic plants within the areas surveyed. One difference between pine- and hemlock-northern hardwood forests is that *Pinus strobus* forests tended to be overall smaller in size. The small size of pine-northern hardwood forests may indicate that they occur as inclusions in an overall larger hemlock-northern hardwood forest. Also, difficulties distinguishing this community occur due to the fact that *Pinus strobus* plantations were planted in a few spots along the West Kill. These plantations are currently in decline leading to increased species diversity over time, resulting in similar vegetation compositions with pine-northern hardwood forest.

The pine-northern hardwood forests generally occur on gently steep to very steep slopes that range from 4 º to 20 º. The aspect of these slopes ranges from 315° to 52°. These forests are also typically stony, with stoniness ranging from stony (1-14%) to very stony (15-50%), with most plots averaging very stony. The stones consisted mainly of small rocks, with only a small percentage of large rocks within each plot. Downed wood abundant in Plot WK13H was most likely due to a declining pine plantation. Sandy loam was the only soil type documented for this community type, and was the dominant soil type for all upland forests along the West Kill riparian area.

Pine-Northern Hardwood Forest Species Composition (average from all plots sampled)

The emergent tree layer (34 m) has 8.6% cover of *Pinus strobus*. The tree canopy layer (29.7 m) has 67.1% cover and *Pinus strobus* (52.9%), *Acer saccharum* (4.3%), *Prunus serotina* (3.6%), *Acer rubrum* (2.9%), *Fraxinus americana* (2.1%) as the most abundant species. *Betula alleghaniensis* comprise less than two percent of the overall layer.

The tree subcanopy layer (21.9 m) has 55.7% cover and *Pinus strobus* (12.0%), *Acer saccharum* (10.3%), *Tsuga canadensis* (9.1%), *Betula alleghaniensis* (8.9%), *Fraxinus americana* (8.6%), *Acer rubrum* (4.0%), and *Prunus serotina* (2.9%) as the most abundant species. *Populus tremuloides* and *Ulmus americana* comprise less than two percent of the overall layer.

The tall shrub layer (7.4 m) has 43.6% cover and *Carpinus caroliniana* (11.9%), *Acer pensylvanicum* (6.0%), *Tsuga canadensis* (5.7%), *Acer saccharum* (5.4%), *Hamamelis virginiana* (4.3%), *Ostrya virginiana* (3.9%) and *Fagus grandifolia* (2.6%) as the most abundant species. *Fraxinus nigra*, *Prunus serotina*, *Pinus strobus*, and *Ulmus americana* comprise less than two percent of the overall layer.

The short shrub layer (0.7 m) has 42.6% cover and *Fraxinus americana* (10.4%), *Acer pensylvanicum* (8.0%), *Carpinus caroliniana* (6.7%) and *Rubus occidentalis* (6.3%) as the most abundant species. *Hamamelis virginiana*, *Acer saccharum*, *Acer spicatum*, *Ribes americanum*, *Tsuga canadensis*, *Rubus pensilvanicus*, *Fagus grandifolia*, *Prunus serotina*, *Amelanchier* sp., *Viburnum acerifolium*, *Rubus idaeus*, *Pinus strobus*, *Picea abies*, *Lonicera canadensis*, *Rosa multiflora*, and *Sorbus americana* comprise less than two percent of the overall layer.

The vine layer (0.3 m) has 1.7% cover and *Vitis* sp. (1.1%), *Amphicarpaea bracteata* (0.9%), *Solanum dulcamara* (0.4%), and *Toxicodendron radicans* (0.3%) as the most characteristic species.

The herbaceous layer (0.3 m) has 35% cover and *Gymnocarpium dryopteris* (5.1%), *Mitchella repens* (3.3%), *Athyrium filix-femina* (2.6%), *Dryopteris* sp. (2.4%), *Onoclea sensibilis* (2.4%), *Dryopteris carthusiana* (2.4%), *Senecio vulgaris* (2.3%), *Geranium bicknellii* (2.1%), and *Oxalis montana* (2.1%) as the most abundant species. *Arisaema triphyllum*, *Polystichum acrostichoides*, *Maianthemum canadense*, *Trientalis borealis*, *Thelypteris noveboracensis*, *Eurybia divaricata*, *Carex swanii*, *Solidago* sp., *Aralia nudicaulis*, *Epipactis helleborine*, *Dryopteris intermedia*, *Oxalis stricta*, *Tiarella cordifolia*, *Geranium* sp., *Galium tinctorium*, *Elymus hystrix*, *Carex debilis*, *Symphyotrichum novae-angliae*, *Blephilia hirsuta*, *Potentilla simplex*, and *Dryopteris marginalis* comprise less than two percent of the overall layer.

Plots and Ranking of Factors

Table 12: Pine-northern hardwood forest Plot Quality Rank Summary Table:

Plot	% Native Species	Size structure	Species condition	Coarse Woody Debris	Disturbances	Size of natural community	Estimated size of surrounding natural landscape	% of natural habitat within 1km	Distance to nearest paved road	TOTAL RANK SUM	RANK SCORE QUALITY
WK91F	1	2	1	2	1	3	3	1	1	14	Excellent
WK13H	1	3	3	2	1	3	3	2	1	16	Excellent
WK34C	1	2	1	4	1	4	4	2	1	18	Excellent
WK91D	1	2	2	2	1	3	3	1	4	18	Excellent
WK14B	1	3	3	2	1	3	3	2	1	18	Excellent
WK78A	1	3	3	3	1	4	4	2	2	21	Good

Table 13: Pine-northern hardwood forest Plot Quality Rank System/Plant Stewardship Index Quality (Conservation Coefficient) Summary Table

PLOT	+PQRS Rank	*PSI (adjusted)	**PSI Mean coefficient	***Difference between PSI and PQRS
WK91F	14	25.47	6.18	11.47
WK34C	18	27.24	6.25	9.24
WK91D	18	26.86	5.73	8.86
WK78A	21	14.24	3.45	6.76
WK14B	18	22.49	5.30	4.49
WK13H	16	17.51	4.86	1.51

+ Plot Quality Rank System final rank of biotic, abiotic, and landscape factors (lower score constitutes higher quality ranking plot).
* Plant Stewardship Index (adjusted) (higher score indicates higher diversity and quality)
** Plant Stewardship Index mean-average of all scores of plants found in plot (higher score indicates more species with higher ranks).
******* Difference between PSI and PQRS (since low score of PQRS indicates high quality, and high score of PSI indicates high quality, the difference between these two could indicate a final "quality" ranking between biotic, abiotic, landscape, and floral rank factors).

Plot selected as reference examples are highlighted in yellow.

Pine-Northern Hardwood Forest Discussion/Recommendations

According to the results of the PQRS and PSI, Plot WK91F appears to be a best candidate for a natural community reference for pine-northern hardwood forests along the West Kill. This plot is attributed to NVC type "CEGL006328 *Pinus strobus - Tsuga canadensis* Lower New England/Northern Piedmont Forest" (Grossman *et al.* 1998). This NVC type is equivalent to "hemlock-northern hardwood forest" for New York classification (Edinger *et al.* 2002, Grossman *et al.* 1998). Many of the plots assigned to this NVC type are actually a bit more mesic in nature, resulting in an overall richer floral composition. The results of the PSI show that many species in this plot have conservation coefficients of 7 or higher. Species *Acer pensylvanicum*, *Acer spicatum*, *Athyrium filix-femina*, *Fraxinus americana*, *Lonicera canadensis*, *Ostrya virginiana*, *Polystichum acrostichoides*, *Trientalis borealis*, and *Tsuga canadensis* are associated plants with P-NHF that either have a poor range of ecological tolerances or a high degree of fidelity to a narrow range of habitats. Many of these species are good indicators of NVC type CEGL006328. The overall PSI of 25.47 indicates that this plot and surrounding area is comprised of high quality plant species.

The overall rank sum of the PQRS of 14 is the highest of any P-NHF plot and is tied for the highest rank sum with WK20C of H-NHF. The high quality of this plot is attributed to the lack of exotic species, good size structure and a fair amount of coarse woody debris with decaying matter, no disturbances within and surrounding the plot, is embedded in 90-100% natural habitat within 1 kilometer, and distance to nearest paved road is greater than 100 meters. Below is a summary of the floral PSI, life form strata, and abiotic characteristics of this plot and these are recommendations along with the floral composition in the final "expression" of this type.

Given an existing set of biotic and abiotic conditions along the West Kill, pine-northern hardwood forests will continue to mature and thrive as a white pine (*Pinus strobus*) dominated expression of a hemlock-northern hardwood forest. It does appear, however, that eastern hemlock (*Tsuga canadensis*), given the current set of biotic and abioitic conditions, may out live eastern white pine; succeeding into a hemlock-northern hardwood forest (CEGL006109) (Godman and Lancaster 1990). However, given the possible future threat of the woolly adelgid to hemlock mentioned earlier in this report, preferences for planting white pine over hemlock may be an option since both community types occupy areas with very similar biotic and abiotic conditions along the West Kill.

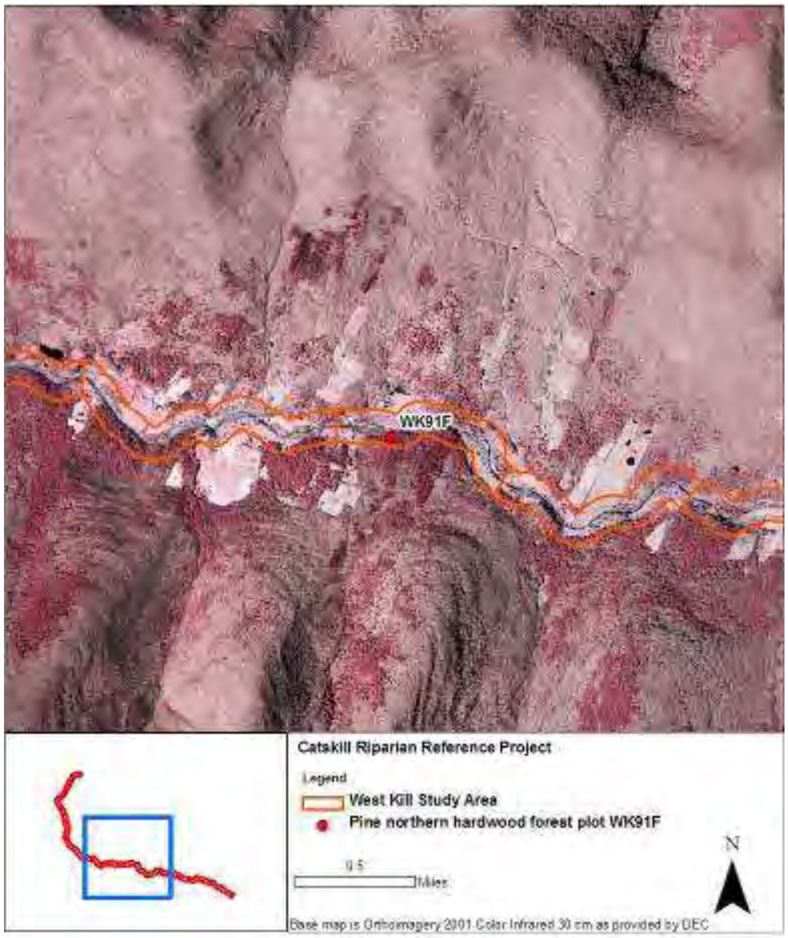

Figure 8. Location of Pine-northern hardwood forest **Plot WK91F**

Figure 9. Pine-northern hardwood forest **Plot WK91F**

Table 14: Pine-northern hardwood forest **Plot WK91F** Species and PSI Conservation Coefficient (as developed in New Jersey)

Species	**Common name**	**PSI Coefficient**
Acer pensylvanicum	moosewood/ striped maple	N 7
Acer saccharum var. saccharum	sugar maple	N 5
Acer spicatum	mountain maple	N 8
Aralia nudicaulis	wild sarsaparilla	N 5
Athyrium filix-femina var. *angustum*	lady fern	N 7
Betula alleghaniensis	yellow birch	N 10
Carpinus caroliniana	musclewood	N 7
Dryopteris carthusiana	spinulose wood fern	N 5
Fraxinus americana var. *americana*	white ash	N 7
Lonicera canadensis	fly honeysuckle	N 10
Mitchella repens	partridge-berry	N 5
Ostrya virginiana	hop-hornbeam	N 7
Pinus strobus	eastern white pine	N 3
Polystichum acrostichoides	Christmas fern	N 7
Prunus serotina	wild black cherry	N 1
Thelypteris noveboracensis	New York fern	N 3
Trientalis borealis	star-flower	N 7
Tsuga canadensis	Eastern hemlock	N 8

*** N=Native, I=Introduced**

Table 15: Pine-northern hardwood forest **Plot WK91F** growth life form summary

Growth life form	**Cover %**	**average height (meters)**
T2 (Tree canopy >5m)	60%	32
T3 (Tree sub-canopy >5m)	60%	25
S1 (Tall shrub 2-5m, tree saplings)	55%	10
S2 short shrub (<2m) include tree seedlings	40%	0.5
H (Herbaceous)	15%	0.2m

Table 16: Pine-northern hardwood forest **Plot WK91F** abiotic characteristics summary

Unvegetated surface	15% small rocks, 5% litter and duff, and 10% wood >1cm
Surface	Very stony
Soil type	Sandy loam, dry
Slope	8 degree
Slope aspect	314 degrees

Floodplain Forest Description

This palustrine forest type occurs on slightly elevated alluvial terraces that are typically very close to the riverbanks of the West Kill main stem. The soils are typically stony and coarse and less regularly inundated than floodplain forests supporting silver maple (*Acer saccharinum*). The canopy consists of species such as sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*) that are more characteristic of beech-maple mesic forests. In addition, unlike other floodplain forests, a prominent tall shrub layer occurs with musclewood (*Carpinus caroliniana*) being a distinctive and dominant member of this layer.

The difference between beech-maple mesic forests and floodplain forests lies mainly in understory species and setting. Within the West Kill riparian area, beech-maple mesic forests tended to occur on sandy loam soils and ranged from stone free to 70% stony within the delineated plot area. Floodplain forests along the West Kill tended to occur on silty soils, and averaged around 15% stones within the delineated plots. Floodplain forests also occurred on flat terraces, while beech-maple mesic forests were generally found along gentle slopes ranging from 1 to 10 degrees. The species composition was quite similar in the tree canopy and tree subcanopy layers. However, yellow birch (*Betula alleghaniensis*) was a fairly significant component of beech-maple mesic forests (16.2%, percentage of combined canopy layers), but comprised a relatively small percentage (6.0%) of the combined canopy layers of floodplain forests. American basswood (*Tilia americana*) may be a good distinguishing species between floodplain forests and beech-maple mesic forests along the West Kill main stem, as it comprised 6.0% of the overall canopy layers but was not recorded within beech-maple mesic forests. However, this species is the dominant species in the scarce examples of maple-basswood rich mesic forests along the West Kill riparian area.

The tall and short shrub layers for both floodplain forests and beech-maple mesic forests were fairly similar. Both forest types averaged about 40% cover for combined tall and short shrub layers. This relatively high shrub cover is typical for this particular type of high terrace floodplain forest, but not within other floodplain forest types in the region (Grossman *et al.* 1998). The most abundant species within the shrub layer of floodplain forests is musclewood (*Carpinus caroliniana*), which comprised 27.7% of the combined tall and short shrub layers. This species was not as abundant in beech-maple mesic forests, comprising only 9.1% of the combined tall and short shrub layers. American beech (*Fagus grandifolia*) and striped maple (*Acer pensylvanicum*) were much more abundant within beech-maple mesic forests. *Fagus grandifolia* comprised 9.3% of both tall and short shrub layers within beech-maple mesic forests, and only 1.5% within floodplain forests. *Acer pensylvanicum* comprised 14.6% of both tall and short shrub layers within beech-maple mesic forests, and only 2.4% within floodplain forests.

As indicative of other floodplain forest types, the high terrace floodplain forest found along the West Kill had a significant vine component. This is in sharp contrast with beech-maple mesic forests, which had a very small vine component, averaging only 1.9% cover. The vine layer averaged 15.8% with Virginia creeper (11.1%) being the most abundant species. This species is also an indicator species based on results of the ecological indicator analysis (Table 3).

Perhaps the most distinguishing vegetation layer between West Kill main stem floodplain forests and beech-maple mesic forests lies in the herbaceous layer. Several of the most abundant species within the floodplain forests, garlic mustard (*Alliaria petiolata*), Virginia waterleaf (*Hydrophyllum virginianum*), and jack-in-the-pulpit (*Arisaema triphyllum*) were considered indicator species based on results from the ecological indicator analysis (Table 3). Other typical species, wood nettle (*Laportea canadensis*) and common cow parsnip (*Heracleum maximum*), were not found in beech-maple mesic forests, or if were found, were scarce. On the other hand, many species most abundant within beech-maple mesic forests such as Canada mayflower (*Maianthemum canadense*), hay-scented fern (*Dennstaedtia punctilobula*), intermediate fern (*Dryopteris intermedia*), spinulose fern (*Dryopteris carthusiana*), oak fern (*Gymnocarpium dryopteris*), New York fern (*Thelypteris noveboracensis*), and wood sorrel (*Oxalis montana*), were not found or were scarce throughout floodplain forests along the West Kill.

The examples of the high terrace floodplain forests along the West Kill riparian area were generally small, less than one hectare in size. Many of these small floodplain forests are in poor landscape position, which allows favorable conditions for invasive plants such as garlic mustard (*Alliaria petiolata*) to become abundant.

Floodplain Forest Species Composition (average from all plots sampled)

The tree canopy layer (29 m) has 68.8% cover with *Acer saccharum* (23.8%), *Fraxinus americana* (18.7%), *Prunus serotina* (4.1%), *Pinus strobus* (3.6%), *Tilia americana* (3.6%), and *Quercus rubra* (3.6%) as the most abundant species. *Platanus occidentalis*, *Populus tremuloides*, *Acer rubrum*, *Betula alleghaniensis*, *Acer rubrum*, *Pinus resinosa*, *Betula lenta*, and *Tsuga canadensis* comprise less than two percent of the overall layer.

The tree subcanopy layer (21.3 m) has 49.7% cover and *Acer saccharum* (21.9%), *Fraxinus americana* (8.9%), *Betula alleghaniensis* (4.9%), *Acer rubrum* (3.4%), *Tilia americana* (2.4%), and *Prunus serotina* (2.1%), as the most abundant species. *Fraxinus pennsylvanica*, *Ulmus americana*, *Quercus rubra*, *Celtis occidentalis*, *Acer negundo*, *Acer pensylvanicum*, *Betula lenta*, *Ostrya virginiana*, *Carpinus caroliniana*, *Pinus resinosa*, and *Tsuga canadensis* comprise less than two percent of the overall layer.

The tall shrub layer (5.7 m) has 40.3% cover and *Carpinus caroliniana* (20.4%), *Acer saccharum* (6.7%), *Salix nigra* (4.4%), and *Ostrya virginiana* (3.1%) as the most abundant species. *Fraxinus americana*, *Tsuga canadensis*, *Platanus occidentalis*, *Fagus grandifolia*, *Ulmus americana*, *Acer pensylvanicum*, *Acer spicatum*, *Carya ovata*, *Quercus rubra*, *Ulmus rubra*, *Carya glabra*, *Acer rubrum*, *Betula alleghaniensis*, *Hamamelis virginiana*, *Prunus virginiana*, *Tilia americana*, and *Fraxinus nigra* comprise less than two percent layer.

The short shrub layer (0.9 m) has 40.5% cover and *Carpinus caroliniana* (7.3%), *Acer saccharum* (6.4%), *Fraxinus americana* (4.4%), *Berberis thunbergii* (3.0%), *Rubus allegheniensis* (2.7%), *Lonicera tatarica* (2.1%), *Acer pensylvanicum* (2.0%), *Prunus virginiana* (2.0%) as the most abundant species. *Rubus occidentalis*, *Prunus serotina*, *Rosa multiflora*, *Fagus grandifolia*, *Rubus pubescens*, *Rumex acetosella*, *Ostrya virginiana*, *Sambucus racemosa*, *Ulmus americana*, *Tilia americana*, *Ribes lacustre*, *Acer rubrum*, *Rubus flagellaris*, *Cornus racemosa*, *Tsuga canadensis*, *Populus deltoides*, *Lonicera morrowii*, *Carya ovata*, and *Ribes americanum* comprise less than two percent of the overall layer.

The vine layer (0.8 m) has 15.8% cover and *Parthenocissus quinquefolia* (11.1%), and *Toxicodendron radicans* (3.4%) as the most abundant species. *Mikania scandens*, *Polygonum* sp., *Clematis* sp., *Vitis riparia*, *Amphicarpaea bracteata*, and *Solanum dulcamara* comprise less than two percent of the overall layer.

The herbaceous layer (0.4 m) has 58.8% cover and *Alliaria petiolata* (8.3%), *Hydrophyllum virginianum* (7.9%), *Arisaema triphyllum* (4.8%), *Laportea canadensis* (4.1%), *Athyrium filix-femina* (2.8%), *Heracleum maximum* (2.5%), *Leersia virginica* (2.5%), *Ageratina altissima* (2.4%), *Eurybia divaricata* (2.4%), *Boehmeria cylindrica* (2.2%), *Solidago canadensis* (2.2%), *Matteuccia struthiopteris* (2.1%), and *Maianthemum canadense* (2.0%) as the most abundant species. *Thalictrum pubescens*, *Impatiens capensis*, *Polystichum acrostichoides*, *Hydrocotyle americana*, *Elymus hystrix*, *Geranium robertianum*, *Veratrum viride*, *Onoclea sensibilis*, *Symphyotrichum* sp., *Carex platyphylla*, *Circaea lutetiana*, *Geum aleppicum*, *Persicaria virginiana*, *Gymnocarpium dryopteris*, *Tiarella cordifolia*, *Carex lacustris*, *Vinca minor*, *Trientalis borealis*, *Poa alsodes*, *Barbarea vulgaris*, *Symphyotrichum novi-belgii*, *Carex plantaginea*, *Cardamine concatenata*, *Ranunculus recurvatus*, *Galium mollugo*, *Carex echinata*, *Solidago arguta*, *Maianthemum racemosum*, *Trillium erectum*, *Arabis caucasica*, *Satureja hortensis*, *Carex radiata*, *Dryopteris carthusiana*, *Euthamia graminifolia*, *Epipactis helleborine*, *Fallopia japonica*, *Urtica dioica*, *Dryopteris marginalis*, *Symphyotrichum prenanthoides*, *Prenanthes altissima*, *Carex swanii*, *Cinna arundinacea*, *Oxalis montana*, *Lysimachia nummularia*, *Lobelia cardinalis*, *Thalictrum revolutum*, *Chelone glabra*, *Carex tribuloides*, *Carex atlantica*, *Stellaria pubera*, *Prenanthes alba*, *Monotropa uniflora*, *Mitchella repens*, *Glyceria striata*, *Glyceria canadensis*, *Geum canadense*, *Monotropa uniflora*, and *Eutrochium maculatum* comprise less than two percent of the overall layer.

Plots and Ranking of Factors

Table 17: Floodplain forest Plot Quality Rank Summary Table

Plot	% Native Species	Size Structure	Hydrological regime	Species condition	Coarse Woody Debris	Disturbances	Size of natural community	Estimated size of surrounding natural landscape	% of natural habitat (within 1km)	Distance to nearest paved road	TOTAL RANK SUM	RANK SCORE QUALITY
WK91G	2	3	1	1	2	1	3	2	1	1	17	Excellent
WK15B	2	2	1	1	3	3	2	2	2	1	19	Excellent
WK12H	1	3	2	1	4	2	3	2	1	1	20	Good
WK34E	2	3	2	2	3	1	3	2	1	1	20	Good
WK13B	1	3	1	2	3	2	3	2	2	1	20	Good
WK56C	1	3	1	2	3	2	3	3	2	1	21	Good
WK91E	2	3	1	1	4	2	3	2	1	3	22	Good
WK17J	3	4	1	1	2	3	3	2	2	2	23	Good
WK91B	3	3	1	2	3	3	2	2	2	3	24	Good
WK15D	3	3	2	1	4	3	3	2	2	2	25	Good
WK56D	2	3	1	1	4	2	3	4	2	4	26	Fair
WK56E	1	3	1	3	3	3	3	3	2	4	26	Fair
WK78E	3	2	1	3	2	3	3	3	2	4	26	Fair
WK17A	2	3	1	3	4	3	3	3	2	2	26	Fair
WK19F	2	3	1	3	4	3	3	4	2	2	27	Fair

Table 18: Floodplain forest Plot Quality Rank System/Plant Stewardship Index Quality (Conservation Coefficient) Summary Table.

PLOT	+PQRS Rank	*PSI (adjusted)	**PSI Mean coefficient	***Difference between PSI and PQRS
WK91G	17	27.78	5.45	10.78
WK12H	20	30.01	6.13	10.01
WK13B	20	28.56	5.30	8.56
WK56E	26	34.51	5.91	8.51
WK15B	19	25.80	4.30	6.8
WK34E	20	24.60	4.39	4.60
WK56C	21	24.37	5.45	3.37
WK56D	26	29.19	5.50	3.19
WK91B	24	23.21	4.84	-0.79
WK17J	23	21.34	4.23	-1.66
WK91E	22	19.88	5.13	-2.12
WK78E	26	22.86	4.62	-3.14
WK19F	27	23.67	4.18	-3.33
WK17A	26	21.82	4.00	-4.18
WK15D	25	19.18	3.07	-5.82

+ Plot Quality Rank System final rank of biotic, abiotic, and landscape factors (lower score constitutes higher quality ranking plot).
* Plant Stewardship Index (adjusted) (higher score indicates higher diversity and quality)
** Plant Stewardship Index mean-average of all scores of plants found in plot (higher score indicates more species with higher ranks).
******* Difference between PSI and PQRS (since low score of PQRS indicates high quality, and high score of PSI indicates high quality, the difference between these two could indicate a final "quality" ranking between biotic, abiotic, landscape, and floral rank factors).
Plots selected as reference examples are highlighted in yellow

Floodplain Forest Discussion/Recommendations

According to the results of the PQRS and PSI, plots WK91G and WK12H appear to be the best overall candidates for a natural community reference for floodplain forests along the West Kill main stem. These plots are attributed to NVC type "CEGL006114 *Acer saccharum - Fraxinus* spp. - *Tilia americana / Matteuccia struthiopteris - Ageratina altissima* forest (Grossman *et al.* 1998). This NVC type is crosswalked to "floodplain forest" for New York. This NVC type fits fairly well with the plots labeled as floodplain forest. These plots are located adjacent to the West Kill on flat topography, but the vegetation is much more indicative of an upland forest. In addition, typical shrub species described in CEGL006114, *Corylus americana*, *Viburnum lentago*, and *Prunus virginiana*, are missing from all plots. The results of the PSI show that many species in these plots have conservation coefficients of 7 or higher (Tables 10 and 11). Examples of these species include *Acer pensylvanicum*, *Acer spicatum*, *Athyrium filix-femina*, *Carex plataginea*, *Caulophyllum thalictroides*, *Fraxinus americana*, *Hamamelis virginiana*, *Hydrophyllum virginianum*, *Ostrya virginiana*, *Polystichum acrostichoides*, *Rubus pubescens*, *Taxus canadensis*, *Tiarella cordifolia*, *Tilia americana*, *Trientalis borealis*, and *Trillium erectum*. These species are associated plants within floodplain forests with either a poor range of ecological tolerances or with a high degree of fidelity to a narrow range of habitats (Tables 10 and 11). The overall PSI's of 27.78 and 30.01 indicate that these plots are comprised of high quality plant species.

The overall PQRS rank sums of plots WK12H (17) and WK91G (20) indicate that these areas are within high quality natural areas. Three other plots, WK34E, WK15B, and WK13B, also had equally high quality PQRS rank sums, but their overall PSI and mean conservation coefficient was lower. Still, these plots indicate high quality and could be used as natural community references. The high quality of Plot WK91G is attributed to 1) a very high percentage of natural habitat within 1 kilometer, 2) relatively far distance to nearest paved road, 3) large size of surrounding natural community, 4) excellent species condition, and 5) little to no disturbances. The high quality of Plot WK12H is attributed to 1) a very high percentage of native species, 2) excellent species condition, 3) a very high percentage of natural habitat within 1 kilometer, and 4) far distance to nearest paved road. These two plots also have the largest difference between the PSI (high scores), and PQRS (low scores). Despite the fact that other plots scored high on both PQRS or PSI, plots WK91G and WK12H represent the best examples for natural community references for floodplain forests. Below is a summary of the biotic and abiotic characteristics of this plot and these are recommendations along with the floral composition in the final "expression" of this type (Table 12 and 13).

Given an existing set of biotic and abiotic conditions along the West Kill, alluvial terrace floodplain forests will continue to mature and thrive as an ecological unit. However, any major hydrologic changes would ultimately affect species composition; higher stream levels would increase flooding frequency, making favorable conditions for plant species more tolerant of frequent flooding. It is not known whether current canopy tree species would continue to thrive under extreme hydrological changes, but it is possible that different canopy species may emerge from such changes. Tree canopy floodplain forest species such as American sycamore (*Platanus occidentalis*), and eastern cottonwood (*Populus deltoides*), both documented in very small amounts along the West Kill main stem, would benefit from a higher flooding frequency. If stream levels would lower, canopy species are likely to remain, but the mesic understory may be replaced by upland beech-maple mesic forest understory species (CEGL006252 or CEGL006211).

Figure 10. Location of Floodplain forest **Plot WK12H**

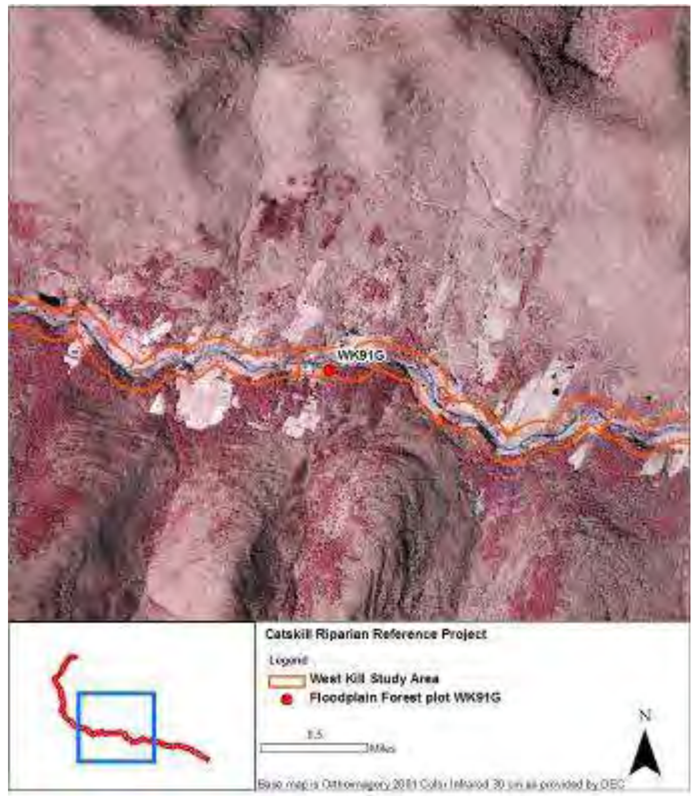

Figure 11. Location of Floodplain forest Plot **WK91G**

Figure 12. Floodplain forest **Plot WK12H**

Figure 13. Floodplain forest **Plot WK91G**

Table 19: Floodplain forest **Plot WK91G** species and PSI Conservation Coefficient (as developed in New Jersey)

Species	**Common name**	**PSI Coefficient**
Acer pensylvanicum	Striped maple	N 7
Acer spicatum	Mountain maple	N 8
Acer saccharum	Sugar maple	N 5
Alliaria petiolata	Garlic mustard	I 0
Arisaema triphyllum	Jack-in-the-pulpit	N 5
Athyrium filix-femina var. *angustum*	Northern lady fern	N 7
Carex plataginea	Plaintain sedge	N 10
Carpinus caroliniana	Musclewood	N 7
Circaea lutetiana ssp. *canadensis*	Enchanter's nightshade	N 6
Eurybia divaricata	White wood aster	N 4
Fraxinus americana var. *americana*	White ash	N 7
Galium mollugo	White bedstraw	I 0
Geranium robertianum	Herb-robert	N 4
Gymnocarpium dryopteris	Common oak fern	N 10
Hamamelis virginiana	Witch-hazel	N 7
Hydrocotyle americana	Marsh pennywort	N 5
Hydrophyllum virginianum	Virginia waterleaf	N 9
Impatiens capensis	Jewelweed	N 2
Leersia virginiana	Cutgrass/white grass	N 3
Lysimachia nummularia	Moneywort	I 0
Maianthemum canadense	Canada mayflower	N 4
Ostrya virginiana	Hop-hornbeam	N 7
Oxalis montana	Mountain wood-sorrel	N ?
Prunus serotina	Black cherry	N 1
Taxus canadensis	Canada yew	N 10
Thalictrum pubescens	Tall meadow-rue	N 5
Tiarella cordifolia	Foamflower	N 10
Tilia americana	American basswood	N 7
Trientalis borealis	Star-flower	N 7
Trillium erectum	Wake-robin	N 8

*** N=Native, I=Introduced**

Table 20: Floodplain forest **Plot WK12H** species and PSI Conservation Coefficient (as developed in New Jersey)

Species	**Common name**	**PSI Coefficient**
Acer pensylvanicum	Striped maple	N 7
Acer rubrum	Red maple	N 3
Acer saccharum	Sugar maple	N 5
Arisaema triphyllum	Jack-in-the-pulpit	N 5
Athyrium filix-femina var. *angustum*	Northern lady fern	N 7
Caulophyllum thalictroides	Blue cohosh	N 9
Eupatorium rugosum	White snake-root	N 3
Fraxinus americana var. *americana*	White ash	N 7
Galium concinnum	Shining bedstraw	N 10
Hamamelis virginiana	Witch-hazel	N 7
Hydrophyllum virginianum	Virginia waterleaf	N 9
Laportea canadensis	Wood-nettle	N 6
Leersia virginiana	Cutgrass/white grass	N 3
Maianthemum racemosum	False solomon's seals	N 5
Ostrya virginiana	Hop-hornbeam	N 7
Poa alsodes	Woodland bluegrass/grove bluegrass	N 9
Prunus serotina	Black cherry	N 1
Quercus rubra	Red oak	N 7
Rubus allegheniensis	Common blackberry	N 3
Rubus pubescens	Dwarf blackberry	N 9
Thalictrum pubescens	Tall meadow-rue	N 5
Tiarella cordifolia	Foamflower	N 10
Trillium erectum	Wake-robin	N 8
Veratrum viride	False hellebore	N 7

*** N=Native, I=Introduced**

Table 21: Floodplain forest Plot **WK12H** growth life form summary

Growth life form	Cover %	Average height (meters)
T2 (Tree canopy >5m)	55%	28 m
T3 (Tree sub-canopy >5m)	55%	17 m
S1 (Tall shrub 2-5m, tree saplings)	20%	3.1 m
S2 short shrub (<2m) include tree seedlings	75%	1.3 m
V Vine/liana	0	0
H (Herbaceous)	50%	0.5 m

Table 22: Floodplain forest **Plot WK19G** growth life form summary

Growth life form	Cover %	Average height (meters)
T2 (Tree canopy >5m)	75%	28 m
T3 (Tree sub-canopy >5m)	30%	20 m
S1 (Tall shrub 2-5m, tree saplings)	28%	10 m
S2 short shrub (<2m) include tree seedlings	8%	0.2 m
V Vine/liana	0	0
H (Herbaceous)	70%	0.3 m

Table 23: Floodplain forest **Plot WK12H** abiotic characteristics summary

Unvegetated surface	30% small rocks, 5% litter duff
Stoniness	Very stony (15-50%)
Soil type	Sandy loam
Soil drainage	Somewhat poorly drained

Table 24: Floodplain forest **Plot WK91G** abiotic characteristics summary

Unvegetated surface	5% small rocks, 12% litter duff, 8% wood >1 cm
Stoniness	Stony (1-14%)
Soil type	Sandy loam
Soil drainage	Somewhat poorly drained

Beech-Maple Mesic Forest Description

This upland forest type was most frequently found closer to the headwaters section of the West Kill main stem, occurring along gentle slopes ranging from 1 to 10 degrees up from the stream. Beech-maple mesic forests tended to occur on sandy loam soils and ranged from stone free to 70% stony within the delineated plot area. The species composition was quite similar to floodplain forests within the tree canopy and tree subcanopy layers. However, yellow birch (*Betula alleghaniensis*) was a fairly significant component of beech-maple mesic forests (16.2%, percentage of combined canopy layers), but comprised a relatively small percentage (6.0%) of the combined canopy layers of floodplain forests. The herbaceous layer consists of Canada mayflower (*Maianthemum canadense*), Northern lady fern (*Athyrium filix-femina*), hay-scented fern (*Dennstaedtia punctilobula*), and Intermediate fern (*Dryopteris intermedia*). See below for full species composition of beech-maple mesic forests.

The beech-maple mesic forest encountered along the West Kill main stem is part of a high quality statewide significant example for this natural community type. This extensive beech-maple mesic forest is a large occurrence that varies from excellent to moderate condition. This beech-maple mesic forest also has excellent connectivity to other patches of the same community type and amidst a very large greater interconnected ecosystem (Howard & Gebauer 2001). The occurrences of beech-maple mesic forests along the West Kill main stem contained more a more mesic and richer suite of species that was documented on the low slopes of Hunter, Westkill, and Rusk mountains and all associated peaks. It is also possible that the beech-maple mesic forest example along the West Kill main stem headwaters may be, in part, in better ecological condition than at least some of the mountain examples that have a long history of logging (Howard & Gebauer 2001). The headwaters is part of an extensive and relatively undisturbed forest contributing greatly to the excellent ecological condition of most plots labeled beech-maple mesic forests within this area.

Beech-Maple Mesic Forest Species Composition (average from all plots sampled)

The tree canopy layer (29.2 m) has 60.5% cover and *Acer saccharum* (22.6%), *Fraxinus americana* (10.4%), *Prunus serotina* (9.7%), *Betula alleghaniensis* (8.8%), and *Populus tremuloides* (3.3%) as the most abundant species. *Acer rubrum*, *Quercus rubra*, *Tsuga canadensis*, *Fagus grandifolia*, *Betula papyrifera*, and *Picea rubens* comprise less than two percent of the overall layer.

The tree subcanopy layer (20.4 m) has 58.7% cover and *Acer saccharum* (23.4%), *Betula alleghaniensis* (7.4%), *Fraxinus americana* (5.9%), *Acer pensylvanicum* (4.4%), *Ostrya virginiana* (4.3%), *Prunus serotina* (3.8%), *Acer rubrum* (2.8%), and *Fagus grandifolia* (2.7%) as the most abundant species. *Acer spicatum*, *Tsuga canadensis*, *Carpinus caroliniana*, *Amelanchier* sp., *Picea rubens*, *Quercus rubra*, *Amelanchier arborea*, and *Betula lenta* comprise less than two percent of the overall layer.

The tall shrub layer (5.7 m) has 39.1% cover and *Acer saccharum* (9.6%), *Acer pensylvanicum* (8.1%), *Fagus grandifolia* (6.1%), *Carpinus caroliniana* (5.7%), and *Hamamelis virginiana* (2.5%) as the most abundant species. *Ostrya virginiana*, *Picea rubens*, *Prunus serotina*, *Fraxinus americana*, *Betula alleghaniensis*, *Acer rubrum*, *Ulmus americana*, *Fraxinus pennsylvanica*, *Tilia americana*, *Tsuga canadensis*, *Amelanchier* sp., and *Carya ovata* comprise less than two percent of the overall layer.

The short shrub layer (1.1 m) has 42.3% cover and *Rubus allegheniensis* (6.7%), *Acer pensylvanicum* (6.5%), *Acer saccharum* (5.8%), *Rubus* sp. (3.8%), *Carpinus caroliniana* (3.4%), *Fagus grandifolia* (3.2%) and *Picea rubens* (3.1%) as the most abundant species. *Fraxinus americana*, *Prunus serotina*, *Prunus pensylvanica*, *Ostrya virginiana*, *Corylus americana*, *Cornus alternifolia*, *Ribes americanum*, *Rubus pubescens*, *Picea* sp., *Euonymus* sp., *Tsuga canadensis*, *Rubus occidentalis*, *Rubus flagellaris*, *Ribes* sp., *Amelanchier* sp., *Acer rubrum*, *Betula alleghaniensis*, *Pinus strobus*, *Picea abies*, *Viburnum lantanoides*, *Quercus rubra*, *Crataegus* sp., *Ulmus americana*, *Acer spicatum*, *Carya ovata*, *Sambucus racemosa*, *Lonicera tatarica*, *Populus tremuloides*, *Cornus racemosa*, *Berberis vulgaris* comprise less than two percent of the overall layer.

The vine layer (2.1 m) has 1.9% cover with *Parthenocissus quinquefolia* (0.1%) and *Vitis riparia* (0.1%) as the characteristic species.

The herbaceous layer (0.3 m) has 51.1% cover and *Maianthemum canadense* (11.8%), *Athyrium filix-femina* (3.2%), *Dennstaedtia punctilobula* (3.0%), and *Dryopteris intermedia* (2.5%) as the most abundant species. *Dryopteris carthusiana*, *Leersia virginica*, *Ageratina altissima*, *Carex debilis*, *Aralia nudicaulis*, *Polystichum acrostichoides*, *Poa alsodes*, *Gymnocarpium dryopteris*, *Arisaema triphyllum*, *Thalictrum pubescens*, *Solidago* sp., *Thelypteris noveboracensis*, *Oxalis montana*, *Dryopteris marginalis*, *Polygonatum biflorum*, *Mitchella repens*, *Phegopteris connectilis*, *Onoclea sensibilis*, *Galium mollugo*, *Trientalis borealis*, *Potentilla* sp., *Tiarella cordifolia*, *Eurybia divaricata*, *Dryopteris* sp., *Osmunda claytoniana*, *Carex* sp., *Symphyotrichum* sp., *Medeola virginiana*, *Glyceria striata*, *Veratrum viride*, *Viola* sp., *Maianthemum racemosum*, *Solidago caesia*, *Trillium undulatum*, *Symphyotrichum novi-belgii*, *Carex plantaginea*, *Epipactis helleborine*, *Alliaria petiolata*, *Angelica atropurpurea*, *Elymus hystrix*, *Galium asprellum*, *Geum canadense*, *Prenanthes* sp., *Carex swanii*, *Circaea lutetiana*, *Sanguinaria canadensis*, *Galium concinnum*, *Senecio* sp., *Poa* sp., *Trillium erectum*, *Carex echinata*, *Lycopodiella* sp, *Uvularia perfoliata*, *Caulophyllum thalictroides*, *Dendranthema* sp., *Diphasiastrum digitatum*, *Satureja hortensis*, *Carex tribuloides*, *Hydrophyllum virginianum*, *Erythronium americanum*, *Solidago arguta*, *Dicentra cucullaria*, *Geranium robertianum*, *Osmunda cinnamomea*, *Equisetum palustre*, *Ribes lacustre*, and *Oxalis stricta*, *Hepatica nobilis, Actaea pachypoda*, *Geum aleppicum*, *Persicaria arifolia*, *Geranium bicknellii*, *Carex trisperma*, *Carex vulpinoidea*, *Impatiens capensis*, and *Monotropa uniflora* comprised less than two percent of the overall layer.

Plots and Ranking of Factors

Table 25: Beech-maple mesic forest Plot Quality Rank Summary Table:

Plot	% Native Species	Size structure	Species condition	Coarse Woody Debris	Disturbances	Size of natural community	Estimated size of surrounding natural landscape	% of natural habitat (within 1km)	Distance to nearest paved road	TOTAL RANK SUM	RANK SCORE QUALITY
WK12A	1	2	1	3	1	2	1	1	1	13	Excellent
WK12D	1	3	1	2	1	2	1	1	1	13	Excellent
WK12C	1	3	1	3	1	2	1	1	1	14	Excellent
WK12E	1	3	1	3	1	2	1	1	1	14	Excellent
WK12B	1	3	1	2.5	2	2	1	1	1	14.5	Excellent
WK12F	2	3	1	2	1	2	2	1	1	15	Excellent
WK12G	1	3	1	3	1	3	1	1	1	15	Excellent
WK19E	1	3	1	2	2	2	2	2	2	17	Excellent
WK56B	1	3	1	2	1	2	3	2	2	17	Excellent
WK17G	1	3	1	4	1	3	1	2	1	17	Excellent
WK17M	2	3	1	3	2	4	1	2	1	19	Excellent
WK78F	1	3	1	2	2	4	2	1	3	19	Excellent
WK14C	1	2	1	2	2	4	2	2	3	19	Excellent
WK19G	1	3	1	4	1	4	1	2	2	19	Excellent
WK13C	1	3	2	2	2	4	1	2	1	19	Excellent
WK12I	2	3	3	3	2	4	3	1	1	21	Good

Table 26: Beech-maple mesic forest Plot Quality Rank System/Plant Stewardship Index Quality (Conservation Coefficient) Summary Table.

PLOT	+PQRS Rank	*PSI (adjusted)	**PSI Mean coefficient	***Difference between PSI and PQRS
WK12A	13	35.03	6.74	22.03
WK12C	14	30.41	6.19	16.41
WK56B	17	31.75	6.11	14.75
WK12F	15	29.19	5.72	14.19
WK13C	19	32.68	5.68	13.68
WK12E	14	27.28	6.1	13.28
WK19G	19	31.60	5.45	12.6
WK19E	17	29.48	5.29	12.48
WK14C	19	31.38	5.83	12.38
WK12B	14.5	26.19	6.35	11.69
WK78F	19	30.44	6.08	11.44
WK12D	13	23.40	5.37	10.40
WK12G	15	24.75	5.83	9.75
WK17M	19	26.38	5.63	7.38
WK17G	17	23.24	6.00	6.24
WK12I	21	17.47	4.37	-3.53

+ Plot Quality Rank System final rank of biotic, abiotic, and landscape factors (lower score constitutes higher quality ranking plot).
* Plant Stewardship Index (adjusted) (higher score indicates higher diversity and quality)
** Plant Stewardship Index mean-average of all scores of plants found in plot (higher score indicates more species with higher ranks).
******* Difference between PSI and PQRS (since low score of PQRS indicates high quality, and high score of PSI indicates high quality, the positive difference between these two could indicate a final "quality" ranking between biotic, abiotic, landscape, and floral rank factors).
Plot selected as reference examples are highlighted in yellow

Beech-Maple Mesic Forest Discussion/Recommendations

According to the results of the PQRS and PSI, plots WK12A and WK12C appear to be the best overall candidates for a natural community reference for beech-maple mesic forests along the West Kill main stem (Tables 25 and 26). These two plots are attributed to NVC type "CEGL006211–*Acer saccharum - (Fraxinus americana) / Arisaema triphyllum* forest" (Grossman *et al.* 1998). This NVC type fits fairly well with many other plots along the West Kill main stem labeled as beech-maple mesic forest. Some beech-maple mesic forest plots, however, were attributed with NVC type "CEGL006252–*Acer saccharum - Betula alleghaniensis - Fagus grandifolia / Viburnum lantanoides* Forest" (Grossman *et al.* 1998). The difference between NVC types CEGL006252 and CEGL006211 is attributed to the amount of enriched indicator plant species that are typical for each type. CEGL006252, the typical "northern hardwood forest", contains less rich indicator species such as yellow trout lily (*Erythronium americanum*), and jack-in-the-pulpit (*Arisaema triphyllum*) compared with NVC type CEGL006211. CEGL006252 is associated with the statewide significant expression of beech-maple mesic forests found in the Catskill Mountain (Howard & Gebauer 2001). Within this large and significant forest are inclusions of a richer beech-maple mesic forest NVC type, CEGL006211, and perhaps others. These inclusions appeared to be common throughout the extent of the West Kill main stem. Hence, there are two NVC types attributed to beech-maple mesic forests along the West Kill.

The results of the PSI show that many species documented in these two plots have conservation coefficients of 7 or higher (Tables 27 and 28). Examples of these species include *Acer pensylvanicum*, *Acer spicatum*, *Caulophyllum thalictroides*, *Cornus alternifolia*, *Dicentra cucullaria*, *Dryopteris marginalis*, *Fagus grandifolia*, *Fraxinus americana*, *Hamamelis virginiana*, *Hydrophyllum virginianum*, *Ribes lacustre*, *Tiarella cordifolia*, *Trientalis borealis*, and *Viburnum lantanoides* are associated plants with either a poor range of ecological tolerances or with a high degree of fidelity to a narrow range of habitats (Tables 27 and 28). The overall PSI's of 35.03 and 30.41 indicate that these plots and surrounding area are comprised of high quality plant species.

The overall PQRS rank sums of plots WK12A (13) and WK12C (14) indicate that they are located within high quality natural areas. Many other plots labeled beech-maple mesic forests, WK12B, WK12D, WK12E, WK12F, and WK12G also had equally good PQRS rank sums, but their overall PSI and mean conservation coefficient were generally lower than plots WK12A and WK12C. All of the plots labeled within section "WK12" occurred closest to the headwaters section of the West Kill main stem, and the undisturbed surrounding habitat was a major factor in the overall high quality PQRS scores. The high quality of plots WK12A and WK12C is attributed to 1) high percentage of native species, 2) a very high percentage of natural habitat within 1 kilometer, 3) far distance to nearest paved road, 4) large size of surrounding natural community, 5) excellent species condition, and 6) little to no disturbances. These two plots have the largest difference between the PSI (high scores), and PQRS (low scores).Therefore, these plots indicate high quality and could be used as natural community references. Despite the fact that other plots scored high on PQRS or/and PSI, plots WK12A and WK12C represent the best overall candidates for natural community references for beech-maple mesic forests. Below is a summary of biotic and abiotic characteristics of this plot and these are recommendations along with the floral composition in the final "expression" of this type (Tables 29-32).

Given an existing set of biotic and abiotic conditions along the West Kill, beech-maple mesic forests will continue to mature and thrive as an ecological unit. However, American beech (*Fagus grandifolia*), a species that is already currently in a slow long-term decline due to a scale insect (*Cryptococcus fagisuga*), may not be a viable member of a beech-maple mesic forest (CEGL006252) in the future. Climate change, invasive species that include insect outbreaks, and soil and moisture changes, are just some of the factors that could lead to future alterations of this natural community type.

Figure 14. Location of Beech-maple mesic forest **Plots WK12A** and **WK12C**

Figure 15. Beech-maple mesic forest Plot **WK12A** (left) and **Plot WK12C** (right)

Table 27: Beech-maple mesic forest **Plot WK12A** species and PSI Conservation Coefficient (as developed in New Jersey)

Species	**Common name**	**PSI Coefficient**
Acer pensylvanicum	Striped maple	N 7
Acer saccharum	Sugar maple	N 5
Aralia nudicaulis	Wild sarsaparilla	N 5
Arisaema triphyllum	Jack-in-the-pulpit	N 5
Caulophyllum thalictroides	Blue cohosh	N 9
Dicentra cucullaria	Dutchman's-breeches	N 9
Dryopteris marginalis	Marginal wood fern	N 9
Erythronium americanum	Yellow trout-lily	N 5
Fagus grandifolia	American beech	N 8
Fraxinus americana var. *americana*	White ash	N 7
Galium concinnum	Shining bedstraw	N 10
Geranium robertianum	Herb-robert	N 4
Glyceria striata	Fowl mannagrass	N 3
Maianthemum racemosum	False solomon's seals	N 5
Oxalis montana	Mountain wood-sorrel	N ?
Picea rubens	Red spruce	N 10
Polygonatum biflorum var. biflorum	Solomon's-seal	N 8
Polystichum acrostichoides	Christmas fern	N 7
Prunus serotina	Black cherry	N 1
Ribes lacustre	Swamp gooseberry	N 10
Sambucus racemosa	American elder	N 2
Rubus alleghaniensis	Common blackberry	N 3
Spiraea alba var. alba	meadowsweet	N 10
Thalictrum pubescens	Tall meadow-rue	N 5
Tiarella cordifolia	Foamflower	N 10
Trientalis borealis	Star-flower	N 7
Uvularia perfoliata	bellwort	N 8

*** N=Native, I=Introduced**

Table 28: Beech-maple mesic forest **Plot WK12C** species and PSI Conservation Coefficient (as developed in New Jersey)

Species	**Common name**	**PSI Coefficient**
Acer rubrum	Red maple	N 3
Acer saccharum	Sugar maple	N 5
Acer spicatum	Mountain maple	N 8
Aralia nudicaulis	Wild sarsaparilla	N 5
Arisaema triphyllum	Jack-in-the-pulpit	N 5
Betula alleghaniensis	Yellow birch	N 10
Carex debilis var. debilis	White edged sedge	N 6
Cornus alternifolia	Alternate-leaved dogwood	N 8
Dicentra cucullaria	Dutchman's-breeches	N 9
Dryopteris marginalis	Marginal wood fern	N 9
Fraxinus americana var. *americana*	White ash	N 7
Geum aleppicum	Yellow avens	N 9
Hamamelis virginianum	Witch-hazel	N 7
Hydrophyllum virginiana	Virginia waterleaf	N 9
Leersia virginica	Cutgrass/white grass	N 3
Maianthemum racemosum	False solomon's seals	N 5
Medeola virginiana	Indian cucumber-root	N 8
Oxalis montana	Mountain wood-sorrel	N ?
Picea abies	Norway spruce	I 0
Polygonatum biflorum var. biflorum	Solomon's-seal	N 8
Prunus serotina	Black cherry	N 1
Ribes americanum	Wild black currant	N 8
Sambucus racemosa	American elder	N 2
Rubus alleghaniensis	Common blackberry	N 3
Spiraea alba var. alba	meadowsweet	N 10
Thalictrum pubescens	Tall meadow-rue	N 5
Tiarella cordifolia	Foamflower	N 10
Viburnum lantanoides	Hobble-bush	N 9

*** N=Native, I=Introduced**

Table 29: Beech-maple mesic forest **Plot WK12A** growth life form summary

Growth life form	**Cover %**	**Average height (meters)**
T2 (Tree canopy >5m)	65	31
T3 (Tree sub-canopy >5m)	55	22
S1 (Tall shrub 2-5m, tree saplings)	50	11
S2 short shrub (<2m) include tree seedlings	45	1.5
V Vine/liana	0	0
H (Herbaceous)	50	0.3

Table 30: Beech-maple mesic forest **Plot WK12C** growth life form summary

Growth life form	**Cover %**	**Average height (meters)**
T2 (Tree canopy >5m)	60	29
T3 (Tree sub-canopy >5m)	75	18
S1 (Tall shrub 2-5m, tree saplings)	40	3
S2 short shrub (<2m) include tree seedlings	70	0.4
H (Herbaceous)	0.3	65

Table 31: Beech-maple mesic forest **Plot WK12A** abiotic characteristics summary

Unvegetated surface	1% stones, 6% litter duff
Stoniness	Moderately stony
Soil type	Loamy sand
Soil drainage	Moderately well drained
Soil moisture	Moist

Table 32: Beech-maple mesic forest **Plot WK12C** abiotic characteristics summary

Unvegetated surface	Stones 1%, litter duff 35%, wood 5%
Slope	5 degrees
Slope aspect	210 degrees
Stoniness	Moderately stony
Soil type	Sandy loam
Soil drainage	Well-drained

Shrub Swamp Description

Six plots labeled as shrub swamps were found along the West Kill main stem in the summer of 2008. These shrub swamps occurred as clusters within wide stretches of the West Kill where many were found on small islands and gravel bars. Most of these shrub swamp expressions can be classified to NVC type "CEGL006065 - *Salix nigra/Carex torta* temporarily flooded shrubland"(Grossman *et al.* 1998). This NVC type is described as a willow shrubland of low riverbanks along moderate to high-energy rivers in the northeast and High Allegheny Plateau (Grossman *et al.* 1998). It occurs on cobble substrates with sand and gravel in areas that are typically flooded only during high-water events, but may receive winter ice-scour. This shrub dominated natural community occupies on intermediate position along disturbance gradient between open herbaceous cobble shores and higher terrace floodplain forests (Grossman *et al.* 1998). This NVC type fits fairly well with many other plots along the West Kill main stem labeled as shrub swamp. Only one plot, WK78C, located a further distance from most of the other plots within the shrub swamp group, was attributed loosely to NVC type "CEGL006576 *Cornus* (*amomum, sericea*) – *Viburnum dentatum* – *Rosa multiflora* Shrubland". The difference between CEGL006576 and CEGL006065 lies in the species dominating the site and substrate. CEGL006576 is a catch-all shrubland and wet meadow type consisting of gray dogwood (*Cornus racemosa*) and the substrate is typically mucky soils.

Shrub Swamp Species Composition (average from all plots sampled)

The tree subcanopy layer (19.3 m) has 5.3% cover and *Robinia pseudoacacia* (3.6%), *Platanus occidentalis* (1.4%), and *Prunus serotina* (0.3%) as the characteristic species.

The tall shrub layer (5.4 m) has 50.7% cover with *Salix* sp. (24.3%), *Salix nigra* (19.3%), *Prunus pensylvanica* (3.6%), and *Malus* sp. (2.1%) as the most abundant species. *Rhus typhina*, *Pinus strobus*, *Platanus occidentalis*, *Acer rubrum*, *Robinia pseudoacacia*, *Acer negundo*, *Carpinus caroliniana*, and *Alnus incana* comprise less than two percent of the overall layer.

The short shrub layer (1.5 m) has 29.3% cover and *Salix* sp. (17.4%), *Lonicera morrowii* (3.7%), and *Rosa multiflora* (2.9%) as the most abundant species. *Rubus occidentalis*, *Spiraea alba*, *Cornus racemosa*, *Rubus allegheniensis*, *Sambucus racemosa*, *Spiraea tomentosa*, *Populus deltoides*, *Salix nigra*, *Spiraea alba*, *Ulmus rubra*, and *Fraxinus americana* comprise less than two percent of the overall layer.

The vine layer (3.8 m) has 22.4% cover with *Vitis riparia* (7.9%), *Vitis* sp. (4.3%), *Clematis* sp. (4.0%), and *Parthenocissus quinquefolia* (3.3%) as the most abundant species. *Clematis virginiana*, *Mikania scandens*, *Polygonum* sp., and *Sicyos angulatus* comprise less than two percent of the overall layer.

The herbaceous layer (1 m) has 72.1% cover and *Onoclea sensibilis* (10.3%), *Impatiens capensis* (8.9%), *Solidago gigantea* (7.4%), *Phalaris arundinacea* (7.1%), *Eutrochium maculatum* (5.9%), *Solidago canadensis* (5.0%), *Tanacetum vulgare* (4.3%), *Lythrum salicaria* (4.1%), *Alliaria petiolata* (3.9%), *Leersia virginica* (3.6%), *Achillea millefolium* (2.9%), *Galium palustre* (2.7%), *Solidago altissima* (2.6%) and *Euthamia graminifolia* (2.1%) as the most abundant species. *Eupatorium perfoliatum*, *Rumex obtusifolius*, *Cinna latifolia*, *Centaurea jacea*, *Satureja hortensis*, *Rumex acetosella*, *Mentha arvensis*, *Lysimachia punctata*, *Verbena hastata*, *Stellaria pubera*, *Symphyotrichum puniceum*, *Apocynum cannabinum*, *Carex lacustris*, *Symphyotrichum novi-belgii*, *Symphyotrichum lanceolatum*, *Glyceria striata*, *Lycopus uniflorus*, *Carex stricta*, *Scirpus cyperinus*, *Leersia oryzoides*, *Eutrochium purpureum*, *Symphyotrichum* sp., *Persicaria arifolia*, *Calamagrostis canadensis*, *Stellaria* sp., *Matteuccia struthiopteris*, *Heracleum maximum*, *Vicia cracca*, *Juncus effusus*, *Oxalis stricta*, *Poa alsodes*, *Phleum pratense*, *Urtica dioica*, *Persicaria virginiana*, *Thalictrum pubescens*, *Oenothera biennis*, and *Solidago odora* comprise less than two percent of the overall layer.

Table 33: Shrub swamp Plot Quality Rank Summary Table:

Plots and Ranking of Factors

Plot	**% Native Species**	**Species condition**	**Disturbances**	**Hydrological regime**	**Size of natural community**	**Estimated size of surrounding natural landscape**	**% of natural habitat (within 1km)**	**Distance to nearest paved road**	**TOTAL RANK SUM**	**RANK SCORE QUALITY**
WK17H	3	1	1	1	2	1	2	1	12	Excellent
WK17L	3	1	1	1	2	1	2	1	12	Excellent
WK17B	3	1	1	1	3	3	2	1	15	Good
WK78C	2	1	2	1	4	2	2	2	16	Good
WK17F	3	1	2	1	4	3	2	1	17	Good
WK91C	3	1	2	1	4	2	2	3	18	Good

Table 34: Shrub swamp Plot Quality Rank System/Plant Stewardship Index Quality (Conservation Coefficient) Summary Table.

PLOT	**+PQRS Rank**	***PSI (adjusted)**	****PSI Mean coefficient**	*****Difference between PSI and PQRS**
WK17L	12	15.28	3.19	3.28
WK17H	12	14.39	3.39	2.39
WK17B	15	13.25	3.42	1.75
WK78C	16	11.07	3.07	-4.93
WK17F	17	6.44	1.94	-10.56
WK91C	18	5.36	1.79	-12.64

+ Plot Quality Rank System final rank of biotic, abiotic, and landscape factors (lower score constitutes higher quality ranking plot).
* Plant Stewardship Index (adjusted) (higher score indicates higher diversity and quality)
** Plant Stewardship Index mean-average of all scores of plants found in plot (higher score indicates more species with higher ranks).
******* Difference between PSI and PQRS (since low score of PQRS indicates high quality, and high score of PSI indicates high quality, the difference between these two could indicate a final "quality" ranking between biotic, abiotic, landscape, and floral rank factors).
Plots selected as reference examples are highlighted in yellow

Shrub Swamp Discussion/Recommendations

According to the results of the PQRS and PSI, plots WK17H and WK17L appear to be the best overall candidates for a natural community reference for shrub swamps along the West Kill main (Tables 33 and 34). These two plots are attributed to NVC type "CEGL006065 - *Salix nigra*/*Carex torta* temporarily flooded shrubland" (Grossman *et al.* 1998).

The results of the PSI show that several species documented in these two plots have conservation coefficients of 7 or higher (Tables 35 and 36). Examples of these species include *Alnus incana*, *Cinna latifolia*, *Carpinus caroliniana*, *Spiraea alba* var. *alba*, *Poa alsodes*, *Salix exigua*, and *Matteucia struthiopteris* are associated plants with either a poor range of ecological tolerances or with a high degree of fidelity to a narrow range of habitats (Tables 35 and 36). The overall PSI's of 15.28 and 14.39 of WK17L and WK17H, respectively, indicate that these plots and surrounding area are comprised of the highest quality plant species within the shrub swamp cluster group (Table 34).

The results of the PQRS show that plots WK17H and WK17L have 1) excellent species condition, 2) little or no disturbances, 3) large surrounding natural landscape and percent of natural habitat within 1 kilometer, and 4) occur relatively far from the nearest paved road. These factors along with a relatively high PSI make these plots the highest quality examples of shrub swamps along the West Kill main stem. Below is a summary of biotic and abiotic characteristics of this plot and these are recommendations along with the floral composition in the final "expression" of this type (Tables 37-40). According to the results, these plots could be used as natural community references for this area.

Assuming that the current suite of bioitic and abiotic conditions along the West Kill main stem remain stable, shrub swamps will likely continue to thrive as an ecological unit. However, it is likely that a change in ecological conditions will favor some species over others, resulting in possible succession of shrub swamps to early successional floodplain forests. It is difficult to determine the long-term viability of this natural community along the West Kill, but even without a major climatic shift, the inevitable change in natural processes along the West Kill is likely to influence species composition and structure of shrub swamps to a certain degree.

Figure 16. Locations of Shrub swamp plots **WK17H** and **WK17L**

Figure 17. Shrub swamp **Plots WK17L** (left) and **WK17H** (right)

Table 35: Shrub swamp **Plot WK17L** species and PSI Conservation Coefficient (as developed in New Jersey)

Species	**Common name**	**PSI Coefficient**
Acer negundo	Box-elder	N 2
Calamagrostis canadensis var. canadensis	Canada bluejoint	N 5
Carpinus caroliniana	Musclewood	N 7
Cinna latifolia	Drooping woodreed/Slender wood-reed	N 10
Clematis virginiana	Virgins-bower	N 5
Eupatorium maculatum	Spotted joe-pye-weed	N 5
Euthamia gramnifolia var. gramnifolia	Grass-leaved goldenrod	N 1
Leersia virginica	Cutgrass/white grass	N 3
Lonicera morrowii	Morrow's honeysuckle	I 0
Lysimachia ciliata	Fringed loosestrife	N 2
Lysimachia punctata	Spotted loosestrife	I 0
Matteuccia struthiopteris	Ostrich fern	N 6
Mikania scandens	Climbing hempweed	N 3
Onoclea sensibilis	Sensitive fern	N 2
Oxalis stricta	Common yellow wood-sorrel	N 0
Parthenocissus quinquefolia	Virginia creeper	N 1
Platanus occidentalis	American sycamore	N 4
Polygonum virginianum	Jumpseed	N 4
Prunus serotina	Wild black cherry	N 1
Rubus occidentalis	Black raspberry	N 1
Salix exigua	Sandbar willow	N 8
Satureja hortensis	Summer savory	I 0
Solidago gigantea var. gigantea	Smooth goldenrod	N 3
Tanacetum vulgare	Common tansy	I 0
Thalictrum pubescens	Tall meadow-rue	N 5
Vitis riparia	Frost grape/riverbank grape	N 4

*** N=Native, I=Introduced**

Table 36: Shrub swamp **Plot WK17H** species and PSI Conservation Coefficient (as developed in New Jersey)

Species	**Common name**	**PSI Coefficient**
Alnus incana	Speckled alder	N 6
Apocynum cannabinum var. cannabinum	Indian-hemp	N 2
Carex gynandra	Nodding sedge	N 5
Eupatorium maculatum	Spotted joe-pye-weed	N 5
Eupatorium perfoliatum	Boneset	N 3
Galium palustre	Marsh bedstraw	N 5
Impatiens capensis	jewelweed	N 2
Juncus effusus	Common rush	N 1
Lonicera morrowii	Morrow's honeysuckle	I 0
Lysimachia ciliata	Fringed loosestrife	N 2
Lysimachia punctata	Spotted loosestrife	I 0
Lythrum salicaria	Purple loosestrife	I 0
Mentha arvensis	Field mint	N 2
Onoclea sensibilis	Sensitive fern	N 2
Phalaris arundinacea	Reed-canary grass	I 0
Poa alsodes	Grove bluegrass	N 9
Robinia pseudoacacia	Black locust	I 0
Prunus serotina	Wild black cherry	N 1
Rubus occidentalis	Black raspberry	N 1
Salix exigua	Sandbar willow	N 8
Scirpus cyperinus	Wool-grass	N 2
Solidago gigantea var. gigantea	Smooth goldenrod	N 3
Spiraea alba var. alba	Meadowsweet	N 10
Tanacetum vulgare	Common tansy	I 0
Thalictrum pubescens	Tall meadow-rue	N 5
Verbena hastata	Blue vervain	N 3

*** N=Native, I=Introduced**

Table 37: Shrub swamp **Plot WK17H** growth life form summary

Growth life form	**Cover %**	**Average height (meters)**
T2 (Tree canopy >5m)	65	31
T3 (Tree sub-canopy >5m)	55	22
S1 (Tall shrub 2-5m, tree saplings)	50	11
S2 short shrub (<2m) include tree seedlings	45	1.5
V Vine/liana	0	0
H (Herbaceous)	50	0.3

Table 38: Shrub swamp **Plot WK17L** growth life form summary

Growth life form	**Cover %**	**Average height (meters)**
T2 (Tree canopy >5m)	65	31
T3 (Tree sub-canopy >5m)	55	22
S1 (Tall shrub 2-5m, tree saplings)	50	11
S2 short shrub (<2m) include tree seedlings	45	1.5
V Vine/liana	0	0
H (Herbaceous)	50	0.3

Table 39: Shrub swamp **Plot WK17H** abiotic characteristics summary

Unvegetated surface	8% water
Stoniness	Stone free
Soil type	Muck
Soil drainage	Somewhat poorly drained
Soil moisture regime	wet

Table 40: Shrub swamp **Plot WK17L** abiotic characteristics summary

Unvegetated surface	1% small rocks, 2% litter/duff
Stoniness	Moderately stony
Soil type	Muck
Soil drainage	Poorly drained
Soil moisture	Somewhat wet

Cobble Shore Description

Nine plots labeled as cobble shore were found along the West Kill main stem in the summer of 2008. These cobble shores were scattered throughout the entire stretch of the West Kill main stem. About half of the cobble shore plots were classified as NVC type "CEGL006536- *Carex torta - Apocynum cannabinum - Cyperus* spp. herbaceous vegetation", in which these plots were without a significant amount of willow (*Salix* spp.)(Grossman *et al.* 1998). The other half of these cobble shore communities contained a fairly significant amount of *Salix* spp., and these plots resulted in a similar classification of many of the shrub swamp natural community plots. Hence, several cobble shore communities contained enough *Salix* spp. to be classified as NVC type "CEGL006065 - *Salix nigra/Carex torta* temporarily flooded shrubland" (Grossman *et al.* 1998). This NVC type is described as a willow shrubland of low riverbanks along moderate to high-energy rivers in the northeast and High Allegheny Plateau (Grossman *et al.* 1998). It occurs on cobble substrates with sand and gravel in areas that are typically flooded only during high-water events, but may receive winter ice-scour. This shrub dominated natural community occupies on intermediate position along disturbance gradient between open herbaceous cobble shores and higher terrace floodplain forests (Grossman *et al.* 1998).

If both shrub swamps and cobble shores are classified with CEGL006065, are there enough differences to separate them out at the New York classification? Several differences are worth noting between the two natural communities. First, Table 41 shows the average of all vegetation strata layers of all plots labeled shrub swamps and cobble shores. The table shows that shrub swamps overall have a much higher density of plant abundance compared with cobble shores. Second, this table shows that each shrub layer and vine percentage is much higher within the shrub swamps (Table 41). Additional differences lie in the substrate and position on the landscape. Most of the shrub swamps, especially those classified to CEGL006065, occur along the West Kill where it widens and contains "islands" that are frequently flooded. Due to these frequently flooded conditions, shrub swamps have a slightly more palustrine flora than do cobble shores, especially in the herbaceous layer. The two most abundant herbaceous species found within shrub swamp plots include sensitive fern (*Onoclea sensibilis*) and spotted jewelweed (*Impatiens capensis*), two species that are typically found in swamps and floodplain forests. The two most abundant herbs found in cobble shore plots were tussock sedge (*Carex stricta*) and white bedstraw (*Galium mollugo*). Another difference between shrub swamps and cobble shores is the amount of stoniness. Cobble shore examples were typically exceedingly stony (>60%), and shrub swamps tended to be stony to nearly stone free. Due to these differences, shrub swamps and cobble shore plots were separated out.

Table 41: Average percent cover of vegetation by stratum for cobble shore and shrub swamp.

Stratum	Shrub Swamp % cover	Cobble Shore % cover
Tree subcanopy	5.3%	0.0%
Tall Shrubs	50.7%	22.0%
Short Shrubs	29.3%	15.3%
Vine	22.4%	6.1%
Herbaceous	72.4%	46.3%

Cobble Shore Species Composition (average from all plots sampled)

The tall shrub layer (2.2 m) has 22.1% cover and *Salix* sp. (11.9%), *Salix x bebbii* (6.3%) and *Populus deltoides* (2.8%) as the most abundant species. *Robinia pseudoacacia* and *Populus tremuloides* comprise less than two percent of the overall layer.

The short shrub layer (0.8 m) has 15.3% cover and *Salix* sp. (4.1%) and *Rubus allegheniensis* (2.6%) as the most abundant species. *Rosa multiflora*, *Pinus strobus*, *Robinia pseudoacacia*, *Cornus racemosa*, *Corylus americana*, *Rubus pensilvanicus*, *Populus deltoides*, *Rubus hispidus*, *Rhus typhina, Platanus occidentalis*, *Corylus* sp., *Rubus odoratus*, *Acer pensylvanicum*, *Rubus pubescens*, *Amelanchier* sp., *Fraxinus americana*, *Sorbus americana*, *Betula alleghaniensis*, and *Picea* sp. comprise less than two percent of the overall layer.

The vine layer (0.5 m) has 6.1% cover and *Fallopia scandens* (2.5%), *Vitis* sp. (1.3%), *Clematis virginiana* (1.3%), *Clematis* sp. (0.6%), and *Solanum dulcamara* (0.4%) as the characteristic species.

The herbaceous layer (0.8 m) has 46.3% cover and *Carex stricta* (4.8%), *Galium mollugo* (4.5%), *Rumex obtusifolius* (2.9%), *Achillea millefolium* (2.9%), *Centaurea jacea* (2.8%), *Duchesnea indica* (2.5%), *Persicaria sagittata* (2.3%), *Galium* sp. (2.3%), *Solidago* sp. (2.1%), *Silene* sp. (2.1%), *Eutrochium maculatum* (2.1%), *Apocynum cannabinum* (2.1%), and *Heracleum maximum* (2.0%) as the most abundant species. *Stachys tenuifolia*, *Tussilago farfara*, *Melilotus albus*, *Solidago altissima*, *Solidago canadensis*, *Lythrum salicaria*, *Achillea* sp., *Impatiens capensis*, *Calamagrostis canadensis*, *Centaurea* sp., *Tanacetum vulgare*, *Lotus corniculatus*, *Pastinaca sativa*, *Eutrochium purpureum*, *Laportea canadensis*, *Carum carvi*, *Mentha arvensis*, *Solidago gigantea*, *Carex lacustris*, *Trifolium pratense*, *Stellaria pubera*, *Zizania palustris*, *Vicia cracca*, *Ranunculus acris*, *Saponaria officinalis*, *Coronilla varia*, *Eupatorium perfoliatum*, *Poa* sp., *Euthamia graminifolia*, *Hieracium* sp., *Poa palustris*, *Carex tetanica*, *Silene vulgaris*, *Phleum pratense*, *Lapsana communis*, *Geranium bicknellii*, *Xanthium spinosum*, *Verbascum thapsus*, *Erigeron philadelphicus*, *Bidens frondosa*, *Persicaria maculosa*, *Anthoxanthum odoratum*, *Symphyotrichum* sp., *Andropogon gerardii*, *Daucus carota*, *Equisetum* sp., *Agrostis* sp., *Lysimachia punctata*, *Pilea pumila*, *Poa pratensis*, *Melilotus officinalis*, *Phalaris arundinacea*, *Linaria vulgaris*, *Rumex acetosella*, *Juncus acuminatus*, *Juncus* sp., *Vernonia noveboracensis*, *Cicuta bulbifera*, *Calamagrostis* sp., *Satureja hortensis*, *Carex scabrata*, *Poa compressa*, *Verbena hastata*, *Cerastium* sp., *Brachyelytrum erectum*, *Elymus hystrix*, *Galium palustre*, *Myosotis scorpioides*, *Persicaria hydropiperoides*, *Panicum virgatum*, *Leucanthemum vulgare*, *Epilobium* sp., *Echium vulgare*, *Onoclea sensibilis*, *Galium verum*, *Panicum* sp., and *Hypericum* sp. comprise less than two percent of the overall layer.

Table 42: Cobble shore Plot Quality Rank Summary Table:

Plot	% Native Species	Species condition	Hydrological regime	Disturbances	Size of natural community	Estimated size of surrounding natural landscape	% of natural habitat (within 1km)	Distance to nearest paved road	TOTAL RANK SUM (See Appendix 4)	RANK SCORE QUALITY
WK17D	3	1	1	1	2	2	2	1	13	Good
WK13G	4	1	1	1	4	1	2	1	15	Good
WK34D	4	1	1	1	3	4	1	1	16	Good
WK15C	3	1	1	2	3	3	2	1	16	Good
WK19A	2	1	1	2	4	3	2	2	17	Good
WK34A	4	1	1	2	4	3	2	1	18	Good
WK78B	4	1	1	2	4	2.5	2	2	18.5	Good
WK91A	4	1	1	2	3	3	2	3	19	Good
WK15A	4	1	1	2	3	3	2	3	19	Good

Table 43: Cobble shore Plot Quality Rank System/Plant Stewardship Index Quality (Conservation Coefficient) summary table

PLOT	+PQRS Rank	*PSI (adjusted)	**PSI Mean coefficient	***Difference between PSI and PQRS
WK34A	18	20.91	3.52	2.91
WK34D	16	15.5	2.82	-0.5
WK17D	13	11.68	2.83	-1.32
WK78B	18.5	16.28	2.45	-2.22
WK19A	17	13.13	2.80	-3.87
WK15C	16	11.76	1.86	-4.24
WK13G	15	7.05	2.13	-7.95
WK91A	19	10.5	1.62	-8.5
WK15A	19	7.63	2.12	-11.37

+ Plot Quality Rank System final rank of biotic, abiotic, and landscape factors (lower score constitutes higher quality ranking plot).

* Plant Stewardship Index (adjusted) (higher score indicates higher diversity and quality)
** Plant Stewardship Index mean-average of all scores of plants found in plot (higher score indicates more species with higher ranks).
******* Difference between PSI and PQRS (since low score of PQRS indicates high quality, and high score of PSI indicates high quality, the difference between these two could indicate a final "quality" ranking between biotic, abiotic, landscape, and floral rank factors).
Plots selected as reference examples are highlighted in yellow

Cobble Shore Discussion/Recommendations

According to the results of the PQRS and PSI, Plot WK34A appears to be the best overall candidate for a natural community reference for cobble shore along the West Kill main stem (Table 42 and 43). This plot is likely a variant of NVC type "CEGL006065 - *Salix nigra/Carex torta* temporarily flooded shrubland".

The results of the PSI show that several plant species documented in this plot have conservation coefficients of 7 or higher (Table 43). Examples of these species include *Fraxinus nigra, Sorbus americana, Rubus pubescens, Salix exigua, Betula alleghaniensis,* and *Hamamelis virginiana* are associated plants with either a poor range of ecological tolerances or with a high degree of fidelity to a narrow range of habitats (Table 44). The overall PSI of 20.91 was by far the highest PSI of any cobble shore plot, but this was mostly due to the sparse cover of stunted tree species labeled with high PSI values such as *Fraxinus nigra* and *Betula alleghaniensis*. These species comprised a very low percentage of the overall plant cover. Species with the highest percent cover within this plot, *Galium mollugo* and *Duchesnea indica*, are both exotic plants with an index of 0. Unfortunately, even though this plot recorded the highest PSI of any cobble shore example, it was still dominated mostly by exotic plants. The plant quality of all encountered cobble shores is quite low, and this could be due to the surrounding disturbed landscape where exotic plant seeds are carried down the West Kill and deposited on these cobble shorelines.

The results of the PQRS show that Plot WK34A has 1) excellent species condition (i.e. no signs of defoliation or predation by herbivores), 2) little to no man made disturbances, 3) a relatively large surrounding natural landscape and a large percent of natural habitat within 1 kilometer of the plot, and 4) occurs relatively far from the nearest paved road (Table 42). These factors along with a relatively high PSI make this plot the "highest" quality example of cobble shore along the West Kill main stem. Below is a summary of biotic and abiotic characteristics of this plot and these are recommendations along with the floral composition in the final "expression" of this type (Table 45-46). According to the results, these plots could be used as natural community references for this area. However, it should be noted that it may be advantageous to possibly seek more "undisturbed" examples of cobble shores that have a higher percentage of native species and similar substrates within similar landscapes in adjacent watersheds to be used as natural community references for "cobble shores".

Assuming that the current suite of bioitic and abiotic conditions along the West Kill main stem remain stable, cobble shores will likely continue to thrive as an ecological unit. Given the documentation of the dominance of upland herbaceous plants within cobble shores, it appears that they flood irregularly and for short very short durations. However, any hydrological change will result in a definite change within natural community, possibly eliminating them along the main stem of the West Kill. The influence of West Kill main stem levels to cobble shore communities cannot be understated here, and any long-term change in stream level will likely cause significant species composition, abiotic, and structural changes to cobble shores.

Figure 18. Location of Cobble shore **Plot WK34A**

Figure 19. Cobble shore **Plot WK34A**

Table 44: Cobble shore **Plot WK34A** species and PSI Conservation Coefficient (as developed in New Jersey)

Species	**Common name**	**PSI Coefficient**
Acer rubrum	Red maple	N 3
Acer saccharum var. saccharum	Sugar maple	N 5
Betula alleghaniensis	Yellow birch	N 10
Carum carvi	Caraway	I 0
Cornus racemosa	Gray dogwood	N 3
Daucus carota	Queen Anne's-lace	I 0
Duchesnea indica	Indian strawberry	I 0
Fraxinus nigra	Black ash	N 10
Hamamelis virginiana	Witch-hazel	N 7
Pinus strobus	White pine	N 3
Populus tremuloides	Quaking aspen	N 2
Prunus pensylvanica	Pin cherry	N 3
Rubus hispidus	Swamp dewberry	N 5
Rubus pubescens	Dwarf blackberry	N 9
Rumex acetosella	Sheep sorrel	I 0
Salix exigua	Sandbar willow	N 8
Sorbus americana	American mountain ash	N 10
Stellaria pubera	Great chickweed	N ?
Tragopogon pratensis	Meadow salsify	I 0
Trifolium pratense	Red clover	I 0
Tussilago farfara	coltsfoot	I 0

*** N=Native, I=Introduced**

Table 45: Cobble shore **Plot WK34A** growth life form summary

Growth life form	Cover %	Average height (meters)
S1 (Tall shrub 2-5m, tree saplings)	10	2.9
S2 short shrub (<2m) include tree seedlings	20	1.3
V Vine/liana	0	0
H (Herbaceous)	50	1

Table 46: Cobble shore **Plot WK34A** abiotic characteristics summary

Unvegetated surface	45% small rocks
Stoniness	Exceedingly stony
Average mineral soil texture	sand
Soil drainage	Poorly drained
Topographic position	Lowlevel
Soil moisture	Dry to wet
Hydrologic regime of plot	Intermittently flooded

Shallow Emergent Marsh Description

Four plots labeled as shallow emergent marsh were found along the West Kill main stem in the summer of 2008. Three of these marsh plots, WK17K, WK17I, and WK17C, occurred relatively close together were scattered throughout the entire stretch of the West Kill main stem. The fourth plot, WK14F, a very small area, occurred further upstream from the previous three plots. Two of four plots were classified as NVC type "CEGL006571 Steeplebush / Reed Canarygrass Successional Wet Meadow", and the other two plots were classified as "CEGL006044 Reed Canarygrass Eastern Marsh" (Grossman *et al.* 1998). The only plot without reed canary grass (*Phalaris arundinacea*) was within the very small area of WK14F. Two plots, WK17I, and WK17K, both contained 35% or more reed canary grass and were clearly of type "Reed Canarygrass Eastern Marsh". Plot WK17C, on the other hand, contained less reed canary grass and contained more wet meadow species such as *Solidago gigantea*, *Eutrochium maculatum*, and *Euthamia gramnifolia*. This wet meadow vegetation is more aligned with CEGL006571, an association that typically occurs in low-lying pastures, meadows, and/or beaver wetlands (Grossman *et al.* 1998). The setting for West Kill main stem is beaver impacted areas adjacent to the main section of the stream. These natural disturbances have allowed for more wet meadow species to thrive in what would ordinarily be a fast moving and high energy moving stream. It is unknown whether the hydrological conditions will stay favorable for these small shallow emergent marshes to remain along the West Kill, and severe flooding events, beaver abandonment, and/or draughts may threaten them.

Shallow Emergent Marsh Species Composition (average from all plots sampled)

The tree subcanopy layer (28 m) has 6.3% cover of *Tsuga canadensis*.

The tall shrub layer (3.4 m) has 7.5% cover with *Acer pensylvanicum* (2.5%) and *Salix* sp. (2.0%) as the most abundant species. *Rubus allegheniensis*, *Sambucus racemosa*, *Rosa multiflora*, and *Lonicera morrowii* comprise less than two percent of the overall layer.

The short shrub layer (0.7 m) has 7.8% cover with *Rubus allegheniensis* (4.5%) as the most abundant species. *Spiraea alba*, *Spiraea tomentosa*, *Sambucus racemosa*, *Salix* sp., *Alnus incana*, *Tsuga canadensis*, *Rubus pubescens*, *Cornus racemosa*, and *Acer rubrum* comprise less than two percent of the overall layer.

The vine layer (2.2 m) has 8.3% cover with *Vitis* sp. (4.5%), *Convolvulus pilosellifolius* (2.5%), *Mikania scandens* (1.3%), *Parthenocissus quinquefolia* (0.8%), and *Clematis virginiana* (0.3%) as the characteristic species.

The herbaceous layer (1.2 m) has 78.8% cover with *Phalaris arundinacea* (22.8%), *Solidago gigantea* (12.5%), *Eutrochium maculatum* (7.5%), *Heracleum maximum* (6.3%), *Juncus effusus* (6.3%), *Equisetum* sp. (6.3%), *Rumex obtusifolius* (5.0%), *Onoclea sensibilis* (4.8%), *Carex scabrata* (3.8%), *Scirpus cyperinus* (3.8%), *Solidago altissima* (3.0%), *Tussilago farfara* (2.5%), *Symphyotrichum novi-belgii* (2.5%), *Lythrum salicaria* (2.0%), *Mentha arvensis* (2.0%) and *Poa palustris* (2.0%) as the most abundant species. *Impatiens capensis*, *Euthamia graminifolia*, *Verbena urticifolia*, *Fallopia japonica*, *Carex lacustris*, *Eutrochium purpureum*, *Carex lupulina*, *Dryopteris* sp., *Elymus villosus*, *Tanacetum vulgare*, *Rumex acetosella*, *Lysimachia punctata*, *Galium palustre*, *Glyceria striata*, *Persicaria sagittata*, *Cinna latifolia*, *Epilobium hirsutum*, *Elymus virginicus*, *Coronilla varia*, *Solidago* sp., *Myosotis scorpioides*, *Symphyotrichum puniceum*, *Persicaria virginiana*, *Poa* sp., *Geranium bicknellii*, *Asclepias* *incarnata*, *Carex lurida*, *Symphyotrichum novae-angliae*, *Doellingeria umbellata*, *Potentilla* sp., *Symphyotrichum* sp., *Achillea* sp., *Satureja hortensis*, *Persicaria hydropiperoides*, *Agrostis* sp., *Galium mollugo*, *Bidens* sp., *Verbena hastata*, *Thalictrum pubescens*, *Circaea lutetiana*, *Eupatorium perfoliatum*, and *Scirpus atrovirens* comprise less than two percent of the overall layer.

Table 47: Shallow emergent marsh Plot Quality Rank Summary Table:

Plot	% Native Species	Species condition	Hydrological regime	Disturbances	Size of natural community	Estimated size of surrounding natural landscape	% of natural habitat (within 1km)	Distance to nearest paved road	TOTAL RANK SUM	RANK SCORE QUALITY
WK17C	3	1	1	1	3	3	2	1	15	Good
WK17I	3	1	1	1	4	2	2	1	15	Good
WK17K	3	1	2	2	4	1	2	1	15	Good
WK14F	3	1	1	1	4	3	2	3	18	Good

Table 48: Shallow emergent marsh Plot Quality Rank System/Plant Stewardship Index Quality (Conservation Coefficient) summary table

PLOT	+PQRS Rank	*PSI (adjusted)	**PSI Mean coefficient	***Difference between PSI and PQRS
WK17I	15	14.64	3.55	-0.36
WK14F	18	14.09	4.07	-3.91
WK17K	15	10.69	2.52	-4.31
WK17C	15	8.37	2.24	-6.63

+ Plot Quality Rank System final rank of biotic, abiotic, and landscape factors (lower score constitutes higher quality ranking plot).
* Plant Stewardship Index (adjusted) (higher score indicates higher diversity and quality)
** Plant Stewardship Index mean-average of all scores of plants found in plot (higher score indicates more species with higher ranks).
******* Difference between PSI and PQRS (since low score of PQRS indicates high quality, and high score of PSI indicates high quality, the difference between these two could indicate a final "quality" ranking between biotic, abiotic, landscape, and floral rank factors).

Shallow Emergent Marsh Discussion/Recommendations

According to the results of the PQRS and PSI, Plot WK17I appears to be the best overall candidate for a natural community reference for shallow emergent marsh along the West Kill main stem (Tables 47 and 48). However, this plot is most closely classified to NVC type "CEGL006044 - Reed Canarygrass Eastern Herbaceous Vegetation, a type dominated by the exotic reed canarygrass *(Phalaris arundinacea)* (Grossman *et al.* 1998). Consequently, this plot should not be used as a reference for the shallow emergent marsh community even though some abiotic factors appeared to be of good quality (Whittier *et al.* 2007). An additional plot, WK17K, was also tagged with NVC type CEGL006044. This plot was attributed with lower quality PQRS and PSI scores. The two remaining plots were attributed to NVC type "CEGL006571 Steeplebush - Blackberry species / Reed Canarygrass Shrubland", which can occur as either a shrubland or a wet herbaceous meadow. Plot WK17C consisted of a mix of wet meadow species, but the overall PSI results, including the mean conservation coefficient, indicated that this plot did not contain species of a high conservation coefficient (Tables 47 and 48). In addition, Plot WK14F had a fairly high PSI and mean conservation coefficient, but the size of this natural community was very small, and hence, should not be used as a natural community reference for "shallow emergent marsh" along West Kill main stem.

The results of the PSI show that only a few species documented in Plot WK17I have a conservation coefficient of 7 or higher (Table 49). These species include *Brachyelytrum erectum* and *Salix exigua*, and these are plants show either a poor range of ecological tolerances or occur within a high degree of fidelity to a narrow range of habitats (Table 49). The overall PSI of 14.64 was the highest score of any shallow emergent marsh attributed plot, but this is a relatively low score compared with the highest PSI of cobble shores (Table 53). Since only four plots were tagged as "shallow emergent marsh" along the West Kill main stem, and these four plots were not of high quality, a recommendation for a reference for a natural community reference cannot be given. It is concluded that shallow emergent marshes are indeed very uncommon along the West Kill, and where present, are generally of low quality with reed canarygrass as a dominant or significant species. It is recommended to inventory larger and more "undisturbed" examples of shallow emergent marshes that have a higher percentage of native species in adjacent watersheds if a reference is needed for the West Kill.

Assuming that the current suite of bioitic and abiotic conditions along the West Kill main stem remain stable, shallow emergent marshes, albeit rare in this valley, will likely continue to thrive as an ecological unit. Beaver activity appears to influence the development of shallow emergent marshes along the West Kill. In fact, without beaver influence, shallow emergent marshes would not likely exist along the West Kill due to the very flashy nature of the West Kill that is not conducive for the development of impounded or basin areas with mucky soils. Any hydrological change and/or change in beaver activity, however, will result in either an increase of these shallow emergent marshes, or an eradication of these small wetlands along the West Kill main stem.

Figure 20. Shallow emergent marsh **Plot WK17I**

Figure 21. Shallow emergent marsh **Plot WK17I**

Table 49: Shallow emergent marsh **Plot WK17I** species and PSI Conservation Coefficient (as developed in New Jersey)

Species	**Common name**	**PSI Coefficient**
Alnus incana	Speckled alder	N 6
Asclepias incarnata ssp. incarnata	Swamp milkweed	N 5
Brachyelytrum erectum	Bearded shorthusk	N 7
Carex crinita var. crinita	Short hair sedge	N 5
Carex lacustris	Lake-bank sedge	N 10
Carex lupulina	Hop sedge	N 6
Carex lurida	Sallow sedge	N 4
Eupatorium perfoliatum	Boneset	N 3
Galium palustre	Marsh bedstraw	N 5
Glyceria striata	Fowl mannagrass	N 3
Impatiens capensis	Jewelweed	N 2
Juncus effusus	Common rush	N 1
Lythrum salicaria	Purple loosestrife	I 0
Myosotis scorpioides	Forget-me-not	I 0
Onoclea sensibilis	Sensitive fern	N 2
Phalaris arundinacea	Reed canary-grass	I 0
Poa palustris	Fowl bluegrass	N 5
Persicaria hydropiperoides	Mild water-pepper	N 6
Salix exigua	Sandbar willow	N 8
Scirpus atrovirens	Black bulrush	N 3
Scirpus cyperinus	Wool-grass	N 2
Verbena hastata	Blue vervain	N 3

*** N=Native, I=Introduced**

Table 50: Shallow emergent marsh **Plot WK17I** growth life form summary

Growth form	Cover %	Average height (meters)
S2 short shrub (<2m) include tree seedlings	3%	0.8
V Vine/liana	0	0
H (Herbaceous)	70	1.8

Table 51: Shallow emergent marsh **Plot WK17I** abiotic characteristics summary

Unvegetated surface	25% water
Stoniness	Stone free
Average mineral soil texture	muck
Soil drainage	Poorly drained
Topographic position	Basin Floor
Soil moisture	wet
Hydrologic regime of plot	Saturated

Conclusions/Summary

The approximate 9-mile stretch of riparian habitat along the West Kill main stem offers opportunities for good reference "expressions" of many of the major natural riparian community types encountered. Seventy-six plots were sampled across approximately 16 natural community types (Table 2). Beech-maple mesic forests and floodplain forests were the most commonly encountered natural community along the West Kill main stem. Hemlock-northern hardwood forests, pine-northern hardwood forests, and cobble shores were seen less frequently but were still fairly common along the West Kill main stem (Table 2). Other natural communities such as maple-basswood rich mesic forest were encountered so rarely that sample sizes were too small to include them in the final natural community descriptions. The size, condition, and landscape of all these natural communities varied greatly depending on an assortment of factors. In addition, ecological quality also varied within each natural community. Two tools, Plot Quality Rank System and Plant Stewardship Index, were used to measure the ecological quality of biotic, abiotic, and landscape factors of each of these natural community plot examples with the goal of deriving the best "expressions" of each type. According to the results of the Plot Quality Rank System (PQRS), no plot fell within the "poor" category (See appendix 4). These results are consistent with results of other studies where a quality rank index was used to define "reference" conditions along a riparian zone (Colwell & Hix 2008). The rankings of this PQRS may need to be adjusted to accurately reflect conditions of the West Kill riparian area, and if it is to be used similarly in other watersheds for riparian reference studies. The Plant Stewardship Index results showed a wide range of values from 5.36 (shrub swamp) to 35. 03 (beech-maple mesic forest). This tool was very useful in sorting out floral quality among natural communities and plots within natural communities. The wide range of values was primarily due to the amount of exotic species within certain natural communities found along the West Kill main stem, and cobble shores, shrub swamps, and shallow emergent marshes by far contained the most exotic plants.

Beech-maple mesic forests primarily occurred as part of large matrix forests upstream towards the "headwaters" region of the West Kill, while floodplain forests were scattered with small examples throughout the stretch of the stream. Beech-maple mesic forest examples generally were in excellent ecological condition, with no exotic plants, and in good landscape condition (Table 52). The results of the Plot Quality Rank System and Plant Stewardship Index reflect the excellent quality of the beech-maple mesic forest expressions along the West Kill main stem, and several plots qualify as "references" for this natural community. In contrast, floodplain forests were in overall good condition, with some disconnection to the natural landscape, small size, and contained exotic plants such as garlic mustard (*Alliaria petiolata*). These were the main factors contributing to the lower quality floodplain forests (Table 52). However, several floodplain forest plots were of high enough quality to serve as "references" for this natural community along the West Kill main stem.

Hemlock-northern hardwood and pine-northern hardwood forest examples along the West Kill were generally in excellent condition, with good connection to the natural landscape, little to no exotic plants, and good size (Table 52). Several of these plots qualify as "references", reflecting excellent expressions of these natural communities.

In addition, examples of shrub swamps in general were in good to excellent condition, with little disturbances and a good connection to the natural landscape (Table 52). However, the plant stewardship index scores lowered the overall quality of these shrub swamps due to the moderate amount of exotic plant species found. Small examples of cobble shore natural communities were very frequently found along the West Kill main stem, and in general, were in good ecological condition and fairly well connected to the natural landscape. The main factors contributing to the lower overall quality of these cobble shores is the abundance of exotic plants occurring within the plots and relatively small size of the examples. Due to the disturbed landscape in certain portions of the West Kill, material is frequently deposited on these cobble shores, including seeds from exotic plants. However, even though many exotic plants occurred within these cobble shore plots, Plot WK34A had a PSI of 20.91, by far the highest of any cobble shore plot. This plot, despite not being small in size and having abundant exotic species, may serve as a natural community reference for cobble shores. However, it is recommended that other options be explored, including searching for cobble shores dominated by native species in adjacent watersheds. The same criteria may be true for shallow emergent marshes, which were infrequently encountered along the West Kill main stem. These "expressions" were too small and contained too many exotic plants to be considered references for this natural community. It is recommended that searches be conducted in adjacent watersheds, perhaps in to find larger examples of shallow emergent marshes dominated by native species.

It should also be mentioned that other factors not within the realm of this study could be considered before using our recommended natural community references. Factors such as microclimatic data, frequency of floods, and sediment input and output may also be important in determining which riparian community examples to be used as references for the West Kill main stem (Hughes *et al.* 2005). Using these methods may be helpful since several natural communities (i.e., floodplain forest, shrub swamp, cobble shore, shallow emergent marsh) found in direct hydrological connection with the West Kill main stem are vulnerable to change due to any long-term hydrological changes due to climate and habitat alteration. The variability and unpredictability of these dynamic natural communities should be taken into account when reference conditions are used in restoration efforts (Hughes *et al.* 2005).

Finally, the question of applicability of the above recommendations of natural community references to adjacent watersheds needs to be addressed. The topography of the West Kill riparian area is unique as the West Kill stream and its tributaries flow across a landscape characterized by geologic and geomorphic heterogeneity as a result of the complex distribution of glacial deposits and landforms (Greene County Soil and Water Conservation District Stewardship Program 2005). The narrow valley, steep mountain sides, and high energy and flashy character of the West Kill main stem is reflected in the natural communities that comprise the riparian zone of this watershed. If the recommended riparian references are to be used in another watershed, a topographical and geological review of the watershed is needed to determine if the watershed is of similar geological and topographical features. Natural communities that occurs upslope from the main stem, such as hemlock-northern hardwood and beech-maple mesic forests, are more likely to be applicable to areas outside this watershed. However, riparian zone natural communities heavily influenced by the dynamics of the West Kill main stem, such as shrub swamps and floodplain forests, are perhaps more unique to this particular watershed. However, the same methodology and quality measuring tools used in this study are applicable to reference riparian studies in other watersheds.

Table 52: Average plot factor rank by natural community type

Natural Community type	# Plots	Average Plot Rank Score	Overall Quality
Shrub Swamp	8	11.25	Excellent
Shallow Emergent Marsh	4	15.75	Good
Beech-Maple Mesic Forest	16	16.60	Excellent
Cobble Shore	9	16.83	Good
Hemlock-Northern Hardwood Forest	8	17.25	Excellent
Pine-Northern Hardwood Forest	6	17.50	Excellent
Floodplain Forest	16	22.50	Good

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Appendix 1: Key to suitable restoration types along the West Kill

†The following are two hypothesized successional trajectories along the West Kill (within active stream channel and not within active stream channel). Use the appropriate trajectory to determine what stage along the successional trajectory a restoration site fits. For example, if the key leads to a **"successional shrubland (CEGL006451)[3]"**, notice that "shrubland" occurs as the third stage along the successional trajectory. For restoration purposes, it is important to understand that if restoring the site with appropriate plant species for a "shrubland", the site has potential to eventually succeed into an **upland forest[4]**, given the right biotic and abiotic conditions. For some cases, such types within the active stream channel as exceedingly cobbly shorelines, succession will not likely reach the forest stage due to vegetation growth constraints on cobbly substrates and significant natural disturbances. Each natural community type presented in this key is given a superscript that corresponds to where it occurs along the successional trajectory.

†1a. Site located in the West Kill headwaters upstream from the Petit Brook confluence, generally at or above 2000 ft. elevation.

2a. Site located in low level area, or on low slope, close to the West Kill (generally within about 40 m (130 feet) from the stream channel), dry to somewhat moist soils, and generally >3 m (9-10 feet) above stream level.

→Beech-maple mesic forest (**CEGL006211)** (dominant forest type along the West Kill in the upper West Kill watershed, with Canada mayflower (*Maianthemum canadense*), and wood fern (*Dryopteris* spp.) being indicator species for this community type).

2b. Site located on low level alluvial terrace (very rarely flooded), moist soils, and is about 0.3 m (1 ft.) above stream level forming a relatively narrow band (15 m to 40 m wide) (50-130 feet) along the West Kill.

→ Floodplain forest (**CEGL006114**), with wood nettle (*Laportea canadensis*) or Virginia waterleaf (*Hydrophyllum virginianum*) being indicator species for this community type (occurs rarely along the West Kill in the West Kill headwaters).

2c. Site located on low slope at least 40 m (130 feet) from stream channel, well-drained soils, and is about 15 m (50 ft.) above stream level.

→Beech-maple mesic forest (**CEGL006252)** (dominant forest type in the upper West Kill watershed, less rich than CEGL006211, with hay-scented fern (*Dennstaedtia punctilobula*) being a fairly good indicator of this beech-maple mesic forest type).

†1b. Site located along the West Kill downstream from the Petit Brook confluence, generally below 2000 ft. elevation.

3a. Site located within the active stream channel of the West Kill, at or slightly above stream level, but always less than 0.3 m (1 ft.) above stream level.

4a. Wetland with mucky substrate (5 cm to 15 cm deep) (2-6 in) in slow moving areas of stream, often associated with beaver activity.

5a. Unvegetated or a few herbaceous marsh indicator plants present, such as sedges (*Carex* spp.), and/or bulrushes (*Scirpus* spp.).

→Shallow emergent marsh (**CEGL006571)**

5b. Unvegetated or a few woody shrub swamp indicator plants present, such as shrubby willows (*Salix* spp.), and/or shrubby dogwoods (*Cornus* spp.).

→ Shrub swamp (**CEGL006065)** dominated by willow (*Salix* spp.), or rarely by gray dogwood (*Cornus racemosa*).

4b. Generally upland in appearance, but occasionally flooded for short durations and scoured, with cobbly substrate comprised of round and elliptical stones (10 cm to 30 cm diameter) (4-12 in).

6a. Unvegetated or sparsely vegetated with mostly annual herbs in clumps between cobbles, such as knotweeds (*Persicaria* spp.), and white bedstraw (*Galium mollugo*), upland weeds like knapweed (*Centaurea* spp.) and common yarrow (*Achillea millefolium*), plus graminoids such as tussock sedge (*Carex stricta*) on edge of stream, with evidence of more frequent scour (e.g., very stunted woody vegetation), and generally directly adjacent to waterline.

→Cobble shore (**CEGL006536)**

6b. Moderate to densely vegetated with moist indicator perennial herbs present in clumps, such as spotted joe-pye weed (*Eutrochium maculatum*), and tussock sedge (*Carex stricta*), as well as annual herbaceous plants in clumps between cobbles as mentioned in 6a.

→Cobble shore (**CEGL006536)**

6c. Woody plants present, such as willow shrubs (*Salix* spp.), shrubby dogwoods (*Cornus racemosa*, *C. amomum*), a significant vine layer, and tree saplings, with evidence of flooding and less frequent scour (e.g., broken stems, worn bark, multiple root sprouts, debris on branches, etc.), generally behind, or just above, the cobble shore (**CEGL006536).**

→Floodplain shrubland (**CEGL006065)**

3b. Site not within the active stream channel of the West Kill and at least 0.3 m (1 ft.) above stream level.

7a. Site located on low level alluvial terrace at least 0.3 m (1ft.) above stream level, or on a high bank 9-12 m (30-40 ft.) above stream channel. The face of the high bank is often very steep (10-30% slope) created by the erosional forces of the West Kill.

8a. Site on a low level alluvial terrace adjacent to the West Kill.

9a. Terrace bisected by a small tributary stream of the West Kill (originating about 3 m (10 ft.) above the West Kill stream level) with cool air drainage, dry soils, and relatively stone free.

→ Hemlock-northern hardwood forest (**CEGL006088**)

9b. Terrace not as above with mesic hydric plant indicators, such as Virginia Waterleaf (*Hydrophyllum virginiana*), Virginia creeper (*Parthenocissus quinquefolia*), and garlic mustard* (*Alliaria petiolata*)

→ Floodplain forest (**CEGL006114**) (typical terrace floodplain forest along the West Kill)

8b. Site on or above a high bank adjacent to the West Kill.

10a. Wet depressions on the flat low lying areas on top of the high bank within 30-40 m (110-130 ft.) of the West Kill stream channel***.

→ Shrub swamp (**CEGL006576)** (mixed shrub dominated with gray dogwood (*Cornus racemosa*)

10b. Dry to somewhat moist substrate on gentle or moderately steep slope on or above high bank

11a. Dry stony to very stony substrate, gentle slope, above high bank.
→ Beech-maple mesic forest (**CEGL006211)**

11b. Somewhat moist stony to very stony substrate, gentle to moderately steep slope above high bank, and is on or adjacent to small tributary stream of the West Kill with cool air drainage, open seeps may be present along tributary.
→Hemlock-northern hardwood forest (**CEGL006109**)

11c. Post-agricultural or pasture successional area, open area with scattered tall wolf trees and weedy pasture weeds (**flat slope area east of Auffarth Road).
→Successional shrubland (****CEGL006451**)

7b. Site located on gentle to moderate steep slopes (2-25% slope) 10-100 m (33-328 ft.) from the West Kill stream channel and occurring in areas up to 2000 ft. elevation.

12a. North to northwest facing slope (rarely west facing).

13a. Dry site, not associated with ravine, typically very stony substrate, generally steeper slopes compared to CEGL006109.
→Pine-northern hardwood forest (**CEGL006328**)

13b. Moist environment, close to or in ravine, stony to very stony but typically not as stony as CEGL006328, and generally steep but less steep slopes compared to CEGL006328.
→Hemlock-northern hardwood forest (**CEGL006109**)

12b. Varying facing slope (east, south, west, rarely north) or strictly west-facing slope.

14a. Varying facing slope and substrate, dry to moist soils, slope gentle to moderate
→ Beech-maple mesic forest (**CEGL006211**).

14b. West-facing slope, exceedingly stony substrate (talus) or on bedrock, sometimes sparsely but richer vegetation, and higher pH than CEGL006211.
→ Calcareous talus slope woodland (**CEGL005058**)

* Garlic mustard (*Alliaria petiolata*) is an exotic invasive plant and should not be a recommended plant species for restoration purposes. However, to separate out beech-maple mesic forests and floodplain forests, this species was a key ecological indicator for floodplain forests and would likely be one of the first herbaceous plants to colonize a restoration site suitable for floodplain forest restoration.

Successional shrubland (CEGL006451)** was only sampled once along the West Kill due to field priorities given to more mature stable communities. This community type may be present in other localities and physiognomic settings along the West Kill main stem with additional inventory.

***It is possible that other small examples of wetlands could occur in this setting (including vernal pools, and forested wetlands. These types were not documented during field surveys of 2008.

Trajectories along West Kill main stem

Site located within the active stream channel of the West Kill, at or slightly above stream level, but always less than 0.3 m (1 ft.) above stream level.
Trajectory-> cobble[1] -> herbaceous[2] -> shrubland[3] -> floodplain forest[4];

Site not within the active stream channel of the West Kill and at least 0.3 m (1 ft.) above stream level.cobble[1] -**Trajectory ->agriculture[1]->old field[2] ->shrubland[3] -> upland forest[4]**

[5] This **shrub swamp (CEGL0065676)** is a small wet depression that cannot confidently be applied to the two successional trajectories above.

[6] **Shallow emergent marsh (CEGL006571)** examples are small wetlands that exist mainly due to beaver activity. Therefore, it is difficult to project confidently a successional trajectory for this type.

Appendix 2: Vegetation plot sampling form

COMMUNITY FORM 3: QUANTITATIVE COMMUNITY CHARACTERIZATION revised May 10, 2001

NY Natural Heritage Program

Reviewed by NY Natural Heritage Program: Date:____ Initials: ________

A. IDENTIFIERS / LOCATION (GENERAL EOR INFORMATION)

1. Survey site name_______________
2. **Quad code(s):**_______________
3. **Quad name(s):**_______________
4. County name(s):_______________ 5. Town:_______________
6. Directions to this transect:_______________

7. Sourcecode:_______________ 8. Survey date:_______________ 9. State:
10. Surveyors:_______________

B. ENVIRONMENTAL DESCRIPTION

11. **Community name**_______________
12. National Association_______________

13. Transect/observation point #

14. Image annotation #

15. Elevation:

16. Topographic position:
___Interfluve ___Toeslope
___High slope ___Low level
___High level ___Channel wall
___Midslope ___Channel bed
___Backslope ___Basin floor
___Step in slope ___Other:
___Lowslope

17. Topographic sketch (show where plot is located within surrounding topography):

18. Slope degrees:__________

19. Slope aspect:__________

20. Parent material/bedrock:

21. Soil profile description: note depth, texture, and color of each horizon. Note significant changes such as depth to mottling, depth to water table, root penetration depth
22. Organic horizon depth:__________
23. Organic horizon type: Mor:___ Mull:___
24. Average pH of mineral soil:__________

25. Soil moisture regime:
___Extremely dry ___Very dry
___Dry ___Well drained
___Somewhat moist ___Moist
___Somewhat wet ___Wet
___Permanently inundated ___Very wet
___Periodically inundated
Soil pore salinity__________ppt. (optional)

26. Soil drainage:
___Rapidly drained
___Well drained
___Moderately well drained
___Somewhat poorly drained
___Poorly drained
___Very poorly drained

27. Hydrologic Regime of plot (adapted from Cowardin 1979):
___Semipermanently flooded ___Intermittently flooded
___Seasonally flooded ___Permanently flooded
___Saturated ___Tidally flooded
___Temporarily flooded ___Unknown
___Never inundated

Optional fields below
pH of water__________
Flood depth__________
Tidal range__________

28. Stoniness:
_Stone free <0.1%
_Moderately stony 0.1-1%
_Stony 3-15%
_Very stony 15-50%
_Exceedingly stony 50-90%
_Stone piles >90%

29. Average mineral soil texture (Brewer 1982):
___ sand ___ loamy sand
___ loam ___ sandy loam
___ silt loam ___ sandy clay loam
___ clay loam ___ silty clay loam
___ silt ___ sandy clay
___ clay ___ silty clay

30. Average organic soil texture:
___muck
___peat

Von Post scale of peat decomposition:__________
pH of peat:__________

31. Unvegetated surface (total):__________%
___% Bedrock ___% Litter, duff
___% Large rocks (>10cm) ___% Wood >1cm
___% Small rocks (0.2-10cm) ___% Water
___% Sand (0.1-2mm) ___% Other:
___% Bare soil

32. Environmental Comments: Note homogeneity of vegetation, evidence of erosion/sedimentation, further observations of inundation, etc.__________

33. Plot representativeness:__________

C. VEGETATION

Community name:____________________

34. System:____Terrestrial ___Palustrine ____Estuarine 35. Plot number:__________ 36. Plot dimensions:__________

37. Leaf type:
(of dominant stratum)
__Broad-leaf
__Semi-broad-leaf
__Mixed broad-needle leaf
__Semi-needle-leaf
__Needle-leaf
__Graminoid
__Broad-leaf herbaceous
__Pteridophyte
__Non-vascular

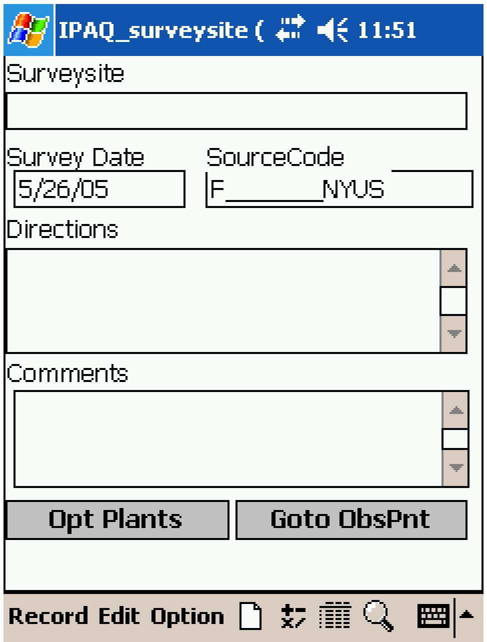
38. Leaf phenology:
(of dominant stratum)
__Forest
__Semi-deciduous
__Mixed deciduous-evergreen
__Semi-evergreen
__Evergreen
__Perennial
__Annual

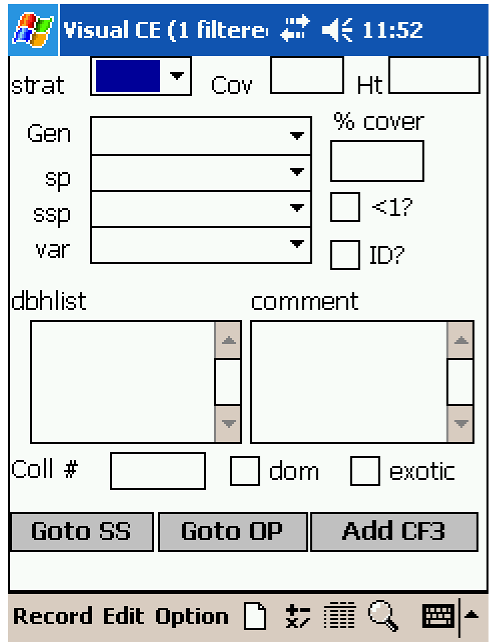
39. Physiognomic type:
__Woodland
__Sparse woodland
__Shrubland
__Sparse shrubland
__Dwarf shrubland
__Sparse dwarf shrubland
__Herbaceous
__Sparsely vegetated
__Non-vegetated

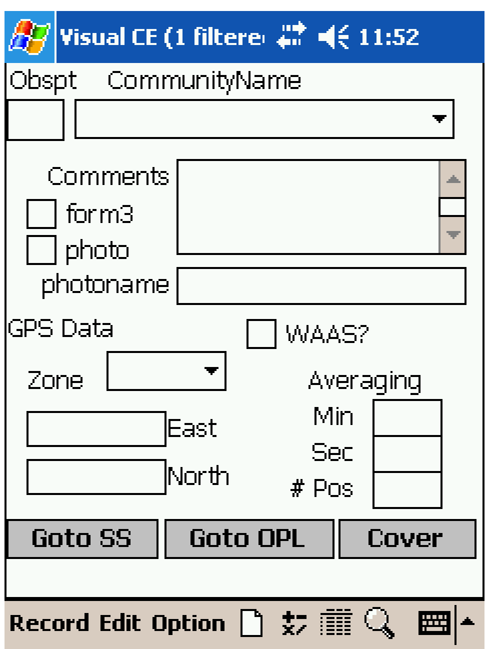
40. Strata/life forms	%cover	height
T1 Emergent tree (>5m)		
T2 Tree canopy (>5m)		
T3 Tree sub-canopy (>5m)		
S1 Tall shrub (2m - 5m)		
S2 Short shrub (< 2m)		
V Vine/liana		
H Herbaceous		
N Non-vascular		
E Epiphyte		
A1 Emergent aquatic		
A2 Floating-leaved aquatic		
A3 Submerged aquatic		

41. Species/percent cover: starting with the uppermost stratum, list all species and % cover for each in the stratum. For forests and woodlands, list the DBH of all trees over 10 cm diameter on a separate line below each tree species. Separate the measurements with a comma and note whether in cm or inches. Estimate number of fauna.

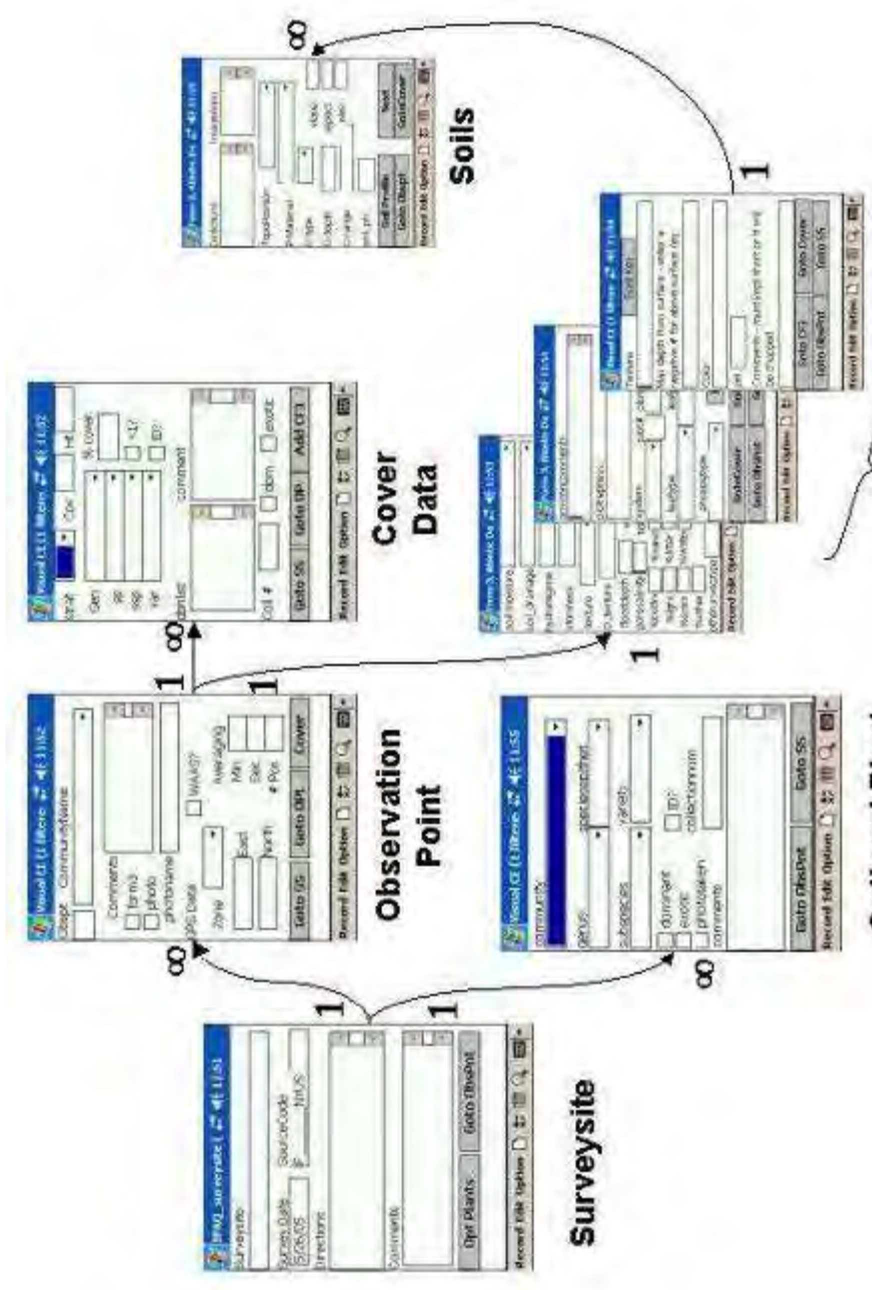
Appendix 3: Hand-held database screen shots

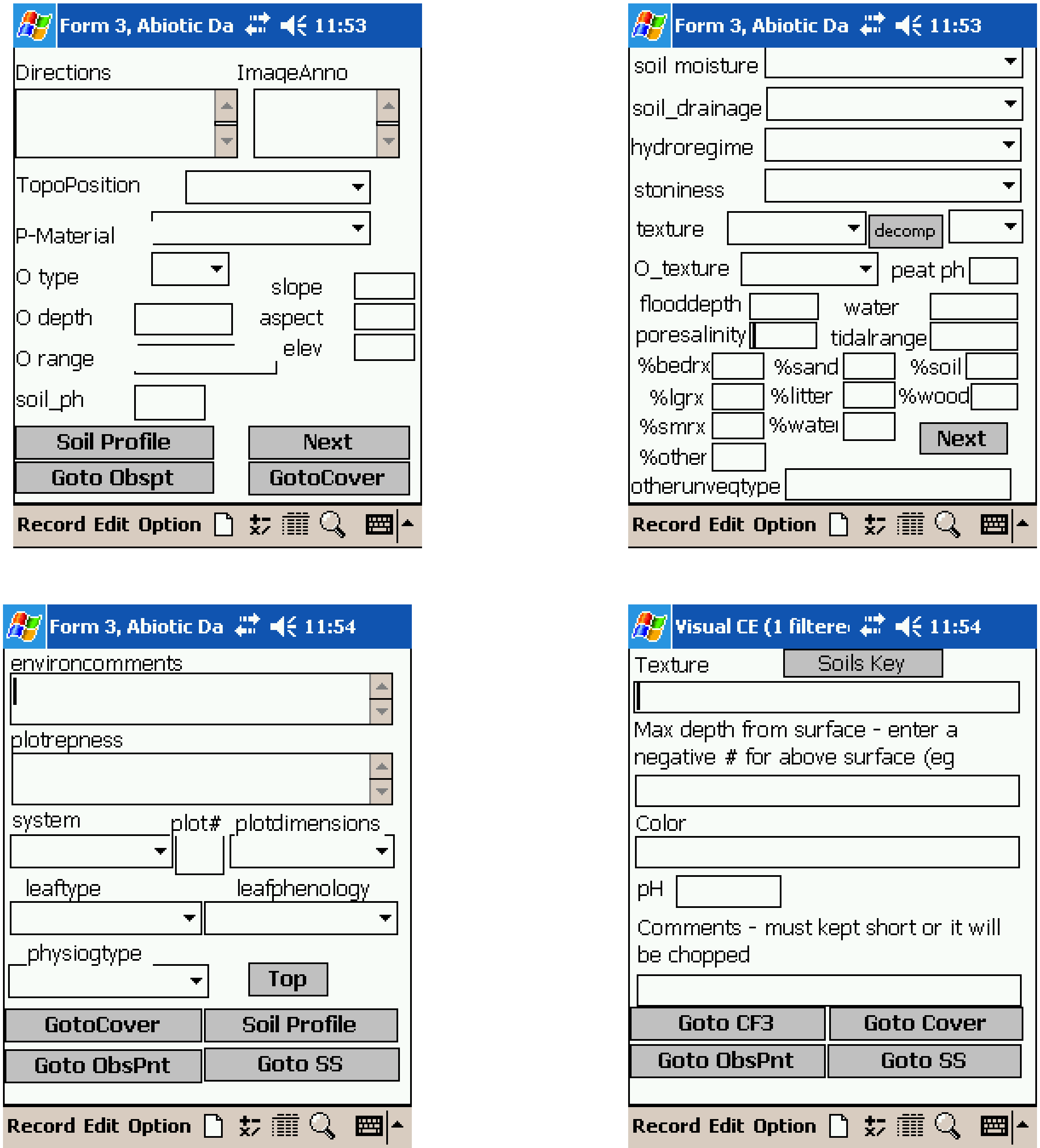






Screen shots of NY Natural Heritage Hand-Held DataBase (HHDB). Survey site information, plot and point spatial data, and vegetation cover data were digitally collected in the field using this software.


Surveysite
Observation Point
Cover Data
Optional Plant List
Form 3
Soils



Screen shots of NY Natural Heritage Hand-Held DataBase (HHDB). Data on the physical characteristics and soils for plots were digitally collected in the field using this software.

Appendix 4: Plot Quality Rank System

Rank system for forested wetlands/uplands

Biotic/Condition Factors

1) Metric: **Percent cover of native plant species (field)**
Definition: Percent cover of the plant species that are native, relative to total (native + non-native) cover (scaled to 100%).

Ratings[1]:
1 = Excellent->99% relative cover of native plant species
2 = Good-90-<99% cover of native plant species
3 = Fair-60-<90% cover of native plant species
4 =Poor-<60% cover of native plant species

[1] Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

2) Metric: **Size structure of forest (based on field measurements)**
Ratings[1]: size classes based on Frelich and Lorimer 1991 (Please refer to this reference for additional information on this metric).

Size classes (sapling (dbh 0-10.9 cm), pole (dbh 11-25.9 cm), mature (dbh 26-45.9 cm), and large (dbh ≥46 cm)

Calculate structural stage with BA Index, then add Large: Mature ratio to determine structural stage of older forests. To assign stage, measure dbh of each canopy tree and assign to size class, 2) calculate basal area (ba) of each stem (3.14 x radius^2), 3) sum ba of all stems in each size class, and calculate the % of the total canopy ba represented by the size class. From these values, assign the stand to the particular stage based on the following criteria.

1) Old-growth structural stage: L:M ≥ 1.5 and in the "old-growth" size class;
2) Transition to old-growth structural stage by a) 0.75 ≤ L:M < 1.5 and in the "mature" or "old-growth" stage or b) L:M ≥ 1.5 and in either the "mature" or "mosaic" stage;
3) Mature structural stage a) L:M < 0.75 and in the "mature" stage or b) 0.75 ≤ L:M < 1.5 and in the "mosaic" stage
4) Pole structural stage a) developmental stage is "pole" or b) L:M < 0.75 and in the "mosaic" stage.

[1]Goodell, L. and D. Faber-Langendoen. 2007. Development of stand structural stage indices to characterize forest condition in Upstate New York. Forest Ecology and Management 249:158-170.

3) Metric: Amount of coarse woody debris within plot (Field)

Definition: Coarse Woody Debris (CWD) refers to all woody debris lying on the forest floor with diameter > 5cm, mainly coming from dead trees resulting from competition and disturbances. The amount of CWD on the forest floor can be an important indicator of the maturity and estimated age of a forest.

Ratings[2]:

1) At least 10% of plot contains downed CWD (Classes 2, 3, 4, 5); presence of standing snags; 2-5 logs and snags exceeding 30cm; forest floor thick with biomass with no signs of trampling
2) Less than 10% downed CWD (Classes 2, 3, 4); standing snags present; 1-2 logs and snags exceeding 30cm; forest floor has fair amount of biomass with no signs of trampling
3) Presence or trace of downed CWD (Narrow size-class and early stage of decay); few standing snags and/or no snags; no logs and snags exceeding 50 cm dbh; forest floor has presence of biomass with possible signs of trampling
4) presence of only downed CWD class 1 and/or absence of CWD; forest has no visible presence of biomass but signs of trampling are present

[2]Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

5) Metric: Species Condition within plot location

Definition: What is the overall health/condition of the species in the plot?

Ratings[6]:

1) No visible signs of disease/pests/wounds on T2/T3 species; No dead branches or poor crowns on T2/T3 species; No visible tree foliage damage; understory shrubs/herbs in excellent condition; No evidence of overbrowse by deer; No visible disturbances in plot that may degrade species condition and dispersal
2) At least one of the following conditions exists: Slight visible signs of disease/pests/wounds on T2/T3 species; T2/T3 species have some signs of dead branches/poor crowns/decay; Visible tree foliage damage; Understory shrubs/herbs condition has been slightly degraded; Slight evidence of overbrowse by deer; Slight visible disturbances in plot possibly degrading species condition and dispersal
3) At least two of the following conditions exist: Slight to moderate signs of disease/pests/wounds on T2/T3 species; T2/T3 species have signs of dead branches/poor crowns/decay; Visible tree foliage damage present;

Understory shrubs/herbs condition has been degraded; Slight to Moderate evidence of overbrowse by deer; Slight to moderate visible disturbances in plot possibly degrading species condition and dispersal

4) At least two of the following conditions exist: Moderate to severe signs of disease/pests/wounds on T2/T3 species; T2/T3 species have signs of dead branches/poor crowns/decay; Moderate to severe visible tree foliage damage present; Understory shrubs/herbs condition has been severely degraded by disturbances; Moderate to severe evidence of overbrowse by deer; Moderate to severe visible disturbances in plot degrading species condition and dispersal

[6] Scott, C., R. Morin, 2006. Mark Twain National Forest Planning Document (Draft), derived from Forest Health Forest Monitoring Toolkit Team Working Group documents (USFS, NPS, NatureServe, and The Nature Conservancy).

Size factor

1) Metric: **Size of natural community where plot is located (remote)**

Definition: What is the patch size of the natural community where the plot is located? This metric is taken from Forest Ecological Integrity Model Table Details (*patch size requirements modified from original metric in order to reflect landscape of West Kill*)

Ratings□ : If Matrix,
1) Plot is located within matrix community patch size that is >2,000 ha
2) Plot is located within matrix community patch size that is 200-2,000 ha
3) Plot is located within matrix community patch size that is 20-200 ha
4) Plot is located within matrix community patch size that is <20 ha

Ratings□ : If Large Patch,
1) Plot is located within large patch community that is >200 ha
2) Plot is located within large patch community that is 20-200 ha
3) Plot is located within large patch community that is 2-20 ha
4) Plot is located within large patch community that is <2 ha

Ratings□ : If Small Patch,
1) Plot is located within small patch community that is >5 ha
2) Plot is located within small patch community that is 1-5 ha
3) Plot is located within small patch community that is 0.2-0.9 ha
4) Plot is located within small patch community that is <0.2 ha

□ Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

Abiotic factors

1) Metric: **Disturbances present in plot and within 50 meters of plot location (Field)**

Definition: Visible human disturbances (ATV trails, logging, fire, exotic plants, clearing, grazing/browse, wind/ice damage, ditching, forest pest/pathogen damage development, erosion from sediment runoff, altered channel morphology, increased stream discharge rates, trash, etc.) that occur within natural community where plot is taken and within 50 meters of plot (Foreman and Alexander 1998).

Ratings: 1) 98-100% of plot and surrounding natural community is not affected by visible disturbances

2) 70-97% of plot and surrounding natural community is not affected by visible disturbances

3) 50-69% of plot and surrounding natural community is affected by visible disturbances

4) 70-100% of plot and surrounding natural community is affected by visible disturbances

2) Metric: **Hydrology regime within plot and surrounding natural community (if applicable) (field)**

Definition: The degree to which onsite or adjacent land uses and human activities have altered hydrological processes.

Ratings[7]: 1) No alterations. No dikes, diversions, ditches, flow additions, or fill present in wetland that restricts or redirects flow

2) Low intensity alteration such as roads at/near grade, small diversion or ditches (< 1 ft. deep) or small amount of flow additions

3) Moderate intensity alteration such as 2-lane road, low dikes, roads w/culverts adequate for stream flow, medium diversion or ditches (1-3 ft. deep) or moderate flow additions.

4) High intensity alteration such as 4-lane Hwy., large dikes, diversions, or ditches (>3 ft. deep) capable to lowering water table, large amount of fill, or artificial groundwater pumping or high amounts of flow additions

[7] NatureServe. 2006. Draft summary version of ecological integrity assessment standard. The Ecological Integrity Assessment Working Group included Don Faber-Langendoen and Pat Comer of NatureServe (co-chairs), David Braun (The Nature Conservancy), Andy Cutko (Maine NHP, now NatureServe), Tom Foti (Arkansas HP), Stephanie Neid (Colorado HP), Joe Rocchio (Colorado HP), Steve Rust (Idaho HP), Mike Schafale (North Carolina HP), and Dan Salzer (The Nature Conservancy). https://transfer.natureserve.org/download/longterm/EIAWG/Deliverables/NatureServe%20%20Ecological%20Integrity%20Assessment_Nov2006.doc

Landscape Factors:

1) Metric: Estimated size of surrounding natural landscape and connectivity of plot and surrounding natural community to other natural landscapes (Remote and some field).

Definition: This factor will be related to whether the plot is located in a natural community that is connected to the natural landscape; natural communities occurring in a natural occurring landscape have better species dispersion and genetic flow, creating a possible high quality reference condition.

Ranking System□ : **Distance of plot to the edge of non-natural habitat (Adjacent land use) (remote with some field notes)**

1) Distance to edge of non-natural habitat is >100m

2) Distance to edge of non-natural habitat is 50-100m

3) Distance to edge of non-natural habitat is 25-50m

4) Distance to edge of non-natural habitat is <25m

□ Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

2) Metric: Estimated percentage of natural habitat within 1km radius circle of plot location.

Ranking System[9]: **Percentage of natural habitat within 1 km radius circle of plot location (Remote)**

1) Embedded in 90-100% natural habitat; connectivity is expected to be high; remaining natural habitat is in good condition (low modification); and a mosaic with gradients

2) Embedded in 60-90% natural habitat; habitat connectivity is generally high, but lower for species sensitive to habitat modification; remaining natural habitat with low to high modification and a mosaic that may have both gradients and abrupt boundaries

3) Embedded in 10-40% natural habitat; connectivity is generally low; but varies with mobility of species and arrangement on landscape; remaining natural habitat with low to high modifications and gradients shortened

4) Embedded in <10% unfragmented natural landscape; relictual; connectivity is essentially absent; remaining natural habitat generally highly modified and generally uniform

[9] Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

3) Metric: Distance of plot location to the nearest paved road

Ranking system[10]: **Distance to nearest paved road (Remote)**

1) Very far >100 m

2) Far 50 to 100 m

3) Near 30 -75 m

4) Very Near <30 m

[10] Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

OVERALL RANKING SCORES FOR FORESTED UPLANDS/WETLANDS:

1) EXCELLENT REFERENCE COMMUNITY: <20

2) GOOD REFERENCE COMMUNITY; 20- 25

3) FAIR REFERENCE COMMUNITY; 26-32

4) POOR REFERENCE COMMUNITY: >32

Rank system for non-forested wetlands/uplands

Biotic/Condition Factors

1) Metric: **Percent cover of native plant species (field)**
Definition: Percent cover of the plant species that are native, relative to total cover (scaled to 100%).

Ratings[1]:
1 = Excellent->99% cover of native plant species
2 = Good-90-<99% cover of native plant species
3 = Fair-60-<90% cover of native plant species
4 =Poor-<60% cover of native plant species

[1]Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

3) Metric**: Species Condition within Plot location (field)**
Definition: What is the overall health/condition of the species in the plot?
Ratings□ :
1) No visible signs of disease/pests/wounds on species; no evidence of overbrowse by deer; No visible disturbances in plot that may degrade species condition and dispersal
2) At least one of the following conditions exist: Slight visible signs of disease/pests/wounds on species; Slight visible evidence of overbrowse by deer; Slight visible foliage damage; Slight visible disturbances in plot possibly degrading species condition and dispersal
3) At least two of the following conditions exist: Slight to moderate signs of disease/pests/wounds on species; Moderate evidence of overbrowse by deer; Visible foliage damage present; Slight to moderate visible disturbances in plot possibly degrading species condition and dispersal
4) At least two of the following conditions exist: Moderate to severe signs of disease/pests/wounds on species; Moderate to severe overbrowse by deer; Moderate to severe visible foliage damage present; Moderate to severe visible disturbances in plot degrading species condition and dispersal

 Scott, C., R. Morin, 2006. Mark Twain National Forest Planning Document (Draft), derived from Forest Health Forest Monitoring Toolkit Team Working Group documents (USFS, NPS, NatureServe, and The Nature Conservancy).

Size factor

1) Metric: **Size of natural community where plot is located (remote)**

Definition: What is the patch size of the natural community where the plot is located? This metric is taken from Forest Ecological Integrity Model Table Details (*patch size requirements modified from original metric in order to reflect landscape of West Kill*)

Ratings : If Large Patch,

1) Plot is located within large patch community that is >200 ha
2) Plot is located within large patch community that is 20-200 ha
3) Plot is located within large patch community that is 2-20 ha
4) Plot is located within large patch community that is <2 ha

Ratings : If Small Patch,

1) Plot is located within small patch community that is >5 ha
2) Plot is located within small patch community that is 1-5 ha
3) Plot is located within small patch community that is 0.2-0.9 ha
4) Plot is located within small patch community that is <0.2 ha

 Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

Abiotic factors

1) Metric: **Disturbances present within natural community where plot is taken (Field)**

Definition: Visible human disturbances (ATV trails, erosion, cutting, trash, etc.) that occur within natural community where plot is taken.

Ratings: 1) 98-100% of plot and surrounding natural community is not affected by visible disturbances

2) 70-97% of plot and surrounding natural community is not affected by visible disturbances

3) 50-69% of plot and surrounding natural community is affected by visible disturbances

4) 70-100% of plot and surrounding natural community is affected by visible disturbances

2) Metric: **Hydrology regime within plot and surrounding natural community (if applicable) (field)**

Definition: The degree to which onsite or adjacent land uses and human activities have altered hydrological processes.

Ratings[7]: 1) No alterations. No dikes, diversions, ditches, flow additions, or fill present in wetland that restricts or redirects flow

2) Low intensity alteration such as roads at/near grade, small diversion or ditches (< 1 ft. deep) or small amount of flow additions

3) Moderate intensity alteration such as 2-lane road, low dikes, roads w/culverts adequate for stream flow, medium diversion or ditches (1-3 ft. deep) or moderate flow additions.

4) High intensity alteration such as 4-lane Hwy., large dikes, diversions, or ditches (>3 ft. deep) capable to lowering water table, large amount of fill, or artificial groundwater pumping or high amounts of flow additions

[7] NatureServe. 2006. Draft summary version of ecological integrity assessment standard. The Ecological Integrity Assessment Working Group included Don Faber-Langendoen and Pat Comer of NatureServe (co-chairs), David Braun (The Nature Conservancy), Andy Cutko (Maine NHP, now NatureServe), Tom Foti (Arkansas HP), Stephanie Neid (Colorado HP), Joe Rocchio (Colorado HP), Steve Rust (Idaho HP), Mike Schafale (North Carolina HP), and Dan Salzer (The Nature Conservancy). https://transfer.natureserve.org/download/longterm/EIAWG/Deliverables/NatureServe%20%20Ecological%20Integrity%20Assessment_Nov2006.doc

Landscape Factor:

1) Metric: Estimated size of surrounding natural landscape and connectivity of plot and surrounding natural community to other natural landscapes (Remote and some field).

Definition: This factor will be related to whether the plot is located in a natural community that is connected to the natural landscape; natural communities occurring in a natural occurring landscape have better species dispersion and genetic flow, creating a possible high quality reference condition.

Ranking System□ : **Distance of plot to the edge of non-natural habitat (Adjacent land use) (remote with some field notes)**

1) Distance to edge of non-natural habitat is >100m

2) Distance to edge of non-natural habitat is 50-100m

3) Distance to edge of non-natural habitat is 25-50m

4) Distance to edge of non-natural habitat is <25m

Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

2) Metric: Estimated percentage of natural habitat within 1km radius circle of plot location.

Ranking System[9]: **Percentage of natural habitat within 1 km radius circle of plot location (Remote)**

1) Embedded in 70-100% natural habitat; connectivity is expected to be high; remaining natural habitat is in good condition (low modification); and a mosaic with gradients

2) Embedded in 40-70% natural habitat; habitat connectivity is generally high, but lower for species sensitive to habitat modification; remaining natural habitat with low to high modification and a mosaic that may have both gradients and abrupt boundaries

3) Embedded in 10-40% natural habitat; connectivity is generally low; but varies with mobility of species and arrangement on landscape; remaining natural habitat with low to high modifications and gradients shortened

4) Embedded in <10% unfragmented natural landscape; relictual; connectivity is essentially absent; remaining natural habitat generally highly modified and generally uniform

[9] Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

3) Metric: Distance of plot location to the nearest paved road

Ranking system[10]: **Distance to nearest paved road (Remote)**

1) Very far >100 m

2) Far 50 to 100 m

3) Near 30 -75 m

4) Very Near <30 m

[10] Tierney, G., D. Faber-Langendoen, R. Morin, R. Shirer, D. Bryant, M. Shyer, C. Scott, and T. Howard. 2006. Forest Ecological Integrity Model Table/Details Working Document. Forest Health Forest Monitoring Toolkit Team Working Group (USFS, NPS, NatureServe, and The Nature Conservancy).

OVERALL RANKING SCORES FOR OPEN UPLANDS/WETLANDS:

1) EXCELLENT REFERENCE COMMUNITY: <=12

2) GOOD REFERENCE COMMUNITY; 13-20

3) FAIR REFERENCE COMMUNITY; 21-26

4) POOR REFERENCE COMMUNITY: >26

Appendix 5: National Land Cover Data Classification

NLCD Classification Schemes (Level II)

Class I and II Definitions

1992 Scheme	2001 Scheme
11 - Open water 12 - Perennial Ice/Snow	11 - Open water 12 - Perennial Ice/Snow
21 - Low Intensity Residential 22 - High Intensity Residential 23 - Commercial/Industrial/Transportation	21 - Developed, Open Space 22 - Developed, Low Intensity 23 - Developed, Medium Intensity 24 - Developed, High Intensity
31 - Bare Rock/Sand/Clay 32 - Quarries/Strip Mines/Gravel Pits 33 - Transitional	31 - Barren Land 32 - Unconsolidated Shore [1]
41 - Deciduous Forest 42 - Evergreen Forest 43 - Mixed Forest	41 - Deciduous Forest 42 - Evergreen Forest 43 - Mixed Forest
51 - Shrubland	51 - Dwarf Scrub [2] 52 - Scrub/Shrub
61 - Orchards/Vineyards/Other	
71 - Grassland/Herbaceous	71 - Grassland/Herbaceous 72 - Sedge Herbaceous [2] 73 - Lichens [2] 74 - Moss [2]
81 - Pasture/Hay 82 - Row Crops 83 - Small Grains 84 - Fallow 85 - Urban/Recreational Grasses	81 - Pasture/Hay 82 - Cultivated Crops
91 - Woody Wetlands 92 - Emergent Herbaceous Wetlands	90 - Woody Wetlands 91 - Palustrine Forested Wetland [1] 92 - Palustrine Scrub/Shrub [1] 93 - Estuarine Forested Wetlands [1] 94 - Estuarine Scrub/Shrub [1] 95 - Emergent Herbaceous Wetland 96 - Palustrine Emergent Wetland

	(Persistent) [1] 97 - Palustrine Emergent Wetland [1] 98 - Palustrine Aquatic Bed [1] 99 - Estuarine Aquatic Bed [1]
	[1]C-CAP Only [2]Alaska only

Appendix 6: Bowman Hill Wildflower Preserve development of PSI for site

Assignment of Coefficients of Conservation[1]

0 to 3 Plants with a high range of ecological tolerances/found in a variety of plant communities (includes exotic plants =0)

4 to 6 Plants with an intermediate range of ecological tolerances/associated with a specific plant community

7 to 8 Plants with a poor range of ecological tolerances/associated with advanced successional state

9 to 10 Plants with a high degree of fidelity to a narrow range of habitats

[1]Bowman's Hill Wildflower Preserve 2006

Methodology[1]

1) Compile a plant list of the species within the assessment area.
2) Assign the Coefficient of Conservatism (CC) to each plant documented on the plant list.
3) Calculate the Native Mean Coefficient value by totaling the CC's and divide the sum by the number of native plant Species within the assessed area.
4) OR Calculate the Total Mean Coefficient value by totaling the CC's and divide by the sum of the total number of Plants (native and introduced) within the assessed area.
5) Multiply the Native Mean Coefficient OR the Total Mean Coefficient by the square root of the total of the number of native plant species

[1]Bowman's Hill Wildflower Preserve 2006

Calculation of PSI[1]

FQI = Native Mean C x Sqrt N FQI = Floristic Quality Index
PSI = Total Mean C x Sqrt N PSI = Plant Stewardship Index
N = Number of native species
I = Number of introduced species
Native Mean C = Sum of Coefficients / N
Total Mean C = Sum of Coefficients / N + I

[1]Bowman's Hill Wildflower Preserve 2006