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

FINAL TECHNICAL REPORT DECEMBER 2012

Prepared for
Ulster County Soil and Water Conservation District
Ashokan Watershed Stream Management Program
and
NYC DEP Stream Management Program

New York Natural Heritage Program
A Partnership betweenSUNY-ESF and the NYS Department of Environmental Conservation
625 Broadway, 5th Floor Albany, NY 12233-4757 (518) 402-8935 Fax (518) 402-8925
www.nynhp.org

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

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Elizabeth Spencer and Bud Sechler New York Natural Heritage Program
625 Broadway, 5th Floor
Albany, New York 12233-4757

Cover photo: Successional southern hardwood forest community, with flood debris from Hurricane Irene, on an sloping terrace along the Esopus.

Photographs by: Elizabeth Spencer, NYNHP

Ulster County Soil and Water Conservation District

907 County Office Building, Phoenicia, NY **12413**

NYC DEP Stream Management Program

71 Smith Avenue, Kingston, NY 12401

The New York Natural Heritage Program is a partnership between NYS Department of Environmental Conservation and the State University of New York College of Environmental Science and Forestry. 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 Ulster County Soil and Water Conservation District's Ashokan Watershed Stream Management Program (UCSWCSD), conducted natural community inventories and ecological quality rank assessments along the Upper Esopus Creek, Stony Clove, and Woodland Valley in the Catskill Mountains with the goal of classifying, mapping, and describing a set of reference riparian habitat types within these three drainages. These reference community descriptions will then be used by the District to guide stream corridor restoration projects within the watershed.

In summary, 106 plots were sampled across approximately 13 natural community types, including plots from the following natural communities: beech-maple mesic forest, hemlock-northern hardwood forest, floodplain forest, maple-basswood rich mesic forest, Appalachian oak-pine forest, cobble shore, cobble shore wet meadow, shallow emergent marsh, shrub swamp, riverside sand/gravel bar, and backwater slough. Plots were also sampled in the following successional communities: successional northern hardwoods/pine plantation, successional northern hardwoods, and successional southern hardwoods. An additional 45 target sites were assessed with observation points collected or marked at sites that were unsamplable due to flood destruction, safety issues, access denial or lack of sufficient cover of native species.

Cluster analyses were performed using 79 plots, excluding both those from successional and cultural communities as well as a few plots identified statistically as having composition and abundance that made them significant outliers among the sampled plots. In addition, an ecological indicator analysis was conducted between maple-basswood rich mesic forest and floodplain forest to determine if certain species were good indicators of each of these community types.

The more than 40-mile stretch of riparian habitat along the Esopus, Stony Clove, and Woodland Valley contained many reference examples of the major natural riparian community types. Plots were sampled in reference examples of beech-maple mesic forests and hemlock-northern hardwood forests representing the variants of each type present. Floodplain forests were small, were in poorer landscape condition, and generally contained many exotic species, but several plots could still qualify as good to fair reference examples for this natural community. An excellent example of the local viariant of cobble shore wet meadow was identified as a preliminary reference due to the lack of additional plot samples for this type. This was also the case for Appalachian oak-pine forest, where one plot representing a fairly good example was sampled and can serve as a preliminary reference for the type. Shrub swamps, cobble shores, riverside sand/gravel bars, and shallow emergent marshes all contained abundant exotic plants that lowered their Plot Quality Rank System (PQRS) and Floristic Quality Index (FQI) scores. However, examples of each occurred in good landscape position, and plots were selected to be used as at least fair quality reference examples for these natural community types, including three variants of shrub swamp. Cobble shores were very common along the Esopus, Stony Clove, and Woodland Valley, but were generally small and typically

contained abundant exotic plants. However, two plots with few exotic species were selected to represent fair quality reference examples for this natural community.

ACKNOWLEDGEMENTS

We thank the following people for their time and assistance with this project. Cory Ritz with NYC DEP, and Adam Doan of UCSWCD provided invaluable expertise on logistics, access, and local information for the Esopus, Stony Clove and Woodland Valley.

Bud Sechler, Timothy Howard, Greg Edinger (NY Natural Heritage), and Adam Doan (NYC DEP) initiated this fruitful collaboration between NY Natural Heritage and NYC DEP/UCSWCD. David Marston provided tireless database support in developing the new Coefficient of Conservatism module in the NY Natural Heritage field forms database. Shelley Cooke and John Schmidt provided database and GIS support. Aissa Feldmann, Greg Edinger, and DJ Evans provided valuable comments and edits in reviewing the document. Aissa Feldmann also provided technical assistance with the natural community crosswalk, conducted field sampling, and aided in the refinement of the field metrics. Julie Lundgren provided invaluable edits to the key of restoration types. Fiona McKinney provided guidance and support for project budgeting.

INTRODUCTION

The New York Natural Heritage Program, in partnership with New York City Department of Environmental Protection and the Ulster County Soil and Water Conservation District's Ashokan Watershed Stream Management Program (UCSWCSD), conducted natural community inventories and ecological quality rank assessments in the streamside (riparian) corridor of the Esopus, Stony Clove, and Woodland Valley Creeks (Figure 1) in the Catskill Mountains with the goal of classifying, mapping, and describing a set of reference riparian habitat types for each drainage. Potential natural community targets were identified and prioritized using methodology detailed in Sechler (2010). Inventory data from 106 sample plots surveyed during 2010 to 2012 were used to identify and describe the natural communities and their current biotic and abiotic condition. This information was then used to identify and describe reference communities for use by the District to guide stream corridor restoration projects within the watershed.

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).

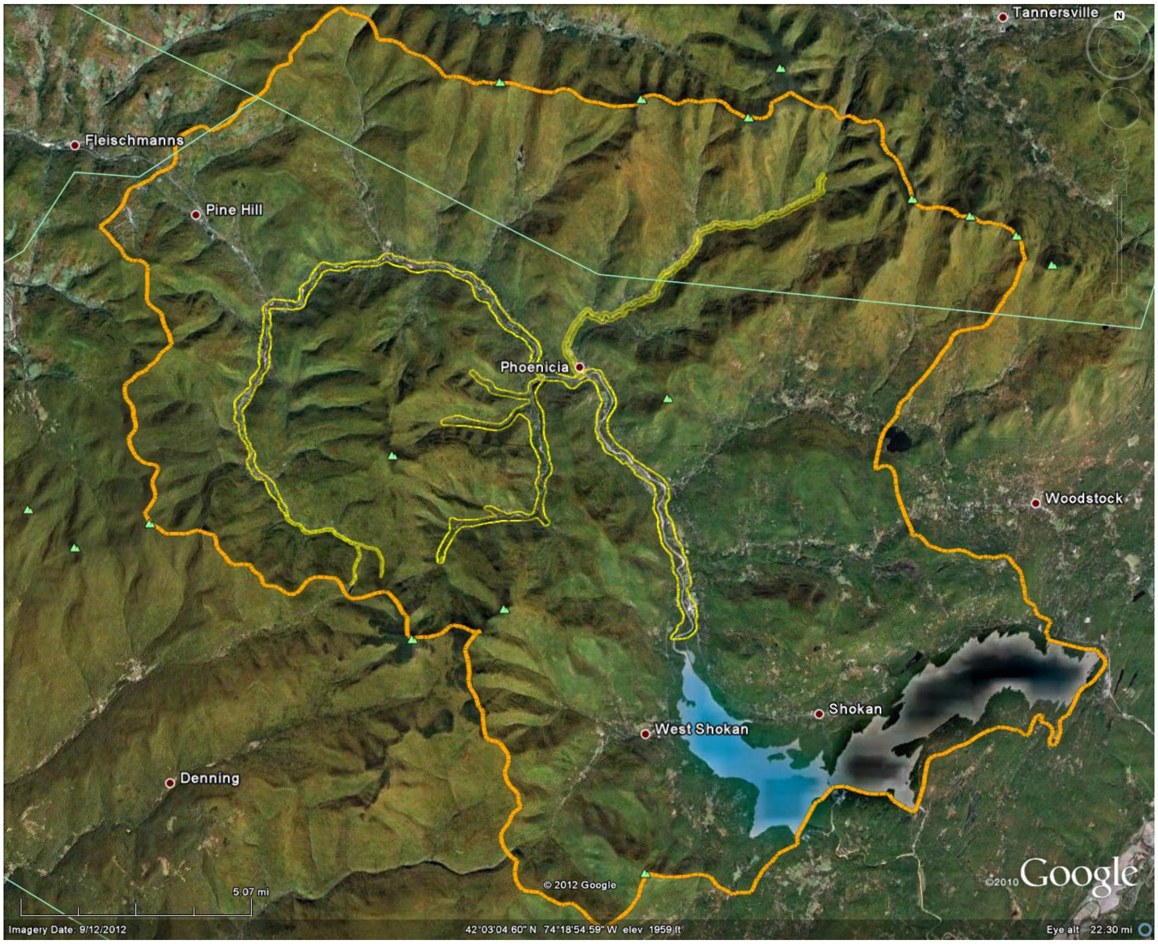

Figure 1. Ashokan Watershed Study Area

METHODS

Field Methodology

All NY Ecological Community types (Edinger *et al.* 2002) were sampled using standardized releve plot collection techniques. Our goal was to sample a minimum of 3 plots per type. Sechler (2010) suggested specific sampling intensities for each community type present in the preliminary vegetation maps provided by the UCSWCSD. Within each polygon selected for sampling, a plot was established in an area that most represented 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), saplings and tall shrubs (2–5 m), tall seedlings and short shrubs (0.5-<2 m), short seedlings and dwarf shrubs (0-<0.5m) 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 (1.4 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, and soil drainage. Any unvegetated area of the plot was characterized by its dominant component (e.g., soil, litter, water). Notes were taken on the plot's representativeness in relation to the surrounding vegetation as well as on other significant environmental information, such as landscape context, herbivory, stand health, recent disturbance, or evidence of historic disturbance. Plot and reference observation point data were entered into a handheld database in the field using a Trimble Nomad, and were imported to a desktop Field Form Database (FFDB).

We collected a digital photograph at most of the plot sampling locations and recorded the GIS coordinates of each plot. 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 Elizabeth Spencer and Bud Sechler of NY Natural Heritage during September 2010, Elizabeth Spencer and Aissa Feldmann in July 2011, and Elizabeth Spencer from July 16-August 23, 2012. In total, we sampled 106 plots and 45 additional observation points throughout the Esopus, Stony Clove, and Woodland Valley riparian areas. These time periods generally captured the highest species richness within each natural community. Using aerial photography and an existing vegetation map provided by UCSWCSD, the vegetation polygons within the riparian area were stratified by type, total acreage and number of polygons to prioritize them for sampling (Sechler 2010). We assumed that cultural or highly disturbed communities did not need to be sampled; they were documented via GPS observation points.

Plot Quality Ranking System

During and following field surveys and preliminary classification of the data, we ranked each plot 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. See Sechler (2010) for detailed descriptions for each plot quality rank factor. The assessment of each factor occurred either in the field or remotely using aerial photography, other GIS layers, and Google Earth (Google Inc. 2012).

Table 1: **Plot Quality Rank System Factors** (additional details in Sechler 2010)

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
Hydrologic regime within plot and surrounding natural community	Abiotic factors	Forested Wetlands/Non-forested Wetlands	Field
Soil/geological condition of plot and surrounding natural community	Abiotic factors	Forest/Non-forest	Field
Amount of coarse woody debris within plot	Biotic factor	Forested plots only	Field
Browse index/Tree regeneration	Biotic factor	Forested plots only	Field
Vegetation structure of floodplain and swamp forest	Biotic factor	Riparian Forest	Field
Percent cover of native plant species	Biotic factor	Forest/Non-forest	Field and remote
Species condition within plot location	Biotic factor	Forest/Non-forest	Field
Size structure of forest	Biotic factor	Forested plots only	Remote calculations based on field measurements
Channel stability	Landscape factor	Riverine systems	Field
Distance of plot to the edge of non-natural habitat (Adjacent land use)	Landscape factor	Forest/Non-forest	Remote
Distance to nearest paved road	Landscape factor	Forest/Non-forest	Remote
Floodplain interactions	Landacape factor	Riparian Wetlands only	Field
Hydrological connectivity	Landscape factor	Riparian Wetlands only	Field
Percentage of natural habitat within 1 km radius circle of plot location	Landscape factor	Forest/Non-forest	Remote using 2006 CCAP National Land Cover data (NLCD) (**Appendix 4**)
Upstream/On site water diversion	Landscape factor	Riparian Wetlands only	Field and remote
Size of natural community where plot is located	Size factor	Forest/Non-forest	Remote

OVERALL RANKING SCORES FOR FORESTED WETLANDS:
1) EXCELLENT REFERENCE COMMUNITY: <30
2) GOOD REFERENCE COMMUNITY; 30-39
3) FAIR REFERENCE COMMUNITY; 40-49
4) POOR REFERENCE COMMUNITY: >=50

OVERALL RANKING SCORES FOR OPEN WETLANDS:
1) EXCELLENT REFERENCE COMMUNITY: <=22
2) GOOD REFERENCE COMMUNITY; 23-30
3) FAIR REFERENCE COMMUNITY; 31-39
4) POOR REFERENCE COMMUNITY: >39

OVERALL RANKING SCORES FOR FORESTED UPLANDS:
1) EXCELLENT REFERENCE COMMUNITY: <25
2) GOOD REFERENCE COMMUNITY; 25-34
3) FAIR REFERENCE COMMUNITY; 35-44
4) POOR REFERENCE COMMUNITY: >=45

OVERALL RANKING SCORES FOR OPEN UPLANDS:
1) EXCELLENT REFERENCE COMMUNITY: <=18
2) GOOD REFERENCE COMMUNITY; 19-26
3) FAIR REFERENCE COMMUNITY; 27-35
4) POOR REFERENCE COMMUNITY: >35

Plant Coefficent of Conservatism and Floristic Quality Index

Floristic Quality Assessment (FQA) is a tool designed to provide indices that aid in the ecological assessment of particular sites and are designed to answer questions regarding 1) the overall naturalness of the site, and 2) how land management practices or their absence have affected the naturalness of the site. Floristic Quality Assessment (FQA) metrics are calculations centered around each species' Coefficient of Conservatism (CoC) value (Swink and Wilhelm 1994). This value, which ranges from 0 to 10, is intended to characterize the species' fidelity to an intact, pre-settlement ecological community. For example, cosmopolitan species that occur in many habitats, like Reed Canarygrass (*Phalaris arundinacea*) receive low scores, a 1 in this case. A score of 10 would be applied to specialists that require intact, possibly relic, habitat, like Northern Bog Aster (*Symphyotrichum boreale*). Non-native species are given a score of zero. The Floristic Quality Index (FQI) summarizes all coefficient conservation values for all plant species at a given site. Draft C-values were recently developed for New York's vascular flora by Stephen M. Young and David Werier (Werier & Young 2011).

We calculated FQA metrics for all natural community plots and a subset of the successional forest plots sampled along the Esopus, Stony Clove, and Woodland Valley riparian areas (Excel table WFQI_Ashokan). However, a couple of caveats should be noted with regard to the resulting indices. First, the CoCs used were developed by botanists, New York Natural

Heritage Program Chief Botanist Steve Young and Independent Botanical Consultant David Werier, as a first draft summary of the species' conservatism statewide. Due to limited time and funding, the currently assigned CoCs were not always fully rectified into one score for each species. In these cases, a mean of the two assigned scores was used as the CoC. As a result, the species scores are not limited to integer values. CoC values could only be assigned to fully identified species, so unknown species or those identified only to the genus level were excluded from the calculations. However, using this index still provides a consistent analysis of floral composition among sites. The use of weighted indices for both the mean C and FQI is designed to incorporate the relative abundance of each species within a measured plot, including non-native and invasive species; this adds quantitative weighting to scores and better reflects the plot's species composition and quality (Milburn *et al.* 2007).

Assignment of Coefficients of Conservation (Swink and Wilhelm 1994)
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.

We calculated four FQA metrics, Mean C (the mean CoC value for all species at a site); weighted Mean C ($w\bar{C}$), which takes abundance of each species into account (equation 1); the Floristic Quality Index (FQI), which incorporates the Mean C score and species richness, equation 2); and a weighted FQI ($wFQI$) (equation 3).

$$w\bar{C} = \sum_{i=1}^{S} p_i C_i \Big/ S \qquad (1)$$

where p is the proportional (relative) abundance, C is the C-value of each species (i), and S is the number of species.

$$FQI = \bar{C}\sqrt{S} \qquad (2)$$

where $\bar{C}$ is the mean C-value, and S is the number of species (species richness).

$$wFQI = w\bar{C}\sqrt{S} \qquad (3)$$

Statistical Analysis Methods

We performed a cluster analysis of 79 plots in PC-ORD 5.10 (McCune 2007) with the goal of grouping plots that contained similar vegetation in the tree, shrub, and herbaceous layers (Figures 2 and 3). This is consistent with other studies that have used cluster analysis to determine reference communities within a stream corridor (Harris 1999). Plots omitted for analysis purposes included all cultural communities and some natural communities, including both northern and southern successional hardwood types, and compositional outliers of the other natural 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 0.02 percent of the total layer were excluded.

We used ecological indicator analysis to further explore the relationships between maple-basswood rich mesic forest and floodplain forest community types. Our goal here was to separate out vegetation differences for the two natural community types and to look for specific indicators for each type. The indicator values ranged from zero (no indication) to 100 (perfect indication). Perfect indication results when a species occurs in only one of the community types analyzed. (McCune 2007).

The initial cluster analysis results did not fully differentiate floodplain forests from maple-basswood rich mesic forests based on species composition. Therefore, a second analysis of only these plots was done; first, we labeled them with their respective community type, and then we ran them through an Indicator Species Analysis within PC-ORD again to identify species that could serve as indicators of each group (McCune 2007).

RESULTS

Between mid-September of 2010 and late August of 2012, we conducted natural community plot surveys and plot quality rank assessments along the Esopus, Stony Clove and Woodland Valley. Table 2 shows a summary of total plots and natural community types sampled. Overall, 106 plots were sampled across approximately 13 natural community types.

Several natural communities predicted to occur in the study area based on the UCSWCSD community mapping were not found during the actual plot sampling during 2010, 2011, or 2012. We did not document any calcareous talus slope woodlands, successional red cedar woodlands, or Appalachian oak-hickory forests within the survey area. The land-use history in combination with the geology and soils of the riparian areas bordering the Esopus, Stony Clove and Woodland Valley were probably the largest contributors to the lack of detection of these community types.

In addition, several natural communities were found that were not predicted in the preliminary assessment. We documented Appalachian oak-pine forest, cobble shore wet meadow and riverside sand/gravel bar along the Esopus during plot surveys. Herbaceous-dominated marshes and wet meadows were scarce along all three drainages, and riverside sand/gravel bars may have been included in areas mapped as wet meadow or shrub swamp.

We omitted all successional and cultural community plots from the in-depth analyses due to their lack of applicability to restoration efforts.

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*	15
Floodplain forest*	19
Cobble shore*	15
Hemlock-northern hardwood forest*	21
Maple-basswood rich mesic forest*	6
Shrub swamp*	6
Shallow emergent marsh*	3
Backwater slough**	2
Riverside sand/gravel bar**	2
Appalachian oak-pine forest**	1
Cobble shore wet meadow**	1
Successional southern hardwoods	7
Successional northern hardwoods	6
Successional northern hardwoods/Pine plantation	1
Pine plantation/Pine-northern hardwood Forest	1
Assessed, unsampled target polygons***	45

* The Esopus, Stony Clove, and Woodland Valley 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 Esopus, Stony Clove and Woodland Valley.
**Although fewer than three plots of these types were sampled they are described to aid in the identification of additional sites supporting these types within the study area. The remaining natural and cultural community types will not be described due to their infrequent occurrence and/or because they are not relevant to this restoration-guiding project.
*** Target polygons were not sampled due to one of the following circumstances: destruction by flooding from Hurricane Irene was determined on-site or via Google Earth, presence of unnatural type (plantation, mowed lawn) not representing any target due to a lack of substantial native species cover, extant polygons included hazards such as steep slopes in combination with areas of flood debris (boards with nails, broken glass etc.), and/or denial of access permission.

Table 3: **Results Tables: Folder Locations and Contents**

All data covering the species composition, abiotic characteristics, plot rank quality metric scoring, and the Floristic Quality indices for the reference and natural community plots and have been included in supplemental, comprehensive Excel or Word Files on the project final report CD. In addition a folder for each reference community type has been created to facilitate use of these data for each individual natural community (named e.g.: FloodplainForest). These folders also contain respective maps and photos for the associated reference plots. The summary folders and files have the following file structure and names:

Folder	File/Worksheet Name(s)	Contents
Floristic_Quality_Assessment	NaturalCommunityPlotFQI.xlsx CombinedFQIandPQRS.xlsx	a)Calculated Floristic Quality Index Values for all natural community plots(not all successional plots are included) b)weighted FQIvalues and PQRS by plot
Forest_References	ForestReferenceCommunitySppandAbioticData_Lists.xlsx	All species composition, strata, CoC and Abiotic data for forest community reference plots
Keys	KeyToRestorationTypes_Ashokan.docx and .pdf AllSpeciesnamesCoC.xlsx	a)Key to natural community restoration types, b)table of scientific and common names for all species documented in surveys
Open_References	OpenCommunityReferenceSppandAbiotic_Lists.xlsx	All species composition, strata, CoC and Abiotic data for open community reference plots
PlotQualityRankTable	PQRSAshokanPlots.xlsx	Plot quality rank metric scores for all ecological community plots
Statistical Analysis	FF_MBRMF_IndAnal.xlsx	Tabular indicator species results for the comparison of floodplain forests and maple-basswood rich mesic forests.
StudyAreaMaps_SpatialData	Forest_ReferencePlots.kmz OpenCommunityReferencePlots.kmz	a)Google Earth .kmz files of reference plot locations b)study area and reference plot location maps
The following tables are worksheets in ForestReferenceCommunitySppandAbioticData_Lists.xlsx		
Community Name	*Data worksheet names*	*Data sheet contents*
AppalachianOakPineForest	AOPFSpp-6293, AOPFAbiotic-6293	All species composition, strata, CoC and Abiotic data for the reference plot
BeechMapleMesicForest	BMMFspp-6045, BMMFAbiotic-6045, BMMFspp-6173, BMMFAbiotic-6173, BMMFspp-6252, BMMFAbiotic-6252	All species composition, strata, CoC and Abiotic data for reference plots
FloodplainForest	FFspp-6036, FFspp-6114, FFspp-6459, FFAbiotic-6036, FFAbiotic-6114, FFAbiotic-6459	All species composition, strata, CoC and Abiotic data for reference plots

HemlockNorthernHardwoodForest	HNHFspp-6088, HNHFspp-6109, HNHFspp-6173, HNHFspp-6206, HNHFspp-6328, HNHFAbiotic-6088, HNHFAbiotic-6109, HNHFAbiotic-6173, HNHFAbiotic-6206, HNHFAbiotic-6328	All species composition, strata, CoC and Abiotic data for reference plots
MapleBasswoodMesicForest	MBRMFspp-5008, MBRMFspp-6211, MBRMFAbiotic-5008, MBRMFAbiotic-6211	All species composition, strata, CoC and Abiotic data for reference plots
The following tables are worksheets in OpenCommunityReferencSppandAbioticData_Lists.xlsx		
Community Name	*Data worksheet names*	*Data sheet contents*
BackwaterSlough	BWSspp, BWSAbiotic	All species composition, strata, CoC and Abiotic data for reference plots
CobbleShore	CSspp-6536, CSAbiotic-6536	All species composition, strata, CoC and Abiotic data for reference plots
CobbleShoreWetMeadow	CSWMspp-4286, CSWM-4286	All species composition, strata, CoC and Abiotic data for the provisiona; reference plot
RiversideSandGravelBar	RSGBSpp-5109, RSGBAbiotic-5109	All species composition, strata, CoC and Abiotic data for the provisional reference plot
ShallowEmergentMarsh	SEMSpp-6349, SEMAbiotic-6349	All species composition, strata, CoC and Abiotic data for the provisional reference plot
ShrubSwamp	FSspp_6065, FSAbiotic_6065, SFSspp_3896, SFSAbiotic_3896, SSspp_2186, SSAbiotic_2186	All species composition, strata, CoC and Abiotic data for reference plots

Statistical Analysis Results

Forested Communities

Six distinct groups emerged from the cluster analysis of the forested natural communities and are labeled as Groups 1 through 6 in Figure 2. Group 1 and Group 2 consisted mainly of hemlock-northern hardwood and beech-maple mesic forests respectively. A plot labeled as maple-basswood rich mesic forest also clustered loosely with the hemlock-northern hardwood forest plots, and this was expected due to similar canopy species within the types.

Groups 3 and 5 included mostly floodplain forests, generally splitting among the community variants. These groups also included the remainder of the maple-basswood rich mesic forests, with the vast majority clustering with Group 5. Group 5 consisted primarily of a combination of the northern-hardwood floodplain forest variant with most of the maple-basswood rich mesic forests and one plot each of beech-maple mesic forest and hemlock-northern hardwood forest. The beech and hemlock forests clustered there primarily due to their similar sapling and emergent tree layers.

Group 4 was a small group of plots including one plot each of beech-maple mesic forest, floodplain forest, and the white pine variant of hemlock-northern hardwood. These plots shared an unusual subset of their composition which resulted in their clustering together.

Group 6 was a specific subset of beech-maple mesic forest plots with red oak as an important canopy tree. This group was comprised of a distinct subset of the beech-maple mesic forests and the lone Appalachian oak-pine forest sampled.

A somewhat unexpected result of the analysis was the very close clustering of floodplain forests and maple-basswood rich mesic forests. Closer examination of the plot data revealed similarities among the canopy and subcanopy species that might explain this pattern of clustering. The canopy species associated with both floodplain forests and maple-basswood rich mesic forests include American basswood *(Tilia americana* var. *americana)*, sugar maple (*Acer saccharum* var. *saccharum*), white ash (*Fraxinus americana*), musclewood (*Carpinus caroliniana* ssp. *virginiana*), red oak (*Quercus rubra*), and 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 performed on 2 groups of maple basswood rich mesic forest and floodplain forest plots showed several plant species emerging as ecological indicators for those types. Excel table FF_MBRMF_IndAnal 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 maple-basswood rich mesic forests ($p=0.05$) include canopy layer (T2) American basswood and yellow birch, and the herbs blue-stemmed goldenrod (*Solidago caesia* var. *caesia*), and Christmas fern (*Polystichum acrostichoides*). The floodplain forest plots lacked indicators at the $p = 0.05$ level, but at the $p= 0.10$ level or below had subcanopy (T3) American elm (*Ulmus americana*), the invasive Japanese knotweed (*Fallopia japonica*), and grove bluegrass (*Poa alsodes*).

The results also showed that species such as sugar maple, and white ash were not good indicators of maple-basswood rich mesic forests or floodplain forests since they occurred frequently in both groups (FF_MBRMF_IndAnal.xlsx). The ecological indicator analysis shows that there are species that can be used to distinguish between the more upland variant of maple-basswood rich mesic forest and the more riparian variant of floodplain forest. These distinguishing features, in turn, may help inform restoration and planting efforts (see also floodplain forest and maple-basswood rich mesic forest discussion/recommendations sections).

Open Communities

A separate detailed cluster analysis was also conducted for the open communities. Six distinct clustering groups emerged from this analysis, and they are labeled as Groups 1 through 6 in Figure 3. Group 1 includes the shallow emergent marshes, a riverside sand/gravel bar and a single cobble shore. Groups 2 through 5 included the remaining cobble shores, a riverside sand/gravel bar, and the one cobble shore wet meadow, and Group 6 are the shrub swamps.

Many of the cobble shores were generally quite sparsely vegetated with different admixtures of species often occupying different shores over a wide area, which helps to explain their distribution within so many groups in the analysis. The six-group level was retained to maintain the segregation of shallow emergent marshes and riverside sand/gravel bars, shrub swamps, and cobble shore communities.

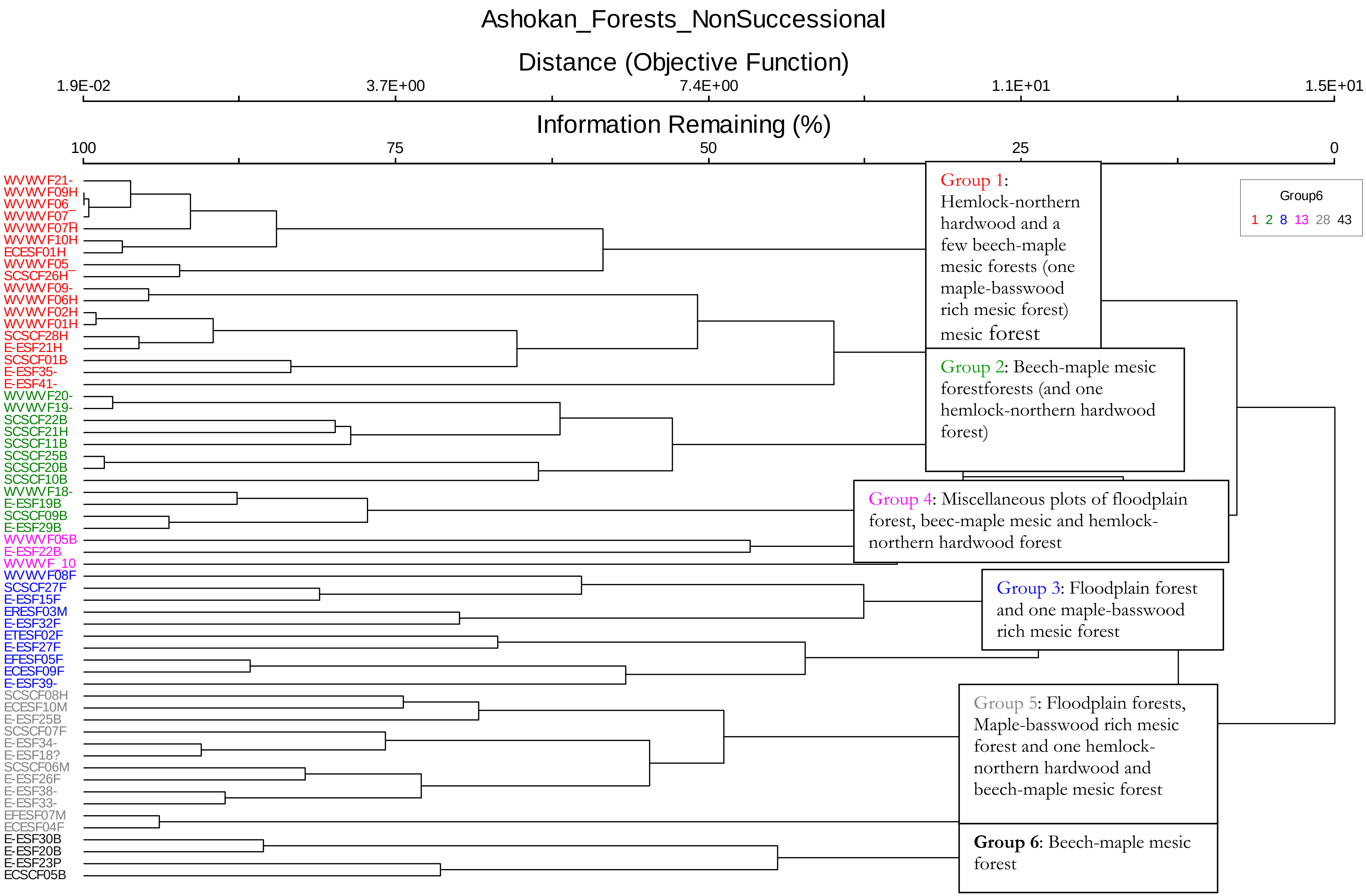

Figure 2: Cluster analysis results for non-successional forests

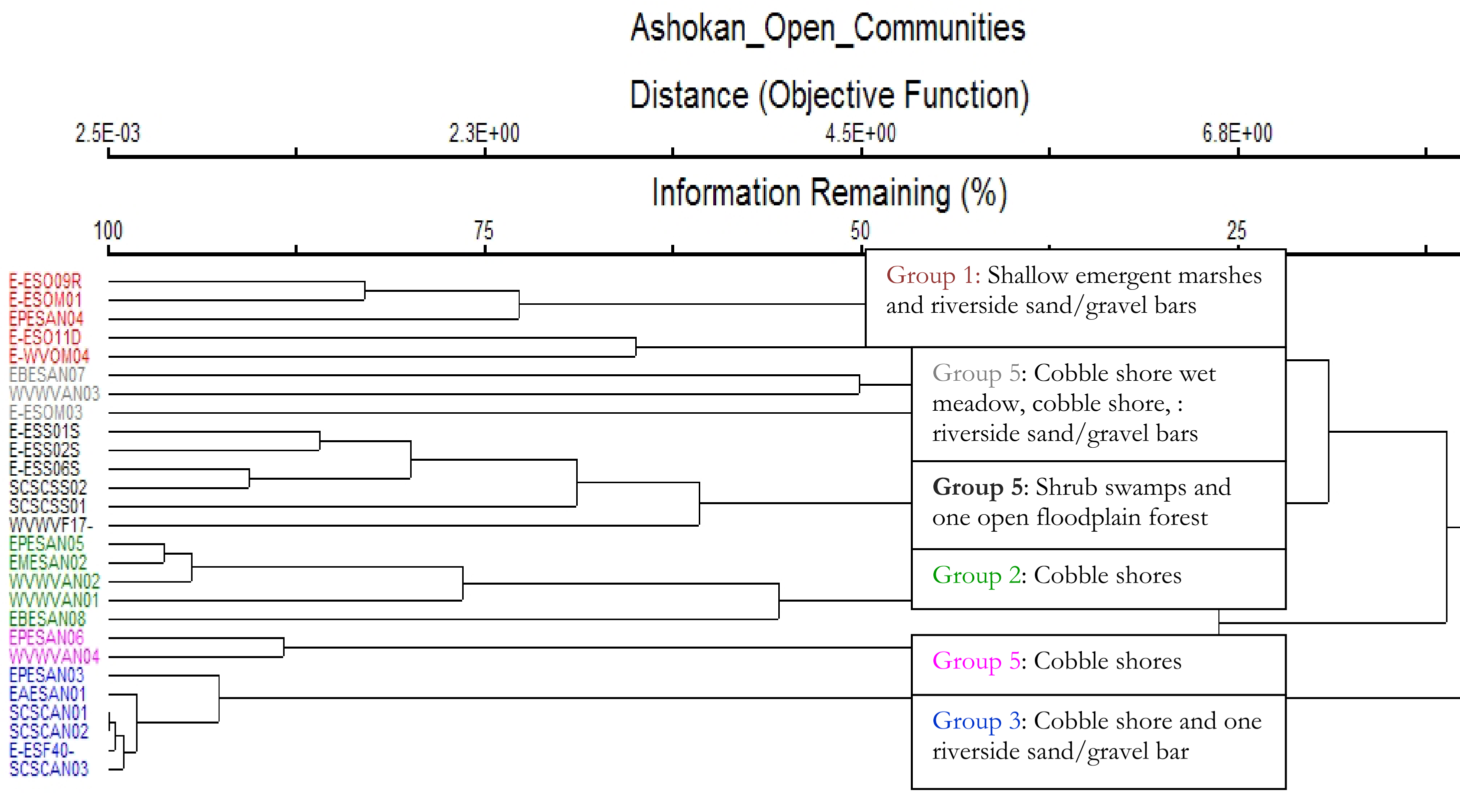

Figure 3: Cluster analysis results for open communities

The Ecological Indicator Analysis results for maple-basswood rich mesic forest and floodplain forest are included in the Excel table: FF_MBRMF_IndAnal.xlsx . This table compares the more abundant species for each growth form, the percentage 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).

NATURAL COMMUNITY DESCRIPTIONS AND COMPOSITION

We provide a detailed description of each community type as it occurred in the Esopus, Stony Clove, and Woodland Valley riparian areas, followed by a broader assessment of species composition determined by averaging all plot data for that type across all drainages. For most communities we were able to meet the three plots per type goal; this allowed us to capture enough variation to describe types broadly along the Esopus, Stony Clove, and Woodland Valley. The following two communities were only encountered one time each in the study area: cobble shore wet meadow and Appalachian oak-pine forest. Given the rarity of these types in the sudy area, their descriptions are based on the single plot sampled for each type. For each natural community, we also provide Excel summary tables of the Plot Quality Rank System (Excel table:CombinedFQIandPQRS.xlsx)and Floristic Quality Assessment results (Excel table: NaturalCommunityPlotFQI.xlsx); classification; and pictures, location maps, and recommendations of specific plots that may serve as "references" for the type. Successional and cultural community types encountered along the Esopus, Stony Clove, and Woodland Valley are omitted from this section. Within each community description, non-native and invasive species have been bolded to aid in understanding their abundance and distribution within each each community.

This report also describes the Catskill riparian zone vegetation in the context of a national and regional vegetation classification (NatureServe, 2012). 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 (NatureServe, 2012).

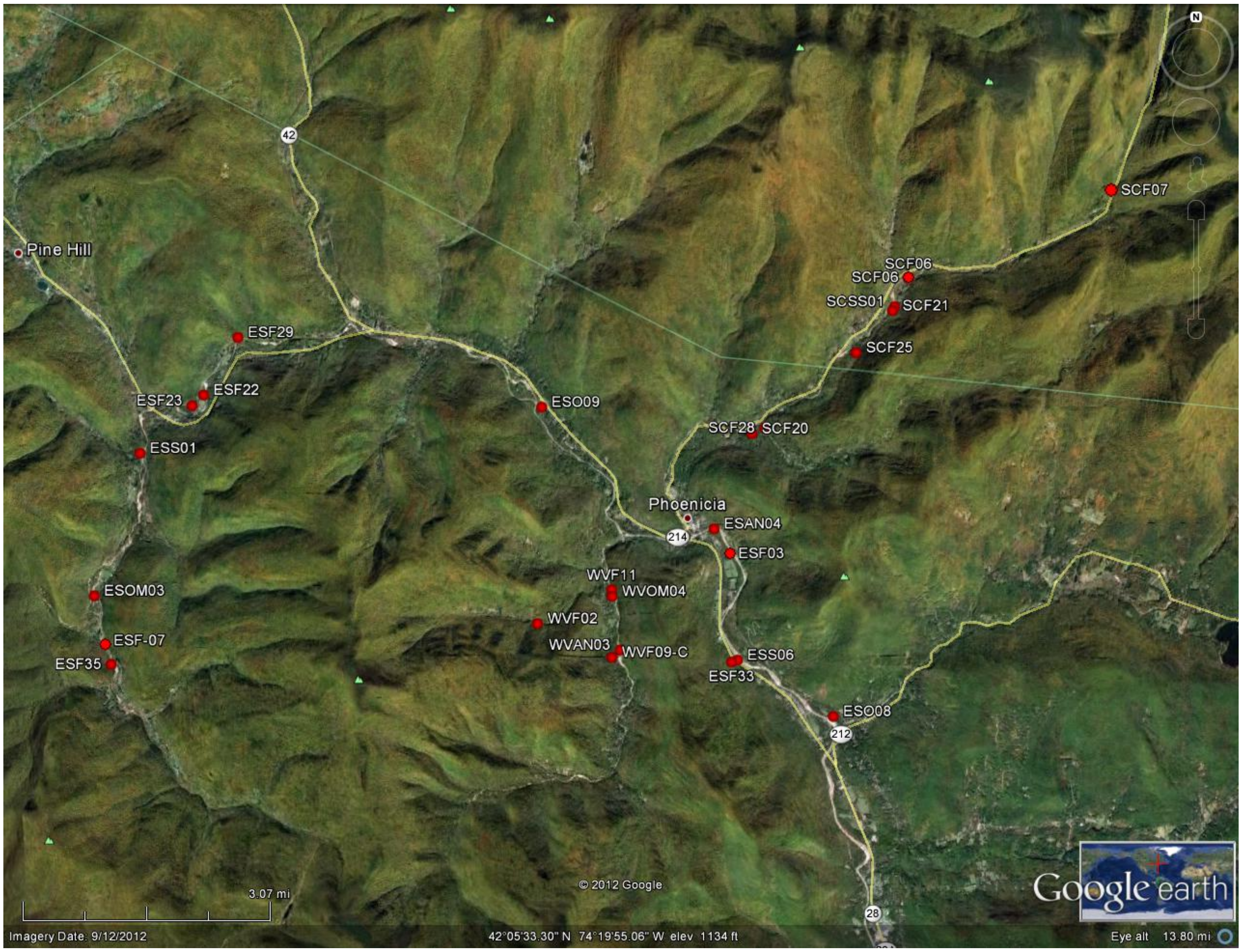

Figure 4. Natural community reference plots along the Esopus, Stony Clove and Woodland Valley

Hemlock-Northern Hardwood Forest Description

This forest type typically occurs on gentle to fairly steep slopes on predominantly west to north facing (with east-facing aspects common for a couple of variants) slopes along the Esopus, Stony Clove and Woodland Valley. Four variants were identified with the plots sampled representing the following NVC types: CEGL006088 *Tsuga canadensis - Fagus grandifolia - Quercus rubra* Forest, CEGL006109 *Tsuga canadensis - Betula alleghaniensis - Acer saccharum / Dryopteris intermedia* Forest, CEGL006206 *Tsuga canadensis - Betula alleghaniensis - Prunus serotina / Rhododendron maximum* Forest, and CEGL006328 *Pinus strobus - Tsuga canadensis* Lower New England / Northern Piedmont Forest.

These forests are dominated by eastern hemlock (*Tsuga canadensis*) with sweet birch (*Betula lenta*), yellow birch (*Betula alleghaniensis)* and in some variants white pine (*Pinus strobus*), as a common canopy associates. 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)*, and red maple (*Acer rubrum*). The shrub layer is generally sparse, but a moderately developed sapling layer is typical with *Tsuga canadensis*, *Fagus grandifolia* , and muslewood (*Carpinus caroliniana* ssp. *virginiana*) occurring most frequently. The herbaceous layer can be typically sparse or surprisingly diverse, such as especially within the more mesic examples. Ferns are relatively common, including evergreen wood fern (*Dryopteris intermedia* ssp. *intermedia*), eastern hay-scented fern (*Dennstaedtia punctilobula*), Christmas fern (*Polystichum acrostichoides*), New York fern (*Thelypteris noveboracensis*), and marginal wood fern (*Dryopteris marginalis*). Other herbaceous plants common in these hemlock-northern hardwood forests include sedges (*Carex* spp.) partridgeberry (*Mitchella repens*), white wood aster (*Eurybia divaricata)*, and in seepy areas spotted jewelweed (*Impatiens capensis*). This forest occurs as a large-patch natural community for the High Allegheny ecoregion, and occurs in fairly large examples along the Esopus, Stony Clove, and Woodland Valley. The largest sections of the hemlock-northern hardwood forest occur in various elevations upslope from the Esopus, Stony Clove, and Woodland Valley.

Occurrences of this forest type within the Esopus, Stony Clove, and Woodland Valley riparian area are situated on topographic positions ranging from basin floor to low slopes of 4 º to 36 º. The aspects of these slopes ranged from west to southeast (268 º to 141 º), with most aspects falling between west and north (275 º and 12 º). Stoniness of hemlock-northern hardwood forest plots typically ranged anywhere from stony (3-15% stones) to exceedingly stony (50-90% stony). The soils were fairly consistently of sandy loam type, but one plot had sandy clay loam as the dominant soil type.

Twenty plots, classified as hemlock-northern hardwood forests, were surveyed within the riparian buffer zone. The overall floral quality of these forests is good to excellent with very little to no evidence of exotic plants. The results of the plot quality ranking system show that all twenty one examples of this natural community type are in good to excellent biotic and abiotic condition, and in typically good landscape conditions.

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

The emergent tree layer (34 m) has 5% cover and *Pinus strobus* (1%), and <1% each of *Acer saccharum* var. *saccharum*, *Acer rubrum* var. *rubrum*, *Tsuga canadensis*, *Quercus rubra*, *Fraxinus americana*, as the most abundant species. The tree canopy layer (29 m) has 71% cover and *Tsuga canadensis* (29%), *Betula lenta* (12%), *Betula alleghaniensis* (9%), *Acer rubrum* var. *rubrum* (10%), *Pinus strobus* (5%), *Acer saccharum* var. *saccharum* (5%), *Quercus rubra* (4%), *Fraxinus americana* (3%), *Fagus grandifolia* (3%), and <1% each of *Prunus serotina*, *Betula papyrifera*, *Populus grandidentata*, *Ostrya virginiana*, *Tilia americana* var. *americana*, *Fraxinus pennsylvanica*. The tree subcanopy layer (17 m) has 37% cover and *Tsuga canadensis* (21%), *Fagus grandifolia* (5%), *Betula alleghaniensis* (4%), *Betula lenta* (3%), *Acer saccharum* var. *saccharum* (2%), *Acer rubrum* var. *rubrum* (2%), and <1% each of *Ostrya virginiana*, *Quercus rubra*, *Fraxinus americana*, *Amelanchier arborea* var. *arborea*, *Castanea dentata*, *Pinus strobus*, *Tilia americana* var. *americana*, *Populus* sp., *Carpinus caroliniana* ssp. *virginiana*, as the most abundant species.

The saplings layer (3.8 m) has 9% cover and *Tsuga canadensis* (4%), *Fagus grandifolia* (3%), *Carpinus caroliniana* ssp. *virginiana* (1%), and <1% each of *Betula alleghaniensis*, *Acer saccharum* var. *saccharum*, *Ostrya virginiana*, *Acer pensylvanicum*, *Betula lenta*, *Picea rubens*, *Ulmus americana*, as the most abundant species. The tall seedlings layer (0.9 m) has 3% cover and *Fagus grandifolia* (2%), and <1% each of *Tsuga canadensis*, *Carpinus caroliniana* ssp. *virginiana*, *Betula lenta*, *Acer pensylvanicum*, *Fraxinus americana*, *Picea rubens*, *Acer saccharum* var. s*accharum*, *Acer rubrum* var. *rubrum*, *Fraxinus pennsylvanica*, *Ostrya virginiana*, *Tilia americana* var. *americana*, *Pinus strobus*, *Betula alleghaniensis*, as the most abundant species. The short seedlings layer (0.2 m) has 2% cover and <1% each of *Acer pensylvanicum*, *Fagus grandifolia*, *Fraxinus americana*, *Acer rubrum* var. *rubrum*, *Tsuga canadensis*, *Carpinus caroliniana* ssp. *virginiana*, *Betula alleghaniensis*, *Ostrya virginiana*, *Prunus serotina*, *Quercus rubra*, *Populus tremuloides*, *Pinus strobus*, *Acer saccharum* var. *saccharum*, *Tilia americana* var. *americana*, *Picea rubens*, *Betula lenta*, *Carya cordiformis*, *Fraxinus pennsylvanica*, as the most abundant species.

The shrub layers are typically very sparse. The tall shrub layer (3 m) has 2% cover and *Hamamelis virginiana* (2%), and <1% each of *Cornus alternifolia*, *Kalmia latifolia*, as the most abundant species. The short shrub layer (0.8 m) has <1% cover and <1% each of *Hamamelis virginiana*, ***Berberis thunbergii***, *Cornus alternifolia*, ***Lonicera xylosteum,*** *Lonicera canadensis*, *Viburnum acerifolium*, *Ribes cynosbati*, *Rubus idaeus* ssp. *strigosus*, as the most abundant species. The dwarf shrub layer (0.2 m) has <1% cover and <1% each of *Lonicera xylosteum*, *Taxus canadensis*, *Viburnum acerifolium*, *Kalmia latifolia*, *Rubus canadensis*, *Rubus allegheniensis*, *Ribes cynosbati*, *Viburnum lantanoides*, ***Lonicera morrowii,*** *Rubus idaeus* ssp. *strigosus*, *Rhododendron periclymenoides*, *Vaccinium angustifolium*, *Lonicera canadensis*, *Hamamelis virginiana*, *Cornus alternifolia*, ***Berberis thunbergii***, as the most abundant species.

The short vine layer (0.2 m) generally absent or present only in trace amounts with <1% combined cover of *Clematis virginiana*, *and Parthenocissus quinquefolia*.

The herbaceous layer (0.3 m) is somewhat poorly developed averaging 9% cover and *Dryopteris intermedia ssp. intermedia* (2%), *Dennstaedtia punctilobula* (2%), and <1% each of *Polystichum acrostichoides*, *Impatiens capensis*, *Thelypteris noveboracensis*, *Dryopteris marginalis*, *Mitchella repens*, *Poa alsodes*, *Eurybia divaricata*, ***Poa nemoralis***, *Onoclea sensibilis*, *Carex pedunculata*, *Solidago caesia* var. *caesia*, *Carex gracillima*, *Maianthemum canadense*, ***Alliaria petiolata***, *Huperzia lucidula*, *Carex radiata*, *Carex tonsa* var. *rugosperma*, *Carex umbellata*, *Prenanthes altissima*, *Osmunda claytoniana*, *Phegopteris hexagonoptera*, *Glyceria melicaria*, *Athyrium filix-femina* ssp. *angustum*, *Trientalis borealis*, *Carex blanda*, *Carex gracilescens*, *Carex albursina*, *Bidens frondosa*, *Epifagus virginiana*, *Geum canadense*, ***Epipactis helleborine*,** *Cardamine diphylla*, *Geranium robertianum*, *Fragaria vesca* ssp. *americana*, ***Fallopia japonica***, *Gaultheria procumbens*, *Elymus hystrix* var. *hystrix*, *Ageratina altissima* var. *altissima*, *Arisaema triphyllum* ssp. *triphyllum*, ***Galeopsis tetrahit* var. *tetrahit*,** *Galium triflorum*, *Aralia nudicaulis*, *Brachyelytrum erectum*, *Danthonia spicata*, *Carex swanii*, *Carex rosea*, *Carex platyphylla*, *Carex laxiflora*, *Cinna latifolia*, *Carex albicans* var. *albicans*, *Cystopteris fragilis*, *Dendrolycopodium dendroideum*, *Dendrolycopodium obscurum*, *Carex debilis* var. *rudgei*, *Deparia acrostichoides*, *Carex arctata*, *Carex appalachica*, *Dryopteris carthusiana*, *Chelone glabra*, *Circaea lutetiana* ssp. *canadensis*, *Symphyotrichum prenanthoides*, *Pteridium aquilinum* var. *latiusculum*, *Pyrola elliptica*, *Rubus pubescens* var. *pubescens*, ***Solanum dulcamara*,** *Solidago hispida*, *Prenanthes alba*, ***Glechoma hederacea*,** *Symphyotrichum cordifolium*, *Lysimachia ciliata*, ***Veronica officinalis*,** *Viola sororia*, *Woodsia obtusa* ssp. *obtusa*, ***Sonchus arvensis* ssp. *arvensis*,** *Oclemena acuminata*, *Thalictrum dioicum*, *Glyceria striata*, *Potentilla simplex*, *Hydrophyllum virginianum*, *Impatiens pallida*, *Lactuca canadensis*, *Monotropa uniflora*, *Osmunda cinnamomea*, ***Oxalis corniculata*,** *Oxalis montana*, *Phegopteris connectilis*, *Pilea pumila*, *Polygonatum pubescens*, *Polypodium appalachianum*, and *Maianthemum racemosum* ssp. *racemosum*.

The non-vascular layer has 3% cover with mosses (3%) and lichens (<1%) as the most abundant species. The unvegetated surface averages litter and duff (15%), large rocks (2%), wood (1%), and <1% each of small rocks, rock-cobble, rock-boulder, bare soil, stumps, and water as the most abundant components.

Hemlock-Northern Hardwood Forest Discussion/Recommendations

According to the results of the PQRS and wFQI, plots SCF28, WVF02, ESF35, and WVF09-C appear to be the best overall candidates for a natural community reference for the four identified NVC variants of hemlock-northern hardwood forests along the Esopus, Stony Clove and Woodland Valley. These four plots correspond respectively to CEGL006088 *Tsuga canadensis - Fagus grandifolia - Quercus rubra* Forest, CEGL006109 *Tsuga canadensis - Betula alleghaniensis - Acer saccharum / Dryopteris intermedia* Forest, CEGL006206 *Tsuga canadensis - Betula alleghaniensis - Prunus serotina / Rhododendron maximum* Forest and CEGL006328 *Pinus strobus - Tsuga canadensis* Lower New England / Northern Piedmont Forest (NatureServe 2012). The majority of the plots crossed to types 6088 and 6109 with only two crossing to 6206 and three to 6328. 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, the 6088 type is by far the most common NVC type sampled with its comprising nearly half (45%) of the 20 hemlock-northern hardwood forest plots along the Esopus, Stony Clove and Woodland Valley. CEGL006088 has oak (*Quercus* sp.), American beech (*Fagus grandifolia*) and black birch (*Betula lenta*) as common associates, and these species were frequently encountered along the Esopus, Stony Clove and Woodland Valley.

The results of the wFQI show that only a few species documented in these plots have conservation coefficients of 6.5 or higher. These included two species documented in SCF28, *Solidago hispida* and *Taxus canadensis* and one, *Cystopteris fragilis*, in WVF02. 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. The overall wFQI's of 23.1 (SCF28), 18.9 (WVF02), 18.2 (ESF35) and 20.7 (WVF09-C), indicate that these plots and surrounding area are comprised of moderate quality and generalist native plant species characteristic of this type, and indicate a well-functioning if not particularly diverse natural community.

The overall PQRS rank sums of 24, 23, 23, and 21.5 respectively for for plots SCF28, WVF02, ESF35 and WVF09-C place them within the highest quality category for all hemlock-northern hardwood forest plots. The high quality of these plots is attributed to 1) the lack of exotic plant species, 2) good size structure within the community strata layers, 3) a fair amount of coarse woody debris with decaying matter, no disturbances within and surrounding the plot, 4) being embedded in 90-100% natural habitat within 1 kilometer, and 5) distance to nearest paved road is greater than 100 meters. A summary of the floral wFQI, life form/strata, and abiotic characteristics for each reference plot is presented in following Excel worksheets : HNHFspp-6088, HNHFspp-6109, HNHFspp-6173, HNHFspp-6206, HNHFspp-6328 and HNHFAbiotic-6088, HNHFAbiotic-6109, HNHFAbiotic-6173, HNHFAbiotic-6206, and HNHFAbiotic-6328. These summary tables and floral composition are recommendations in the final "expressions" of this type.

Given an existing set of biotic and abiotic conditions along the Esopus, Stony Clove and Woodland Valley, hemlock-northern hardwood forests should continue to mature and thrive as a natural community in these valleys. 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, particularly NVC type 6328 along the Esopus, Stony Clove and

Woodland Valley. Fortunately, current infestation levels appeared low and 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 Esopus, Stony Clove and Woodland Valley. One aspect of the type that tends to depart farthest from reference condition arethe low levels of large diameter standing snags and fallen coarse woody debris. Mortality from natural causes and perhaps invasive pests and pathogens will likely continue to increase the prevalence of both of these structural features, but restoration activities could also seek to supplement their stock via griddling of less desirable canopy species or the addition of logs of native species from sites within the study area which have been cleared for other purposes.

Maple-Basswood Rich Mesic Forest Description

This forest type occurs on both gently sloping flats and fairly steep slopes along the Esopus, Stony Clove and possibly Woodland Valley. It is represented by two NVC associations CEGL005008 *Acer saccharum - Fraxinus americana - Tilia americana / Acer spicatum / Caulophyllum thalictroides* Forest and CEGL006211 *Acer saccharum - (Fraxinus americana) / Arisaema triphyllum* Forest which segregate along both their topographic position and steepness of slope. The various strata of these forests are dominated by some combination of tree species favoring mesic, calcareous site conditions and with generally more southern floral affinities including white ash *(Fraxinus americana)*, sugar maple *(Acer saccharum)*, American basswood *(Tilia americana)*, musclewood (*Carpinus caroliniana*) and hop-hornbeam *(Ostrya virginiana).* Species characteristic of northern hardwood, and oak forests such as American beech *(Fagus grandifolia*), yellow birch *(Betula alleghaniensis)*, red oak *(Quercus rubra)* and eastern hemlock *(Tsuga canadensis)* are absent or present as minor associates. The shrub cover is generally fairly sparse. Native species indicative of the shrub layer include, witch-hazel *(Hamamelis virginiana)*, common elderberry (*Sambucus nigra* ssp. *canadensis*), striped maple *(Acer pensylvanicum)*, and Allegheny raspberry *(Rubus allegheniensis).* The herbaceous layer is relatively well developed but the spring ephemeral and rich herbaceous flora typical of these forest types occur at very low abundance. Herbaceous plants typical of this natural community type include jack-in-the-pulpit *(Arisaema triphyllum)*, sedges (*Carex blanda*) and (*Carex platyphylla*), common enchanter's nightshade (*Circaea lutetiana* ssp. *canadensis*), herb robert (*Geranium robertianum*), Virginia waterleaf (*Hydrophyllum virginianum*), grove bluegrass (*Poa alsodes*), and blue-stemmed goldenrod (*Solidago caesia* var. *caesia*).

Within this riparian corridor, maple-basswood rich mesic forests are closely related to beech-maple mesic and floodplain forests and may occur as richer or more upland versions of these forests. However, for the purposes of recognizing these community types for "references", this report will differentiate them based on site flooding frequency, and dominant cover in the tree strata.

Maple-basswood rich mesic forests tend to occur on protected aspects from north to southeast-facing (332° to 133°) on gently sloping flats (1 to 2°) and fairly steep (>10°-26°) lower slopes along the Esopus, Stony Clove and possibly Woodland Valley. These forests are typically in good to excellent condition, with low abundances of exotic plants within the areas surveyed. One difference between maple-basswood rich mesic forest and beech-maple mesic forests is that the rich mesic forests tended to be smaller in overall patch size, often occurring as inclusions within other surrounding forest types where nutrient and moisture conditions support its specific niche. Also, difficulties distinguishing these communities can occur due to the fact that prior land-use and disturbance histories have facilitated the invasion and spread of generalist native, non-native and invasive species which have apparently replaced many of the characteristic rich ground flora.

These forests vary in their stoniness, with stoniness ranging from stone free to very stony on gentle slopes (<.1-50%), and stony to exceedingly slope on steep slopes (3-90%). The stones consisted mainly of large rocks, with only a small percentage of large rocks within each plot.

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

When present the emergent tree layer averages 30 m in height has 5% cover and *Pinus strobus* (3%), *Fraxinus americana* (2%), as the most abundant species. The tree canopy layer (29 m) has 65% cover and *Acer saccharum* var. *saccharum* (18%), *Tilia americana* var. *americana* (14%), *Fraxinus americana* (13%), *Betula alleghaniensis* (8%), *Quercus rubra* (4%), *Acer rubrum* var. *rubrum* (3%), *Prunus serotina* (3%), *Tsuga canadensis* (3%), *Ostrya virginiana* (2%), *Fraxinus pennsylvanica* (1%), *Acer nigrum* (1%), *Populus deltoides* (1%), ***Robinia pseudoacacia*** (<1%), as the most abundant species. The tree subcanopy layer (16 m) has 39% cover and *Ostrya virginiana* (13%), *Acer saccharum* var. *saccharum* (10%), *Carpinus caroliniana* ssp. *virginiana* (4%), *Tilia americana* var. *americana* (3%), *Betula alleghaniensis* (2%), *Prunus serotina* (2%), *Tsuga canadensis* (2%), ***Robinia pseudoacacia*** (1%), *Acer rubrum* var. *rubrum* (1%), *Populus deltoides* (1%), and <1% each of *Fraxinus americana*, *Betula papyrifera*, *Fraxinus pennsylvanica*, *Pinus strobus*, as the most abundant species.

The saplings layer (4 m) has 18% cover and *Carpinus caroliniana* ssp. *virginiana* (7%), *Ostrya virginiana* (7%), *Acer saccharum* var. *saccharum* (2%), *Prunus serotina* (1%), *Tsuga canadensis* (1%), and <1% each of *Tilia americana* var. *americana*, *Fagus grandifolia*, *Acer pensylvanicum*, as the most abundant species. The tall seedlings layer (0.7 m) has 5% cover and *Carpinus caroliniana* ssp. *virginiana* (3%), and <1% each of *Ostrya virginiana*, *Fraxinus pennsylvanica*, *Fagus grandifolia*, *Tilia americana* var. *americana*, *Betula alleghaniensis*, *Acer saccharum* var. *saccharum*, *Acer pensylvanicum*, *Pinus strobus*, *Prunus serotina*, ***Robinia pseudoacacia***, *Acer negundo* var. *negundo*, *Ulmus americana*, *Fraxinus americana*, as the most abundant species. The short seedlings layer (0.3 m) has 2% cover and <1% each of *Fraxinus pennsylvanica*, *Quercus rubra*, *Acer pensylvanicum*, *Carpinus caroliniana* ssp. *virginiana*, *Sassafras albidum*, *Acer rubrum* var. *rubrum*, *Ulmus americana*, *Tilia americana* var. *americana*, *Ulmus rubra*, ***Robinia pseudoacacia***, *Ostrya virginiana*, *Fraxinus americana*, *Carya ovata*, *Carya cordiformis*, *Prunus serotina*, *Acer saccharum* var. *saccharum*, *Tsuga canadensis*, *Betula alleghaniensis*, as the most abundant species.

The tall shrub layer (2.4 m) has 1% cover and *Hamamelis virginiana* (1%), *Sambucus nigra* ssp. *canadensis*, ***Rosa multiflora***, as the most abundant species. The short shrub layer (0.7 m) has 3% cover and <1% each of ***Berberis thunbergii***, ***Rosa multiflora***, *Hamamelis virginiana*, *Prunus virginiana*, *Dirca palustris*, ***Lonicera morrowii, Lonicera xylosteum,*** *Ribes cynosbati*, *Sambucus nigra* ssp. *canadensis*, *Rubus odoratus*, *Rubus idaeus* ssp. *strigosus*, as the most abundant species. The dwarf shrub layer (0.3 m) has 1% cover and <1% each of *Prunus virginiana*, *Rubus allegheniensis*, *Rubus odoratus*, *Sambucus nigra* ssp. *canadensis*, *Hamamelis virginiana*, *Cornus alternifolia*, *Rubus hispidus*, ***Rosa multiflora***, ***Berberis thunbergii***, *Rubus idaeus* ssp. *strigosus*, *Ribes triste*, as the most abundant species.

The short vine layer (0.3 m) has 6% cover and Parthenocissus quinquefolia (4%), Amphicarpaea bracteata (2%), and <1% each of Toxicodendron radicans ssp. radicans, **Celastrus orbiculatus, Lonicera japonica,** Vitis aestivalis var. aestivalis, as the most abundant species.

The herbaceous layer (0.3 m) is well developed and typically diverse, averaging 38% cover. The most prevalent species are *Eurybia divaricata* (11%), *Poa alsodes* (6%), *Solidago caesia* var. *caesia (*3%), *Athyrium filix-femina* ssp. *angustum* (3%), *Impatiens capensis* (2%), ***Alliaria petiolata*** (2%), *Polystichum acrostichoides* (2%), *Aralia nudicaulis* (2%), *Dryopteris intermedia* ssp. *intermedia* (1%), *Carex radiata* (1%), *Dryopteris marginalis* (1%), *Laportea canadensis* (1%), and *Equisetum sylvaticum* (1%). The following species occur as minor associates with average of <1% cover each: *Glyceria melicaria*, *Symphyotrichum prenanthoides*, *Osmunda claytoniana*, ***Tussilago farfara*,** *Carex gracillima*, *Arisaema triphyllum* ssp. *triphyllum*, *Geum canadense*, *Ageratina altissima* var. *altissima*, *Circaea lutetiana* ssp. *canadensis*, *Carex blanda*, *Geranium robertianum*, *Onoclea sensibilis*, *Solidago flexicaulis*, *Prenanthes altissima*, *Eurybia macrophylla*, *Carex albursina*, *Osmorhiza claytonii*, *Brachyelytrum erectum*, *Carex appalachica*, ***Veronica officinalis*, *Saponaria officinalis*,** *Symphyotrichum puniceum* var. *puniceum*, *Thalictrum dioicum*, ***Epipactis helleborine*, *Poa compressa*,** *Thalictrum pubescens*, *Maianthemum racemosum* ssp. *racemosum*, *Diarrhena obovata*, *Desmodium nudiflorum*, *Solidago rugosa* var. *rugosa*, *Viola sororia*, *Elymus hystrix* var. *hystrix*, *Carex platyphylla*, *Carex plantaginea*, *Carex albicans* var. *albicans*, *Cardamine diphylla*, *Anemone quinquefolia* var. *quinquefolia*, *Agrimonia gryposepala*, *Actaea pachypoda*, *Carex sprengelii*, ***Ranunculus acris*,** *Piptatherum racemosum*, *Persicaria sagittata*, *Oxalis stricta*, *Potentilla simplex*, *Prenanthes trifoliolata*, *Urtica dioica* ssp. *gracilis*, *Prunella vulgaris* var. *vulgaris*, ***Fallopia japonica*,** *Maianthemum canadense*, ***Glechoma hederacea*,** *Fragaria vesca* ssp. *americana*, *Fragaria virginiana*, *Galium triflorum*, ***Sedum kamtschaticum*,** *Lysimachia ciliata*, *Hydrophyllum virginianum*, *Rumex* sp., ***Hesperis matronalis*, *Ranunculus repens*,** *and Solidago gigantea.*

The non-vascular layer is nearly absent with <1% cover of mosses. The unvegetated surface averages 52% cover and is comprised of litter and duff (42%), large rocks (7%), wood (3%), boulders (1%), and <1% each of bare soil, and trash.

Maple-Basswood Rich Mesic Forest Discussion/Recommendations

According to the results of the PQRS and wFQI, Plots ESF33 and SCF06 appear to be the best candidates for a natural community reference for the two maple-basswood rich mesic forest types along the Esopus, Stony Clove and Woodland Valley. These plots is attributed to NVC types CEGL005008 and CEGL006211 respectively (Grossman *et al.* 1998). The results of the wFQI show that a few species in these plots have averaged conservation coefficients of 6.5 or higher. These species are *Carex albicans* var. *albicans*, *Carex sprengelii*, *Piptatherum racemosum*, and *Dirca palustris*, which based on their scores are interpreted to have a poor range of ecological tolerances or a high degree of fidelity to a narrow range of habitats. In less disturbed settings many of the plots assigned to these NVC types retain a richer floral composition. However, the overall wFQIs of 27.4 and 24.7 respectively indicate that these plots and their surrounding areas are comprised of good quality plant species.

The overall rank sum of the respective PQRSs of 29.5 for ESF33 and 28 for SCF06 represent two of the best scores of all plots of this natural community type. One plot, ESF41 of CEGL005008, scored better at 23 but its wFQI was low at only 19.8, indicating a markedly lower floristic quality for that site. The good quality of these plots is attributed to their low cover of exotic and invasive species, good size structure and a fair to good amount of coarse woody debris with decaying matter, few disturbances within and surrounding the plots, embedded in 90-100% natural habitat within 1 kilometer, and distance to nearest paved road is greater than 100 meters. A summary of the floral wFQI, life form/strata, and abiotic characteristics of each reference plot is presented in following Excel worksheets : MBRMFspp-5008, MBRMFspp-6211, MBRMFAbiotic-5008, and MBRMFAbiotic-6211.

These are general recommendations along with the floral composition in the final "expression" of this type.

Given an existing set of biotic and abiotic conditions along the Esopus, Stony Clove and Woodland Valley, maple-basswood rich mesic forests will likely undergo changes in composition and structure particularly in relation to the loss of canopy *Fraxinus* spp. due mortality from emerald ash-borer infestations. The loss of this important canopy dominant may change the trajectory of these forests in yet unknown ways that could include a lack of mature *Fraxinus* spp. in the canopy layers. However, in the absence of effective ash borer control, preferences for planting other characteristic tree species such as American basswood, sugar maple, hop-hornbeam and musclewood may be desirable if recruitment and retention of ash species in the canopy is inadequate. This approach may help to maintain the type until a time where ash species are able to be maintained within the mature age and size classes. One addtional aspect of the type that tends to depart farthest from reference condition arethe low levels of large diameter standing snags and fallen coarse woody debris. Mortality from natural causes and perhaps invasive pests and pathogens will likely continue to increase the prevalence of both of these structural features but restoration activities could also seek to supplement their stock via griddling of less desirable canopy species or the addition of logs of native species from sites within the study area which have been cleared for other purposes.

Floodplain Forest Description

This palustrine forest type occurs on slightly elevated alluvial terraces that are close to the riverbanks of the Esopus, Stony Clove and Woodland Valley. The soils are typically stony and coarse and less regularly inundated than floodplain forests supporting silver maple (*Acer saccharinum*). Three variants of floodplain forest where identified in the study area. NVC types CEGL006036 *Platanus occidentalis - Fraxinus pennsylvanica* Forest, CEGL006114 *Acer saccharum - Fraxinus* spp. - *Tilia americana / Matteuccia struthiopteris - Ageratina altissima* Forest and CEGL006459 *Acer saccharum - Fraxinus americana / Carpinus caroliniana / Podophyllum peltatum* Forest. Sycamore (*Platanus occidentalis*), American elm (*Ulmus americana*), cottonwood (*Populus deltoides*), sweet birch (*Betula lenta*) and red maple(*Acer rubrum* var. *rubrum*) are the canopy dominants of 6036. The dominants of 6114 are various admixtures of white ash *(Fraxinus americana)*, sugar maple *(Acer saccharum var .saccharum*), sweet birch (*Betula lenta*)and/or red oak (*Quercus rubra*) with American basswood (*Tilia americana*), sycamore (*Platanus occidentalis*) and cottonwood (*Populus deltoides*) as associates. White ash (*Fraxinus americana*), yellow birch (*Betula alleghaniensis*), red maple(*Acer rubrum*) and hop-hornbeam *(Ostrya virginiana*) dominate 6459. The canopy of 6459 consists of species more characteristic of northern hardwood dominated beech-maple mesic forests. In addition, unlike other floodplain forests, this variant typically supports a prominent sapling layer with musclewood (*Carpinus caroliniana*) being the most prevalent and distinctive member of this layer. Well developed sapling layers are more sporadic in variants 6114 and 6036 with musclewood again the most prevlanet species in each, and American elm occasionally becoming common in stands of 6036.

The difference between these floodplain forest variants lies in the combination of their canopy dominants,understory species and settings. Within the Esopus, Stony Clove and Woodland Valley riparian area, 6036 generally occurs on moderately to exceedingly stony terraces less than 2 meters or less above stream and generally 40 meters or less (0.5 to 65 m) from the channel along the lower reaches of the Stony Clove and Woodland Valley and the midreach of the Esopus. 6114 typically occurs along the Esopus 2 meters above stream level on moderately stony substrate typically 25 or more meters from the channel (4 to 115m). In contrast, 6459 typically occurs on terraces below 1 m, but also is occasionally found above 3 m, with moderately stony to exceedingly stony substrates generally situated 12 or more meters from the channel (1.5 to 73m) along the Esopus or Stony Clove. Floodplain forests along the Esopus, Stony Clove and Woodland Valley can at times closely resemble maple-basswood rich mesic forests but differ in their occurrence on generally poorly drained alluvial soils, increased flooding frequency and duration, in combination with differing combinations of canopy and understory composition.

As indicative of other floodplain forest types, the floodplain forests found along the Esopus, Stony Clove and Woodland Valley had both liana and short vine layers of both higher cover and greater species diversity than the related upland forest type maple-bassswood rich mesic forest. A liana layer was entirely lacking from the maple-basswood rich mesic forests. In addition, the vine layer of the floodplain forests included two species, riverbank grape (*Vitis riparia*) and Canada moonseed (*Menispermum canadense*) which are characteristic of floodplain settings.

The examples of the floodplain forests along the Esopus, Stony Clove and Woodland Valley riparian area were generally small, with patches generally less than one hectare in size. Many of these small floodplain forests are in a poor landscape contexts, which allows favorable conditions for invasive plants such as garlic mustard (*Alliaria petiolata*), and the invasive shrubs multiflora rose, (*Rosa multiflora*), Morrow's honeysuckle (*Lonicera morrowii*), Japanese barberry (*Berberis thunbergii*), and European fly-honey-suckle (*Lonicera xylosteum*) to become abundant.

Floodplain Forest Species Composition (average from all plots sampled)

The emergent tree layer (33 m) is often absent, averaging <1% cover of ***Robinia pseudoacacia***. The tree canopy layer (28 m) has 59% cover and *Fraxinus americana* (17%), *Acer saccharum* var. *saccharum* (10%), *Platanus occidentalis* (9%), *Populus deltoides* (5%), *Robinia pseudoacacia* (4%), *Quercus rubra* (4%), *Acer rubrum* var. *rubrum* (3%), *Betula alleghaniensis* (2%), *Fraxinus pennsylvanica* (2%), *Acer saccharum* (2%), *Tilia americana* var. *americana* (2%), *Ulmus americana* (1%), and <1% cover of *Fagus grandifolia*, *Carya cordiformis*, *Ostrya virginiana*, *Betula lenta*, *Prunus serotina*, as the most abundant species. The tree subcanopy layer (17 m) has 34% cover and *Acer saccharum* var. *saccharum* (10%), *Ulmus americana* (5%), *Fraxinus pennsylvanica* (4%), *Betula alleghaniensis* (3%), *Fraxinus americana* (2%), *Ostrya virginiana* (2%), *Betula lenta* (2%), *Acer rubrum* var. *rubrum* (2%), *Tilia americana* var. *americana* (2%), *Carpinus caroliniana* ssp. *virginiana* (1%), *Quercus rubra* (1%), and <1% each of *Prunus serotina*, *Fagus grandifolia*, *Malus pumila*, *Carya ovata*, *Robinia pseudoacacia*, *Platanus occidentalis*, *Carya cordiformis*, *Pinus strobus*, *Prunus pensylvanica* var. *pensylvanica*, *Populus deltoides*, *Amelanchier arborea* var. *arborea*, as the most abundant species.

The saplings layer (3.9 m) is prominent with 15% cover and *Carpinus caroliniana* ssp. *virginiana* (6%), *Ulmus americana* (3%), *Acer saccharum* var. *saccharum* (2%), *Prunus serotina* (1%), and <1% each of *Ostrya virginiana*, *Fraxinus pennsylvanica*, *Fagus grandifolia*, *Acer rubrum* var. *rubrum*, *Fraxinus americana*, *Betula lenta*, *Betula alleghaniensis*, *Tilia americana* var. *americana*, *Quercus rubra*, *Tsuga canadensis*, ***Robinia pseudoacacia*, ***Pinus strobus*, *Carya cordiformis*, *Ulmus rubra*, *Prunus pensylvanica* var. *pensylvanica*, ***Picea abies*, ***Carya ovata*, *Acer pensylvanicum*, ***Morus alba*,** as the most abundant species. The tall seedlings layer (0.8 m) is quite sparse with 3% cover and *Carpinus caroliniana* ssp. *virginiana* (1%), and <1% each of *Fagus grandifolia*, *Fraxinus americana*, *Prunus pensylvanica* var. *pensylvanica*, *Prunus serotina*, ***Robinia pseudoacacia*, ***Acer saccharum* var. *saccharum*, *Fraxinus pennsylvanica*, *Ostrya virginiana*, *Prunus virginiana*, *Acer pensylvanicum*, *Ulmus americana*, *Tilia americana* var. *americana*, *Acer negundo* var. *negundo*, as the most abundant species. The short seedlings layer (0.2 m) is also very sparse with 2% cover comprised of <1% each of *Carpinus caroliniana* ssp. *virginiana*, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Ostrya virginiana*, *Fraxinus americana*, *Carya cordiformis*, *Prunus pensylvanica* var. *pensylvanica*, *Fraxinus pennsylvanica*, *Quercus rubra*, *Prunus serotina*, *Carya ovata*, *Betula alleghaniensis*, *Ulmus rubra*, *Tilia americana* var. *americana*, ***Robinia pseudoacacia*, ***Populus deltoides*, *Pinus strobus*, ***Picea abies*, ***Fagus grandifolia*, *Acer pensylvanicum*, as the most abundant species.

The tall shrub layer (2.2 m) has is very sparse averaging 2% cover and <1% each of *Hamamelis virginiana*, ***Lonicera morrowii*, ***Spiraea alba* var. *latifolia*, ***Lonicera xylosteum*, ***Sambucus nigra* ssp. *canadensis*, ***Berberis thunbergii***, ***Rosa multiflora***, *Prunus virginiana*, ***Ligustrum vulgare*, ***Cornus alternifolia*, *Ligustrum obtusifolium*, as the most abundant species. The short shrub layer (1 m) is fairly well developed with 16% cover and is dominated by exotic invasive species. . The most abundant species are ***Rosa multiflora*** (6%), ***Lonicera morrowii*** (4%), ***Berberis thunbergii*** (3%), ***Lonicera xylosteum*** (3%), and <1% each of *Prunus virginiana*, ***Ligustrum vulgare*, ***Rubus allegheniensis*, ***Ligustrum obtusifolium*, ***Dirca palustris*, *Rubus idaeus* ssp. *strigosus*, *Rubus odoratus*, *Hamamelis virginiana*, *Cornus alternifolia*, *Rubus hispidus*, *Rubus occidentalis*, *Rhus typhina*, *Spiraea alba* var. *latifolia*, ***Euonymus alatus*, ***Sambucus racemosa* var. *racemosa*, as the most abundant species. The dwarf shrub layer (0.3 m) has 5% cover and ***Rosa multiflora*** (2%), *Lonicera morrowii* (1%), and <1% each of ***Berberis thunbergii*, Lonicera xylosteum*, ***Prunus virginiana*, *Rubus allegheniensis*, ***Ligustrum vulgare*, Ligustrum***

obtusifolium, *Hamamelis virginiana*, *Cornus alternifolia*, *Ribes hirtellum*, *Viburnum* sp., *Rubus canadensis*, *Rubus hispidus*, *Rubus idaeus* ssp. *strigosus*, *Rubus occidentalis*, *Rubus odoratus*, *Lonicera canadensis*, *Ribes lacustre*, as the most abundant species.

The liana layer (10 m) is occasionally present averaging <1% cover, with <1% each of ***Celastrus orbiculatus***, *Vitis riparia*, *Toxicodendron radicans* ssp. *radicans*, as the most abundant species. The short vine layer (0.4 m) has 8% cover and *Parthenocissus quinquefolia* (3%), ***Celastrus orbiculatus*** (3%), *Toxicodendron radicans* ssp. *radicans* (1%), and <1% each of *Vitis riparia*, *Clematis virginiana*, *Amphicarpaea bracteata*, ***Fallopia scandens* var. *scandens***, *Menispermum canadense*, as the most abundant species.

The herbaceous layer (0.5 m) is well developed averaging 37% cover and **Fallopia japonica** (5%), **Alliaria petiolata** (4%), *Eurybia divaricata* (4%), *Impatiens pallida* (3%), *Poa alsodes* (2%), Laportea canadensis (2%), **Microstegium vimineum** (2%), *Circaea lutetiana* ssp. *canadensis* (1%), Solidago caesia var. caesia (1%), and <1% each of *Carex hirtifolia*, ***Hesperis matronalis***, *Persicaria virginiana*, *Rubus pubescens var. pubescens*, *Thalictrum dioicum*, *Solidago gigantea*, *Carex gracilescens*, *Carex gracillima*, *Onoclea sensibilis*, *Elymus hystrix var. hystrix*, ***Glechoma hederacea***, *Agrostis scabra*, *Polystichum acrostichoides*, *Ageratina altissima var. altissima*, *Geum canadense*, ***Galeopsis tetrahit var. tetrahit***, *Carex debilis var. rudgei*, ***Poa pratensis ssp. pratensis***, *Carex appalachica*, *Zizia aurea*, ***Artemisia vulgaris***, ***Agrostis gigantea***, *Lysimachia ciliata*, *Ambrosia trifida var. trifida*, *Athyrium filix-femina ssp. angustum*, *Carex swanii*, *Matteuccia struthiopteris*, *Dryopteris intermedia ssp. intermedia*, *Solidago rugosa var. rugosa*, *Eurybia macrophylla*, ***Stachys palustris***, *Carex blanda*, *Carex sprengelii*, *Geranium robertianum*, *Milium effusum*, *Carex plantaginea*, *Carex radiata*, *Dichanthelium latifolium*, *Osmorhiza claytonii*, ***Lysimachia nummularia***, *Leersia virginica*, *Symphyotrichum prenanthoides*, *Helianthus strumosus*, ***Veronica officinalis***, *Arisaema triphyllum ssp. triphyllum*, *Agrostis hyemalis*, *Brachyelytrum erectum*, *Persicaria pensylvanica*, *Elymus riparius*, *Hydrophyllum virginianum*, *Glyceria melicaria*, *Galium triflorum*, *Galium aparine*, *Impatiens capensis*, *Potentilla simplex*, *Ambrosia artemisiifolia*, *Prenanthes altissima*, ***Tanacetum vulgare***, *Polygonatum biflorum*, *Carex scabrata*, *Urtica dioica ssp. gracilis*, *Veratrum viride*, *Carex* spp., *Rumex obtusifolius*, *Viola sororia*, *Actaea pachypoda*, *Equisetum arvense*, *Boehmeria cylindrica*, ***Epipactis helleborine***, *Bidens tripartita*, *Bidens frondosa*, *Carex arctata*, *Equisetum sylvaticum*, *Aralia nudicaulis*, *Agrimonia gryposepala*, *Allium tricoccum* var. *tricoccum*, *Equisetum variegatum ssp. variegatum*, *Erigeron strigosus var. strigosus*, *Eupatorium perfoliatum*, ***Tussilago farfara***, *Equisetum fluviatile*, *Chelone glabra*, ***Centaurea stoebe ssp. micranthos***, *Collinsonia canadensis*, *Caulophyllum thalictroides*, ***Coronilla varia***, *Carex woodii*, *Cryptotaenia canadensis*, ***Dactylis glomerata***, ***Daucus carota***, *Elymus virginicus var. virginicus*, ***Digitaria sanguinalis***, *Doellingeria umbellata var. umbellata*, *Carex platyphylla*, *Dryopteris carthusiana*, *Carex normalis*, *Dryopteris marginalis*, *Carex laxiculmis* var. *laxiculmis*, *Carex gynandra*, *Carex disperma*, ***Chelidonium majus***, ***Trifolium pratense***, *Scutellaria lateriflora*, *Scirpus atrovirens*, ***Saponaria officinalis***, *Sanicula marilandica*, *Sanicula canadensis*, *Polygonatum pubescens*, ***Rumex acetosella***, ***Solanum dulcamara***, ***Raphanus raphanistrum***, *Euthamia graminifolia*, *Pyrola asarifolia ssp. asarifolia*, ***Prunella vulgaris var. vulgaris***, *Prenanthes alba*, ***Rumex crispus***, *Symphyotrichum puniceum var. puniceum*, *Viola pubescens var. scabriuscula*, *Viola pubescens var. pubescens*, *Verbascum thapsus*, *Trillium erectum*, ***Sedum kamtschaticum***, ***Taraxacum officinale***, *Sium suave*, ***Stellaria media ssp. media***, ***Sonchus arvensis ssp. arvensis***, *Solidago flexicaulis*, *Solidago canadensis var. canadensis*, *Ranunculus hispidus var. hispidus*, *Thalictrum pubescens*, *Glyceria striata*, *Maianthemum canadense*, ***Lythrum salicaria***, *Lycopus uniflorus*, *Hieracium* sp., *Maianthemum racemosum ssp. racemosum*, *Iris versicolor*, *Geranium maculatum*, *Fragaria virginiana*, *Fragaria vesca ssp. americana*, ***Fallopia scandens var. scandens***, *Eutrochium maculatum var. maculatum*, *Rudbeckia laciniata var. laciniata*, *Phryma leptostachya*, *Heracleum maximum*, *Pilea pumila*, ***Melilotus albus***, ***Phleum pratense***, *Phalaris arundinacea*, *Persicaria arifolia*, *Oxalis stricta*, *Oryzopsis asperifolia*, *Oenothera sp.*, ***Myosoton aquaticum***, *Myosotis scorpioides*, *Monotropa uniflora*, *Mitchella repens*, *Osmunda cinnamomea*, ***Plantago lanceolata***, as the most abundant species.

The non-vascular layer is present only as a trace with <1% cover of mosses. The unvegetated surface has 13% cover and litter and duff (6%), sand (5%), bare soil (1%), and <1% each of wood, rock, coarse woody debris, trash, as the most abundant components.

Floodplain Forest Discussion/Recommendations

According to the results of the PQRS and wFQI, plots ESF22, WVF11and SCF07 appear to be the best overall candidates for a natural community reference for floodplain forests along the Esopus, Stony Clove and Woodland Valley. These plots are attributed to NVC types CEGL006114, CEGL006036 and CEGL006459 respectively (Grossman *et al.* 1998) and crosswalked to"floodplain forest" for New York. These plots are located adjacent to the Esopus, Stony Clove and Woodland Valley on flat to gently slope terraces and fit fairly well with there respective NVC types. The results of the wFQI show that a number of species in these plots have averaged conservation coefficients of 6.5 or higher (Excel worksheets: FFspp_6036, FFspp_6114 and FF_6459). Examples of these species include *Allium tricoccum* var.*tricoccum* , *Carex sprengelii*, *Carex scabrata*, *Carex disperma*, *Milium effusum*,*Platanus* o*ccidentalis*,*Polygonatum biflorum*,*Pyrola chlorantha*, *Ribes lacustre*, and *Solidago patula* ssp. *patula*. These species are plants associated with floodplain forests which have either a poor range of ecological tolerances or with a high degree of fidelity to a narrow range of habitats. The overall wFQI's of 23.8, 31.2 and 24.2 indicate that these plots are comprised of high quality plant species.

The overall PQRS sums for plots ESF22, WVF11 and SCF07 were 40.5, 41 and 35.5 respectively indicating that these plots are within fair to good quality natural areas. Although there were plots with lower PQRS than ESF22 and WVF11, the reference slections were based on prioritizing examples with both high native species cover and high wFQI values. Scores were also somewhat confounded by the effect the hurricane Irene flooding had on the channel stability, floodplain interactions in particular. As a result most sites sampled in 2012 receiving higher scores in these categories due to the flood damage and subsequent mitigation activities. Sites sampled in 2011 were not revisited and thus their scores for these metrics are likely inflated relative to their current condition since they do not account for the current condition of these sites post flood.

The good/fair quality of Plot ESF22 is attributed to: 1) good vegetation structure of floodplain forest within the plot, 2) its excellent hydrological connectivity , 3) good canopyspecies condition, size structure, and moderate levels of browse and 5) good channel stability within the plot. Its degrading factors include its somewhat lower percent cover of native species, fair size structure and canopy species condition,and its fair departure from reference condition.

The good quality of Plot SCF07 is attributed to: 1) its relatively high cover of native species, 2)excellent floodplain characteristics, 3) its intact hydrological regime (prior to hurricane Irene), 4) good canopy species condition and size structure, and 5)excellent soil structure and soil/geological condition. Its primary degrading factors are its close proximaty to a road and unnatural land cover.

The fair quality of Plot WVF11 is attributed to: 1) excellent hydrological connectivity, 2) good size structure and very good vegetation structure 3) good soil structure and few disturbances present in the plot. its 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. Its degrading factors include is fair hydrologic regime within and surrounding the plot, fair departure from reference condition of its vegetation, along with poor floodplain interactions and lack of channel stability due to impacts from Hurricane Irene. A summary of the biotic and abiotic characteristics of these reference plots is provided and these are recommendations along with the floral composition in the final "expression" of this type (Excel tables: FFspp-6036, FFspp-6114, FFspp-6459, FFAbiotic-6036, FFAbiotic-6114, FFAbiotic-6459).

Given an existing set of biotic and abiotic conditions along the Esopus, Stony Clove and Woodland Valley, alluvial terrace floodplain forests are likely to continue their current the cycle of maturation and disturbance due to both natural flood regimes and catastrophic flooding associated with human activities continuing to challenge their ecological function. However, any major hydrologic changes or a continuation of the high return frequency of catastrophic flooding would ultimately affect species composition; higher stream levels would increase flooding frequency, shifting the trajectory towards 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 moderate amounts along the Esopus, Stony Clove and Woodland Valley, 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 more upland species characterstic of maple-basswood rich mesic or beech-maple mesic forest understories.

Beech-Maple Mesic Forest Description

This upland forest type was most frequently found along the Stony Clove and Woodland Valley and mid to upper reaches of the Esopus.They occur along gentle to steep slopes ranging from 2 to 28 degrees generally situated 6.5 meters or higher above the stream. Beech-maple mesic forest plot substrates ranged from stony to exceedingly stony and typically had well drained soils, although a few plots were moderately well to poorly drained. Many of these forests exhibited fairly good structural complexity with both well developed canopy and subcanopy layers. Three variants of beech-maple mesic forest where identified in the study area, NVC types CEGL006045 *Acer saccharum - Betula alleghaniensis - Prunus serotina* Forest, CEGl006173 *Quercus rubra - Acer saccharum - Fagus grandifolia / Viburnum acerifolium* Forest and CEGL006252 *Acer saccharum - Betula alleghaniensis - Fagus grandifolia / Viburnum lantanoides* Forest (NatureServe 2012).

The canopies of these beech-maple mesic forests share many species, but differ among the variants with the importance of those species. White ash (*Fraxinus americana*), black cherry *(Prunus serotina*) and hop-hornbeam (*Ostrya virginiana*) are of high importance in 6045, red oak (*Quercus rubra)* and white pine (*Pinus strobes*) have high in importance in 6173, while American beech (*Fagus grandifolia*) and sweet birch (*Betula lenta*)are of high importance in 6252. The most prevalent herbaceous plants are the eastern hay-scented fern (*Dennstaedtia punctilobula*), evergreen woodfern (*Dryopteris intermedia* ssp. *intermedia*), marginal wood fern (*Dryopteris marginalis*), white wood-aster (*Eurybia divaricata*), and blue-stemmed goldenrod (*Solidago caesia* var. *caesia*). Exotic invasive shrubs and herbs are present but in generally quite low abundance and cover.See below for full species composition of beech-maple mesic forests.

Some of the beech-maple mesic forests encountered along the Esopus, Stony Clove and Woodland Valley fall within the edges of a high quality statewide significant example for this natural community type. These forests extend upslope forming a forested matrix that covers extensive areas of the Catskill Mountains within the watershed.. 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).

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

An emergent tree layer (31 m) is occasionally present averaging 2% cover comprised of *Pinus strobus* (1%) and *Acer rubrum* (<1%). The tree canopy layer (29 m) has 56% cover and *Betula lenta* (9%), *Quercus rubra* (9%), *Acer rubrum* var. *rubrum* (7%), *Fraxinus americana* (6%), *Acer saccharum* var. *saccharum* (5%), *Tsuga canadensis* (5%), *Fagus grandifolia* (3%), *Acer saccharum* (3%), *Betula alleghaniensis* (3%), *Pinus strobus* (2%), *Acer rubrum* (2%), *Tilia americana* var. *americana* (2%), *Prunus serotina* (1%), *Fraxinus pennsylvanica* (1%), and <1% each of *Carya glabra*, *Populus grandidentata*, *Betula papyrifera*, *Carya ovata*, *Platanus occidentalis*, *Populus tremuloides*, as the most abundant species. The tree subcanopy layer (15 m) has 44% cover and *Fagus grandifolia* (17%), *Betula lenta* (6%), *Acer saccharum* var. *saccharum* (6%), *Tsuga canadensis* (5%), *Acer rubrum* var. *rubrum* (4%), *Betula alleghaniensis* (4%), *Ostrya virginiana* (3%), *Quercus rubra* (2%), *Pinus strobus* (1%), *Fraxinus americana* (1%), and <1% each of *Carpinus caroliniana* ssp. *virginiana*, *Amelanchier arborea* var. *arborea*, *Fraxinus pennsylvanica*, *Betula papyrifera*, *Acer pensylvanicum*, *Tilia americana* var. *americana*, *Ulmus americana*, as the most abundant species.

The tall shrub layer (3 m) is somewhat developed averaging 5% cover with *Hamamelis virginiana* (5%), and <1% each of *Cornus alternifolia*, *Dirca palustris*, ***Lonicera xylosteum***, *Viburnum lantanoides*, *Acer spicatum*, as the most abundant species. The short shrub layer (0.8 m) has 2% cover and *Hamamelis virginiana* (1%), and <1% each of ***Lonicera xylosteum*, ***Viburnum lantanoides*, *Acer spicatum*, ***Rosa multiflora***, ***Lonicera morrowii*,** *Cornus alternifolia*, ***Berberis thunbergii*,** *Rubus allegheniensis*, *Rubus idaeus* ssp. *strigosus*, *Viburnum acerifolium*, as the most abundant species. The dwarf shrub layer (0.3 m) has 1% cover and <1% each of *Rubus setosus*, ***Lonicera xylosteum*,** *Viburnum lantanoides*, *Rubus flagellaris*, *Hamamelis virginiana*, *Rubus hispidus*, *Cornus alternifolia*, *Viburnum acerifolium*, *Sambucus racemosa* var. *racemosa*, *Rubus occidentalis*, *Rubus idaeus* ssp. *strigosus*, *Dirca palustris*, *Kalmia latifolia*, *Lonicera canadensis*, *Rhododendron periclymenoides*, *Prunus virginiana*, *Rubus allegheniensis*, *Prunus pensylvanica* var. *pensylvanica*, ***Berberis thunbergii*,** as the most abundant species.

The saplings layer (4 m) is very well developed averaging 29% cover and *Fagus grandifolia* (14%), *Carpinus caroliniana* ssp. *virginiana* (3%), *Tsuga canadensis* (2%), *Acer pensylvanicum* (2%), *Acer saccharum* var. *saccharum* (2%), *Betula alleghaniensis* (1%), and *Ostrya virginiana* (1%) are the more prevalent species. Additional minor associates present byt averaging <1% each are *Betula lenta*, *Pinus strobus*, *Ulmus americana*, *Tilia americana* var. *americana*, *Acer rubrum* var. *rubrum*, *Fraxinus americana*, *Prunus serotina*, *Amelanchier arborea* var. *arborea*, *Platanus occidentalis*, *Quercus rubra*, *Carya glabra*, *Fraxinus pennsylvanica*, as the most abundant species. The tall seedlings layer (0.9 m) has 7% cover and *Fagus grandifolia* (5%), and <1% each of *Acer pensylvanicum*, *Carpinus caroliniana* ssp. *virginiana*, *Ostrya virginiana*, *Tsuga canadensis*, *Acer saccharum* var. *saccharum*, *Prunus serotina*, *Fraxinus americana*, *Fraxinus pennsylvanica*, *Acer rubrum* var. *rubrum*, *Amelanchier arborea* var. *arborea*, *Pinus strobus*, *Populus tremuloides*, *Tilia americana var. americana*, *Betula alleghaniensis*, *Betula lenta*, as the most abundant species. The short seedlings layer (0.2 m) has 3% cover and <1% each of *Fagus grandifolia*, *Carpinus caroliniana* ssp. *virginiana*, *Fraxinus pennsylvanica*, *Acer* *pensylvanicum*, *Fraxinus americana*, *Acer rubrum* var. *rubrum*, *Prunus serotina*, *Quercus rubra*, *Acer saccharum* var. *saccharum*, *Amelanchier arborea* var. *arborea*, *Tilia americana* var. *americana*, *Prunus pensylvanica* var. *pensylvanica*, *Carya cordiformis*, *Tsuga canadensis*, *Populus tremuloides*, *Betula lenta*, *Picea rubens*, *Ostrya virginiana*, *Betula alleghaniensis*, *Pinus strobus*, as the most abundant species.

The liana layer (10 m) is generally absent averaging <1% cover of *Vitis riparia*. The short vine layer (0.3 m) is also very poorly developed with <1% cover and *Amphicarpaea bracteata*, ***Celastrus orbiculatus***, *Parthenocissus quinquefolia*, *Vitis riparia*, as the most abundant species.

The herbaceous layer (0.3 m) has 15% cover and *Dennstaedtia punctilobula* (4%), *Eurybia divaricata* (3%), *Dryopteris intermedia* ssp. *intermedia* (2%), *Dryopteris marginalis* (2%), *Solidago caesia* var. *caesia* (1%), ***Alliaria petiolata*** (1%), <1% each of *Aralia nudicaulis*, *Polystichum acrostichoides*, *Poa alsodes*, *Maianthemum canadense*, *Carex pedunculata*, *Mitchella repens*, *Athyrium filix-femina* ssp. *angustum*, *Osmorhiza claytonii*, *Dichanthelium* sp., *Cystopteris fragilis*, *Conopholis americana*, *Dendrolycopodium obscurum*, *Epifagus virginiana*, ***Epipactis helleborine*,** *Eurybia macrophylla*, *Circaea lutetiana* ssp. *canadensis*, *Fragaria vesca* ssp. *americana*, *Carex radiata*, *Fragaria virginiana*, ***Galeopsis tetrahit* var. *tetrahit*,** *Galium aparine*, *Galium circaezans* var. *circaezans*, *Galium triflorum*, ***Fallopia japonica*,** *Carex appalachica*, *Actaea pachypoda*, *Ageratina altissima* var. *altissima*, *Agrimonia gryposepala*, *Agrostis perennans*, *Arisaema triphyllum* ssp. *triphyllum*, *Bidens frondosa*, *Brachyelytrum erectum*, *Cardamine diphylla*, *Carex albursina*, *Carex woodii*, *Carex arctata*, *Carex blanda*, *Carex gracillima*, *Carex laxiculmis* var. *laxiculmis*, *Carex laxiflora*, *Carex lenticularis* var. *lenticularis*, *Carex pensylvanica*, *Carex rosea*, *Geranium robertianum*, *Carex sprengelii*, *Carex swanii*, *Symphyotrichum prenanthoides*, *Rubus hispidus*, *Smilax herbacea*, ***Solanum dulcamara***, *Solidago flexicaulis*, *Glyceria striata*, ***Sonchus arvensis***, *Ranunculus* sp., *Symphyotrichum lowrieanum*, *Solidago hispida*, ***Taraxacum officinale*,** *Thelypteris noveboracensis*, *Trientalis borealis*, *Trillium undulatum*, ***Veronica officinalis***, *Viola sororia*, *Impatiens pallida*, *Impatiens capensis*, *Hieracium* sp., *Symphyotrichum cordifolium*, *Hydrophyllum virginianum*, *Pyrola* sp., *Maianthemum racemosum* ssp. *racemosum*, *Medeola virginiana*, *Oclemena acuminata*, *Persicaria virginiana*, *Pilea pumila*, *Polygonatum biflorum*, *Polygonatum pubescens*, *Polypodium appalachianum*, *Polypodium virginianum*, *Potentilla simplex*, *Prenanthes alba*, *Pteridium aquilinum* var. *latiusculum*, *Poa* sp., *Pteridium aquilinum* var. *pseudocaudatum*, as the most abundant species.

The non-vascular layer has 1% cover of mosses (<1%) and lichen (<1%). The unvegetated surface has 5% cover and litter and duff (18%), rocks (1%), wood (1%), and <1% each of sand, rocks-cobble, bare soil, small rocks, trash, rocks-boulder, as the most abundant components.

Beech-Maple Mesic Forest Discussion/Recommendations

According to the results of the PQRS and wFQI, plots SCF25, ESF29 and SCF20 were selected as reference examples for the NVC types 6045, 6173 and 6252 respectively. These plots appear to be the best overall candidates for their variants of beech-maple mesic forests along the Esopus, Stony Clove and Woodland Valley. Only one plot, SCF25, was attributed to the NVC type CEGL006045 *Acer saccharum - Betula alleghaniensis -Prunus serotina* Forest. Six plots were attributed to CEGl006173 *Quercus rubra - Acer saccharum - Fagus grandifolia / Viburnum acerifolium* Forest and seven plots to CEGL006252 *Acer saccharum - Betula alleghaniensis - Fagus grandifolia / Viburnum lantanoides* Forest (NatureServe 2012). CEGL006252 represents the typical "northern hardwood forest", with a strong component of birch species (*Betula lenta* and *B. alleghaniensis*) and American beech (*Fagus grandifolia*) with musclewood (*Carpinus caroliniana* ssp. *virginiana*),and hop-hornbeam (*Ostrya virginiana*) occurring frequently.A fairly diverse groundlayer of sedges (*Carex* spp.), ferns (*Dryopteris* spp.) and herbs such white wood-aster (*Eurybia divaricata*), and Clayton's sweetroot (*Osmorhiza claytonia*). 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 maple-basswood rich mesic forests NVC type CEGL006211. These inclusions appeared to be less common throughout the extent of the Esopus, Stony Clove and Woodland Valley.

The results of the wFQI show that only a few species documented in these three plots have conservation coefficients of 6.5 or higher (Excel sheets: BMMFspp-6045, BMMFspp-6173 and BMMFspp-6252). These species were *Carex sprengelii* (in plot SCF20 NVC type 6252) and *Trillium unudulatum* (in plot SCF25 NVC type 6045), plot ESF 29 (NVC type 6173) lacked any species scoring over 5.5. Higher conefficients are associated plants with either a poor range of ecological tolerances or with a high degree of fidelity to a narrow range of habitats. The overall wFQI's of 20.5, 20.1, and 27.8 for SCF25, ESF29 and SCF20 respectively indicate that these plots and surrounding area are comprised of moderate to high quality plant species.

Plot SCF25 was the only example for the 6045 NVC and its PQRS of 25.5 falls within the very good category and its wFQI is relatively good at 20.5. While it is the only the plot of its NVC type its selection as a reference was made due the excellent PQRS, and its relatively high $w\bar{C}$ (4.2) ranked 5 out of 14, as compared to other beech-maple mesic forest plots. The excellent quality rank of Plot SCF25 is attributed to its 1) high percentage of native species 2) relatively abundant coarse woody debris, 3) low browse and regeneration of canopy species, 4) good soil/geological condition and soil structure/content, 5) few disturbances within the plot and 6) its distance from both non-natural habitat and paved roads. Its degrading factors include the small size of the natural community it is located within.

While the PQRS of 26 for Plot ESF29 was not the best score for the 6173 NVC type, this plot was selected as a reference for its combination of good PQRS and exceptional $w\bar{C}$ of 4.5, which exceeded the next highest with the group by 0.4. Its wFQI score of 20.1 was third highest in the group. One plot (WVF05_12) had an excellent PQRS score of 23, but its wFQI was very low at 12.2. ESF30 had the same PQRS and a higher wFQI (22.5) but had substantial cover of invasive species in its herbaceous layer. The good quality of Plot ESF29 is attributed to its 1) high percentage of native species, 2) very large size of the community where it occurs, 3) very good soil structure/content, 4) good size structure, and 5) few disturbances within the plot. Its degrading factors include moderate browse and limited tree regeneration, and fairly close proximity to a paved road.

While Plot SCF20 did not have the best PQRS for the 6252 NVC type it was selected for its combination of good PQRS and exceptional wFQI score of 27.8 which exceeded all other plots of the type by values ranging from 2.2 to 13.2. Two plots (WVF18 and SCF11) had excellent PQRS scores of 23.5 and 24.5, respectively, and their respective wFQIs were quite low at 17.3 and 19.5. The good quality of Plot SCF20 is attributed to its 1) high percentage of native species 2) low browse and excellent regeneration of canopy species, 3) excellent soil structure/content, 4) good size structure, 5) good vegetation composition relative to reference condition, and 6) good canopy species condition. Its degrading factors include the small size of the natural community it is located within, and its moderate distance to non-natural habitat and paved roads.

A summary of biotic and abiotic characteristics of these plots are provided (Excel sheets: BMMFspp-6045, BMMFAbiotic-6045, BMMFspp-6173, BMMFAbiotic-6173, BMMFspp-6252, and BMMFAbiotic-6252) and these are recommendations along with the floral composition in the final "expressions" of this type.

Given an existing set of biotic and abiotic conditions along the Esopus, Stony Clove and Woodland Valley, 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 these beech-maple mesic forests in the future. Climate change, invasive species that include insect outbreaks, and soil and moisture changes, are some factors that could lead to future alterations of this natural community type.

Shrub Swamp Description

Six plots labeled as shrub swamps were found along the Esopus, Stony Clove and Woodland Valley These shrub swamps occurred as clusters within wide stretches of the Esopus, Stony Clove and Woodland Valley where many were found on small islands, cobble/gravel bars and elevated terraces. Most of these shrub swamp expressions can be classified to NVC types CEGL006065 - *Salix nigra/Carex torta* temporarily flooded shrubland or CEGL003896 - Platanus occidentalis - Betula nigra - Salix (caroliniana, nigra) Woodland. These NVC types are described as a willow shrubland of low riverbanks along moderate to high-energy rivers in the northeast and High Allegheny Plateau and an early successional woodland community of depositional bars and islands along river and large streams in the High Allegheny Plateau, Central Appalachians and Lower New England ecoregions (NatureServe 2012). They occur on cobble substrates with sand and gravel in areas that are typically flooded only during high-water events in the case of the shrubland and relatively frequently and powerfully in case of the woodland. Both may receive winter ice-scour. These shrub dominated natural communities occupy an intermediate position along disturbance gradient between open herbaceous cobble shores and higher terrace floodplain forests (Grossman *et al.* 1998). Only one plot, SCSS01 was typed to a more traditional swamp variant, CEGL002186 - *Cornus sericea* - *Salix* spp. - (*Rosa palustris*) shrubland. This plot was located a farther from the stream channel and occurred on only moderately stony mineral soils.

Floodplain Shrub Swamp (Woodland) Species Composition CEGL003896 (average from all plots sampled)

The tree canopy layer (6 m) is generally sparse, averaging 3% cover of *Platanus occidentalis* (2%) and *Ulmus americana* (1%).

The saplings layer (4.5 m) is also sparse averaging 3% cover of *Ulmus americana* (2%) and *Platanus occidentalis* (1%).

The tall shrub layer (2.9 m) is very well developed averaging 39% cover with *Salix sericea* (21%), *Salix discolor* (18%), and *Sambucus nigra* ssp. *canadensis* (<1%), as the most abundant species. The short shrub layer (1.5 m) is also very well developed, averaging 37% cover with *Salix sericea* (28%), *Salix discolor* (5%), ***Lonicera xylosteum*** (2%), ***Rosa multiflora*** (2%), *Rubus idaeus* ssp. *strigosus* (1%), *Sambucus nigra* ssp. *canadensis* (1%), and ***Berberis thunbergii*** (<1%), as the most abundant species. The dwarf shrub layer (0.4 m) is sparse averaging 3% cover and 1% each of ***Rosa multiflora*** and *Salix sericea,* and <1% each of *Rubus idaeus* ssp. *strigosus, Cornus* sp., and *Sambucus nigra* ssp. *canadensis*.

The short vine layer (0.7 m) averages 2% cover with *Parthenocissus quinquefolia* (1.0%), and <1% each of *Fallopia scandens* var. *scandena, Vitis riparia, Clematis virginiana*.

The herbaceous layer (0.4 m) is fairly well developed averaging 21% cover but it includes many exotic and invasive species. The most abundant herbs are ***Myosoton aquaticum*** (3%), *Ambrosia artemisiifolia* (3%), ***Raphanus raphanistrum*** (2%), *Potentilla simplex* (2%), *Galium obtusum* (2%), ***Myosotis scorpioides*** (2%), ***Galeopsis tetrahit* var. *tetrahit*** (1%), ***Alliaria petiolata*** (1%), and <1% each of *Solidago gigantea,* ***Solanum dulcamara,*** *Galium trifidum* ssp. *trifidum,* ***Tussilago farfara, Hesperis matronalis,*** *Fragaria virginiana, Eutrochium maculatum* var. *maculatum, Circaea lutetiana* ssp.

canadensis, Elymus virginicus var. *virginicus,* ***Centaurea stoebe* ssp. *micranthos,*** *Carex* spp., *Bidens frondosa,* ***Agrostis gigantea,*** *Ageratina altissima* var. *altissima, Poa alsodes,* ***Agrostis capillaris,*** *Urtica dioica* ssp. *gracilis,* ***Rumex obtusifolius,*** *Pilea pumila,, Oxalis stricta, Onoclea sensibilis, Geranium robertianum, Matteuccia struthiopteris, Impatiens capensis, Hydrophyllum virginianum, Geum canadense, Osmorhiza claytonii.*

The non-vascular layer is typically sparse averaging 1% cover of moss.

Floodplain Shrubland Species Composition CEGL006065 (average from all plots sampled)

The tall shrub layer (2.9 m) is well developed with 34% cover with *Salix sericea* (27%), *Salix serissima* (4%), *Rhus typhina* (3%), *Salix lucida* ssp. *lucida* (3%), and <1% each of *Sambucus nigra* ssp. *canadensis,* ***Rosa multiflora, Lonicera xylosteum,*** as the most abundant species. The short shrub layer (1.3 m) has 8% cover and *Salix sericea* (7%), *Salix serissima* (2%), ***Rosa multiflora*** (1%), as the most abundant species. The dwarf shrub layer (0.3 m) is spaese with <1% with *Rubus idaeus* ssp. *strigosus,* and ***Rosa multiflora*** as the most abundant species.

The saplings layer (3.8 m) somewhat sparse with 5% cover of *Populus deltoides* (3%), ***Robinia pseudoacacia*** (2%), and *Platanus occidentalis* (1%), as the most abundant species. The tall seedlings layer (0.9 m) is also somewhat sparse at 4% cover with *Populus deltoides* (3%), ***Robinia pseudoacacia*** (1%), *Platanus occidentalis* (<1%), as the most abundant species. The short seedlings layer (0.4 m) has 1% cover of *Populus deltoides* (1.0%) and ***Robinia pseudoacacia*** (<1%).

The short vine layer (1.5 m) has <1% cover of *Vitis riparia* and ***Celastrus orbiculatus.***

The herbaceous layer (1 m) is very well developed with 52% cover. The most abundant herbs are *Agrostis scabra* (15%), *Onoclea sensibilis* (13%), *Euthamia graminifolia* (10%), ***Fallopia japonica*** (8%), *Impatiens capensis* (5%), *Eutrochium maculatum* var. *maculatum* (5%), *Symphyotrichum puniceum* var. *puniceum* (4%), *Apocynum androsaemifolium* (4%), ***Galeopsis tetrahit* var. *tetrahit*** (3%), *Myosotis laxa* (2%), ***Myosoton aquaticum*** (2%), *Solidago gigantea* (2%), *Solidago patula* ssp. *patula* (2%), ***Glechoma hederacea*** (1%), ***Alliaria petiolata*** (1%), and <1% each of *Galium* sp., *Persicaria hydropiper,* ***Raphanus raphanistrum,*** *Agrostis hyemalis, Poa alsodes, Galium tinctorium, Ambrosia artemisiifolia, Bidens frondosa, Equisetum arvense, Epilobium coloratum, Elymus virginicus* var. *virginicus,* ***Digitaria sanguinalis,*** *Carex scabrata, Dichanthelium* sp., ***Artemisia vulgaris* var. *vulgaris, Verbascum thapsus, Tanacetum vulgare,*** *Symphyotrichum lateriflorum,* ***Silene latifolia, Saponaria officinalis, Rumex crispus, Rumex acetosella* ssp. *pyrenaicus,*** *Persicaria* sp., ***Phleum pratense,*** *Galium trifidum* ssp. *trifidum, Persicaria hydropiperoides, Oxalis stricta,* ***Melilotus albus,*** *Leersia virginica, Glyceria striata, Geum canadense, Geranium robertianum, Poa* sp., as the most abundant species.

The non-vascular layer is sparse or absent with <1% of moss as the most abundant species.

Shrub Swamp Species Composition CEGL002186 (one plot sampled)

The tall shrub layer (3 m) it well developed with 39% cover of*Salix sericea* (32%), ***Rosa multiflora*** (6%), *Rhus typhina* (2%), and *Sambucus nigra* ssp. *canadensis* (<1%). The short shrub layer (1.3 m) is somewhat sparse with 6% cover of **Rosa multiflora** (3%), Salix sericea (3%), and <1% each of ***Lonicera morrowii,*** and *Rubus pubescens* var. *pubescens*. The dwarf shrub layer (0.4 m) is also sparse with 2% cover of ***Rosa multiflora*** (2%) and *Salix sericea* (1%).

The saplings layer (4 m) is sparse with only 3% cover of *Ulmus americana* (2%), and <1% each of *Fraxinus pennsylvanica* and *Acer rubrum*. The tall seedlings layer is poorly developed with <1% of *Carpinus caroliniana* ssp. *virginiana*. The short seedlings layer (0.2 m) is alos sparse with 2% cover of *Fraxinus pennsylvanica* (2%), and <1% each of *Ulmus americana* and *Acer rubrum* as the most abundant species.

The short vine layer (1.3 m) is very well developed with 10% cover of *Parthenocissus quinquefolia* (5%), *Clematis virginiana* (4%), *Vitis riparia* (3%), and ***Fallopia scandens*** **var.** ***scandens*** (<1%).

The herbaceous layer (1.6 m) is also very well developed in areas without dense shrub cover with 63% cover. The most abundant herbs are ***Fallopia japonica*** (15%), *Agrostis scabra* (15%), *Onoclea sensibilis* (13%), *Euthamia graminifolia* (10%), *Impatiens capensis* (10%), *Eutrochium maculatum* var. *maculatum* (5%), ***Galeopsis tetrahit*** **var.** ***tetrahit*** (4%), *Symphyotrichum puniceum* var. *puniceum* (4%), ***Alliaria petiolata*** (2%), *Myosotis laxa* (2%), *Solidago gigantea* (2%), *Solidago patula* ssp. *patula* (2%), *Poa alsodes* (1%), ***Glechoma hederacea*** (1%), and < 1% each of *Geranium robertianum, Galium* sp., ***Agrostis stolonifera,*** *Geum canadense, Equisetum arvense, Fragaria vesca* ssp. *americana, Eurybia divaricata, Glyceria striata, Hydrophyllum virginianum, Leersia virginica,* ***Stellaria pubera,*** *Laportea canadensis, Bidens frondosa,* ***Agrostis gigantea,*** *Symphyotrichum prenanthoides,* ***Veronica officinalis, Sonchus arvensis*** **ssp.** ***arvensis,*** *Thalictrum pubescens,* ***Lysimachia nummularia***, *Symphyotrichum lateriflorum, Sphenopholis intermedia,* ***Achillea millefolium*** **var.** ***millefolium,*** *Solidago rugosa* var. *rugosa, Solidago flexicaulis,* ***Solanum dulcamara, Rumex crispus,*** *Oxalis* sp., *Oclemena acuminata,* ***Tussilago farfara***.

The non-vascular layer is very sparse with <1% moss species.

Shrub Swamp Discussion/Recommendations

According to the results of the PQRS and wFQI (Excel tables :PQRSAshokanPlots.xlsx and NaturalCommunityPlotFQI.xlsx), plots SCSS01, ESS01, and ESS06 appear to be the best overall candidates for a natural community reference for shrub swamps along the Esopus, Stony Clove and Woodland Valley. These three plots are attributed to NVC types: CEGL002186 *Cornus sericea - Salix* spp. - (*Rosa palustris*) shrubland, CEGL006065 *Salix nigra/Carex torta* temporarily flooded shrubland and CEGL003896 - Platanus occidentalis - Betula nigra - Salix (caroliniana, nigra) Woodland respectively (NatureServe 2012).

The results of the wFQI show that several species documented in plot ESS06 and one species in plot SCSS01 have conservation coefficients of 6.5 or higher (Excel tables: SSspp_3896 and SSspp_2186). In plot ESS06, these species include *Platanus occidentalis*, *Salix serissima,* and *Carex scabrata*, and in plot SCSS01 *Solidago patula* ssp. *patula.* Plants with high coefficients exhibit either a poor range of ecological tolerances or with a high degree of fidelity to a narrow range of habitats (Tables 35 and 36).

Plot SCSS01 was the only true shrub swamp sampled of the 2186 NVC type, and its PQRS of 30 placed it in the good reference category for open wetlands. Its wFQI score of 13.3 is modest but the type as it occurs in riparian settings is not characteristically dominated by species with high coefficients of conservatism. The good quality of Plot ESF29 is attributed to its 1) good percentage of cover by native species, 2) the fairly intact hydrologic regime of the plot, 3) minimal hydrological disconnection from the floodplain, 4) few disturbances present within the plot. Its degrading factors include the small size of the natural community where it occurs, moderately impacted soil structure and content, and poor floodplain interactions and lack of channel stability due to impacts from Hurricane Irene.

Plot ESS01 was one of three plots of the 6065 NVC type sampled and its PQRS of 36 placed it in the fair reference category for open wetlands. Its wFQI score of 15.7 is modest and slightly lower than that of plot ESS02 (15.9). However, its $w\bar{C}$ was 0.4 higher and it had substantially lower cover of exotic and invasive plant species and only a slightly lower PQRS at 36 vs. 35. The fair quality of Plot ESS01 is attributed to its 1) good percentage of cover by native species, 2) minimal hydrological disconnection from the floodplain, and 3) good soil structure/content and vegetation composition relative to reference conditions. Its degrading factors include the small size of the natural community where it occurs, moderate disturbances within the plot and surrounding area, impacted soil/geological conditions surrounding the plot, altered hydrologic regime, low distance to unnatural habitat, and poor floodplain interactions and lack of channel stability due to impacts from Hurricane Irene.

Plot ESS06 was one of two successional floodplain shrublands of the 3896 NVC type sampled. Its PQRS of 29.5 placed it in the good reference category for open wetlands. Its wFQI score of 19.5 is moderately high but lower than that of the other plot WVF17 (21.3). However, its $w\bar{C}$ was 0.3 higher and it had substantially lower cover of exotic and invasive plant species and a notably better PQRS at 29.5 vs. 39. The good quality of Plot ESS06 is attributed to its 1) moderately high percentage of cover by native species, 2) few disturbances present within the plot, 3) good soil structure/content, and 4) excellent hydrological connectivity and fairly good floodplain interactions. Its degrading factors include the fairly small size of the natural community where it occurs, substantial departure from reference vegetation conditions, moderate distance from a paved road, and lack of channel stability due to impacts from Hurricane Irene.

A summary of biotic and abiotic characteristics of these plots is included and these are recommendations along with the floral composition in the final "expression" of this type (Excel tables: FSspp-6065, FSAbiotic-6065, SFSspp-3896, SFSAbiotic-3896, SSspp-2186, and SSAbiotic-2186). According to the results, these plots could be used as natural community references for this area.

The current suite of biotic and abiotic conditions along the Esopus, Stony Clove and Woodland Valley has resulted from substantial impacts following a series of catastrophic floods that have affected their riparian zones. Given the close sequence of catastrophic flooding in the study area it is likely that these swamps have been reduced in extent. It is also likely that their species composition has been modified by these disturbances. Changes in ecological conditions will favor some species over others, resulting in possible succession of shrub swamps to early successional floodplain forests if the near stream riparian zones stabilize. It is difficult to determine the long-term viability of this natural community along the Esopus, Stony Clove and Woodland Valley, but even without a major climatic shift, the inevitable change in natural processes along the Esopus, Stony Clove and Woodland Valley is likely to influence species composition and structure of shrub swamps to some degree.

Cobble Shore Description

The cobble shore community type develops on large coarse substrates along medium– to high-energy river channels in areas where the active channel is exposed at low water or in drought years. Scour from seasonal flooding and ice maintain their open character (NatureServe 2012). Fifteen cobble shore plots were sampled along the Esopus, Stony Clove, and Woodland Valley during the summer of 2011. These shores occured within or along the stream channel, on cobble bars with elevations typically 0.3 m above stream level. The recent catastrophic flooding events tied to Hurricane Irene resulted in substantial stream channel changes, including considerable changes in the size and location of the cobble bars and shores present throughout the study area. This large scale disturbance has almost certainly shifted the vegetation back towards earlier successional phases and reduced the already limited cover of woody species. The cobble shore ecological community type includes a dynamic, diverse flora and range of physiognomic expressions associated with the degree of flooding and length of seasonal cobble exposure. All New York examples cross to the National Vegetation Classification type CEGL006536 (*Carex torta - Apocynum cannabinum - Cyperus* spp. herbaceous vegetation).

Cobble Shore Species Composition (average from all plots sampled)

The tree subcanopy layer (10 m) is frequently absent, averaging <1% cover of *Platanus occidentalis*.

The tall shrub layer was absent from the sampled plots. The short shrub layer (1 m) is very poorly developed averaging 1% cover with <1% each of *Rubus setosus*, *Rubus flagellaris*, *Alnus* sp., and *Salix eriocephala*.

The dwarf shrub layer (0.2 m) is typically very poorly developed, averaging <1% cover of *Rubus odoratus*, *Rhus typhina*, *Rosa multiflora*, *Rubus setosus*, *Rubus* sp., and *Prunus* sp.

The saplings layer (5 m) is often absent, averaging <1% cover of *Betula lenta*.

The tall seedlings layer (1.7 m) is sparse or absent, averaging 2% cover with *Salix petiolaris* (1%), and <1% each of *Salix* sp., *Platanus occidentalis*, *Acer saccharum* var. *saccharum*, and *Acer rubrum* var. *rubrum*.

The short seedlings layer (0.3 m) is very sparse averaging <1% cover with *Carpinus caroliniana* ssp. *virginiana*, *Platanus occidentalis*, *Populus deltoides*, *Prunus* sp., *Quercus* sp., *Salix* sp., and *Fraxinus* sp.

The liana layer is absent. The short vine layer (1.3 m) averages <1% cover with *Clematis virginiana*, *Fallopia cilinodis*, *Vitis riparia*, and *Parthenocissus quinquefolia*.

The herbaceous layer (0.8 m) averages 14% cover with ***Fallopia japonica*** *(6%)*, *Apocynum cannabinum (1%)*, *Solidago rugosa* var. *rugosa (1%)*, ***Saponaria officinalis*** *(1%)*, *Euthamia graminifolia (1%)*, ***Centaurea stoebe*** ssp. ***micranthos*** *(1%)*, and the following species with <1% each: ***Galium mollugo***, *Solidago gigantea*, *Fallopia cilinodis*, ***Tussilago farfara***, *Tanacetum vulgare*, *Equisetum fluviatile*, ***Poa nemoralis***, *Phalaris arundinacea*, *Solidago juncea*, ***Alliaria petiolata***, ***Leucanthemum vulgare***, ***Galeopsis tetrahit*** var. ***tetrahit***, *Lepidium campestre*, *Potentilla simplex* , *Carex stricta*, *Impatiens capensis*, ***Silene vulgaris***, *Teucrium canadense* var. *canadense*, ***Anthriscus sylvestris***, *Eupatorium perfoliatum*, *Eurybia divaricata*, *Equisetum* sp., *Fragaria vesca* ssp. *americana*, *Festuca trachyphylla*, *Eutrochium dubium*, ***Chenopodium album***, *Agrostis hyemalis*, *Ambrosia artemisiifolia*, ***Artemisia vulgaris***, *Persicaria sagittata*, *Bidens frondosa*, *Cardamine rotundifolia*, *Carex* sp., *Digitaria* sp., ***Coronilla varia***, ***Dactylis glomerata***, ***Daucus carota***, *Desmodium* sp., *Dichanthelium* sp., *Dichanthelium clandestinum*, *Carex prasina*, *Symphyotrichum* sp., *Persicaria maculosa*, *Poa palustris*, *Poa* sp., *Ribes* sp., ***Persicaria nepalensis***, ***Stellaria media*** ssp. ***media***, *Symphyotrichum prenanthoides*, ***Taraxacum officinale***, ***Trifolium pratense***, *Urtica dioica* ssp. *gracilis*, ***Verbascum thapsus***, ***Vicia tetrasperma***, ***Rorippa sylvestris***, *Myosotis* sp., *Galium pilosum*, *Galium* sp., *Hypericum perforatum*, *Leersia* sp., ***Lythrum salicaria***, *Pilea pumila*, ***Melilotus officinalis***, *Oxalis* sp., ***Oxalis corniculata***, *Oxalis dillenii*, ***Pastinaca sativa***, *Persicaria* sp., ***Persicaria longiseta***, and ***Medicago lupulina***.

Cobble Shore Discussion/Recommendations

According to the results of the PQRS and wFQI, plots WVAN04 and ESAN04 appear to be the best overall candidates for a natural community reference for cobble shore along the Esopus, Stony Clove, and Woodland Valley (Excel tables: PQRSAshokanPlots.xlsx and NaturalCommunityPlotFQI.xlsx). These plots are both crosswalked to NVC type CEGL006536 *Carex torta - Apocynum cannabinum - Cyperus* spp. herbaceous vegetation.

The PQRS score of 19 for plot WVAN03 was the highest quality for any cobble shore plot and represents a good example of a sparsely vegetated cobble shore with only trace amounts of the invasive species *Alliaria petiolata*. The high relative percent cover of native species also yielded the highest cobble shore wFQI score of 11.40. Four other plots along Woodland Valley and Stony Clove had PQRS scores of ≤ 23 but were dropped from reference consideration due to the presence of non-native species cover; they were dominated by invasive exotics, from >10 to >40%. The PQRS score of 28 and wFQI of 7.04 for Plot ESAN04 did not make it the highest numerically ranked cobble shore plot along the Esopus. Nonetheless, it was selected over ESAN07 (PQRS score of 27 and wFQI of 10.53) due to its substantially lower level of exotic species cover (<1% vs. 23%), placement in a larger example of the natural community, an acceptable level of both disturbance within the plot and good to moderate scores on its floodplain metrics including channel stability. Based on the ranking system, this plot represents a fair example of a sparsely vegetated cobble shore with only trace amounts of the invasive species *Lythrum salicaria* and *Fallopia japonica*.

Both of these plots were situated on level cobble bars approximately 0.3 m above and within a distance of 2 to 8 m of the stream. In these cobble shore plots, trees exceeding 5 m and shrubs exceeding 2 m in height were absent, and the lower woody strata were very sparse or absent. The tall seedlings layer (0-1.9 m) is the upmost strata when present, and it has 1% total cover comprised of *Platanus occidentalis*. The short seedlings layer averages 0.3 m in height and 1% cover with scattered *Carpinus caroliniana* ssp. *virginiana*, *Populus deltoides*, and *Platanus occidentalis*. The short shrub layer (0-1 m), when present, has 1% cover of *Salix eriocephala* , as its only recorded species. The native herbaceous layer (0.4 m) has (1-8% cover) averaging just under 5% with *Apocynum cannabinum* (0-6%), *Phalaris arundinacea* (0-2%) *Carex stricta* (0-1%), and <1% each of *Eutrochium dubium*, *Eurybia divaricata*, *Eupatorium* *perfoliatum*, *Persicaria sagittata*, *Carex* sp., *Galium* sp., *Poa* sp., *Solidago rugosa*, and *Impatiens capensis*. These cobble shores are seasonally flooded but well drained. The unvegetated surface is 90-97% rocks ranging in size from gravel to large boulders with small to medium cobble dominating, 0-10% sand, 0-2% wood >1cm, and 0-3% water.

The results of the wFQI show that among these two plots, only plot ESAN04 had a plant species documented with a conservation coefficient of 6.5 or higher (Excel table: CSspp-6536). This species was *Platanus occidentalis*. Species with higher CoCs are associated with either a poor range of ecological tolerances or with a high degree of fidelity to a narrow range of habitats (Table 44). The floristic quality values of many of the surveyed cobble shores were quite low due to the prevalence of both non-native and exotic invasive plants. Their condition problems are likely due to the flood-induced interactions with the surrounding disturbed landscape. During flood events, seeds from the many existing exotic plant populations present within the riparian corridor are carried down the Esopus, Stony Clove and Woodland Valley and deposited on these cobble shorelines.

According to the results, these plots (Excel tables: CSspp-6536, CSAbiotic-6536) 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 in adjacent watersheds to be used as natural community references for this type.

Assuming that the current suite of bioitic and abiotic conditions along the Esopus, Stony Clove, and Woodland Valley remain stable, cobble shores will likely continue to thrive as an ecological unit. Given the documentation of the abundance of upland herbaceous plants within cobble shores, it appears that they flood for very short durations. However, any hydrological change will result in a definite change within this natural community, possibly eliminating them along the Esopus, Stony Clove and Woodland Valley. The influence of Esopus, Stony Clove, and Woodland Valley water 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 them.

Shallow Emergent Marsh Description

Three shallow emergent marsh plots were sampled along the Esopus and Woodland Valley in the summer of 2012. Two of these marsh plots, ESOM01 and ESO11D, occurred relatively close together on a back channel and terrace along the mid-reach of the Esopus. The third, WVOM04 occurred behind a terrace bordering in the lower reach of Woodland Valley. No marshes were documented along the Stony Clove. The two marshes along the Esopus were classified as NVC type CEGL006044 Reed Canarygrass Eastern Marsh and CEGL002430 *Polygonum* spp. – Mixed Forbs Herbaceous Vegetation and the other plot was classified as CEGL006349 (*Scirpus cyperinus* Seasonally Flooded Herbaceous Vegetation; NatureServe 2012). All three plots were significantly degraded by invasive species, but plot WVOM04 retained the highest quality mix of natural species among the three. Plots ESOM01 and ESO11D may be ephermal communities created by significant hydrological regime and substrate disturbances due to both the flooding in Hurricane Irene and subsequent drought through much of the summer of 2012. The composition and structure of WVOM04 was more typical of a more "mature" shallow marsh community that has developed in place for some time. An additional, somewhat large occurrence of shallow marsh is apparently present near the Sleepy Hollow Campground bordering the Esopus, but could not be surveyed due to access denial. It is unknown whether the hydrological conditions will stay favorable for these small shallow emergent marshes to remain or expand along the Esopus and Woodland Valley, and severe flooding events, beaver abandonment, and/or droughts may threaten them.

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

The canopy layers are generally absent, or sparse and generally hanging into the plots where they occur. The tree canopy layer (24 m) averages 3% cover of *Fraxinus americana*. The tree subcanopy layer (9 m) averages 3% cover and is comprised of *Acer saccharum* var. *saccharum* (2%) and *Tilia americana* var. *americana* (2%).

The saplings layer (3.5 m) generally absent with an average of 2% cover comprised of ***Catalpa speciosa*** (1%) and *Acer saccharum* var. *saccharum* (<1%). The short seedlings layer (0.1 m) has <1 % each of *Populus deltoides* and *Platanus occidentalis*.

The tall and dwarf shrub layers were absent from sampled plots. The short shrub layer (0.7 m) averages <1% of *Salix sericea*.

The short vine layer (1.1 m) are very sparse averaging <1% each of *Menispermum canadense*, *Vitis riparia,* and *Clematis virginiana*.

The herbaceous layer (0.8 m) is very well developed, averaging 78% cover, and includes many exotic and invasive species. The most abundant herbs are *Scirpus atrovirens* (12%), *Phalaris arundinacea* (10%), ***Persicaria maculosa*** (9%), ***Myosotis scorpioides*** (9%), ***Lythrum salicaria*** (4%), *Glyceria striata* (3%), *Poa alsodes* (2%), *Persicaria hydropiper* (2%), ***Galeopsis tetrahit* var. *tetrahit*** (2%), ***Fallopia japonica*** (2%), *Leersia oryzoides* (2%), ***Raphanus raphanistrum*** (2%), ***Poa pratensis* ssp. *pratensis*** (2%), *Ambrosia trifida* var. *trifida* (2%), *Persicaria arifolia* (1%), and ***Persicaria longiseta*** (1%), with 1% each of *Epilobium coloratum, Dichanthelium latifolium, Echinochloa muricata* var. *muricata,* and <1% each of ***Myosoton aquaticum,*** *Carex crinita* var. *crinita, Euthamia graminifolia, Lysimachia ciliata , Persicaria sagittata,* *Scirpus cyperinus, Impatiens capensis, Typha latifolia, Agrostis hyemalis, Dichanthelium* sp., *Solidago gigantea,* ***Plantago lanceolata , Trifolium pratense, Poa annua,*** *Glyceria grandis* var. *grandis, Onoclea sensibilis, Bidens frondosa, Lobelia siphilitica, Eutrochium maculatum* var. *maculatum, Eupatorium perfoliatum, Agrostis perennans, Equisetum arvense,* ***Agrostis stolonifera, Alliaria petiolata,*** *Eleocharis obtusa, Ambrosia artemisiifolia, Argentina anserina,* ***Daucus carota,*** *Carex* spp., *Elymus riparius,* ***Plantago major, Tanacetum vulgare,*** *Symphyotrichum prenanthoides,* ***Sonchus arvensis*** **ssp.** ***arvensis,*** *Scirpus microcarpus, Scirpus expansus, Scirpus atrocinctus,* ***Rumex obtusifolius, Rumex crispus*****,** ***Ranunculus repens, Oxalis stricta, Prunella vulgaris*** **var.** ***vulgaris,*** *Galium palustre, Pilea pumila,* ***Phleum pratense,*** *Persicaria hydropiperoides, Persicaria amphibia,,* ***Medicago lupulina, Lotus corniculatus,*** *Juncus tenuis, Juncus bufonius* var. *bufonius, Helianthus* sp., *Galium tinctorium,* and *Ranunculus hispidus* var. *caricetorum.*

The non-vascular layer is generally absent or present only as a trace with <1% cover of moss as the most abundant species.

Shallow Emergent Marsh Discussion/Recommendations

According to the results of the PQRS and wFQI, Plot WV0M04 appears to be the best overall candidate for a natural community reference for shallow emergent marsh along the Esopus, Stony Clove and Woodland Valley. WVOM04 was one of three shallow emergent marshes sampled and the only of the 6349 NVC type. The two other plots, both on the Esopus - ESOM01 (CEGL006044) and ESO11D (CEGL002430) - were very marginal, early successional marshes apparently resulting from catastrophic flood-induced erosion, altered hydrology of a back water channel, and the breaching of a former pond or backwater slough on an elevated terrace. Plot WVOM04's PQRS of 29 placed it in the good reference category for open wetlands. Its wFQI score of 10.2 is somewhat low as is its $w\bar{C}$ of 2.0. Both are apparently low due in large part to the high cover of exotic and invasive species occurring within the plot. These scores are also somewhat lower than ESO11D's scores of 15.8 and 2.4 respectively. However, the scores for that plot appear to have been inflated by upland woody vegetation hanging into it and thus included in its cover and CoC calculation. The good quality PRQS score of Plot WVOM04 is attributed to its 1) lack of disturbance within the plot, 2) good soil structure/content and soil/geological condition, 3) slightly altered hydrologic regime, and 4) excellent hydrological connectivity. Its degrading factors include the small size of the natural community where it occurs, substantial departure from reference vegetation conditions particularly related to the high percentage of exotic and invasive species present, and its proximity to a paved road and non-natural habitat.

The results of the wFQI show that only one species documented in Plot WVOM04 has a conservation coefficient of 6.5 or higher (Excel table: SEMSpp-6349). This species was *Scirpus atrocinctus*. Species with higher coefficients show either a poor range of ecological tolerances or occur within a high degree of fidelity to a narrow range of habitats. Since only three plots were tagged as "shallow emergent marsh" along the Esopus, Stony Clove and Woodland Valley, and none were of good to high quality, the recommendation of WVOM04 for a natural community reference should be considered provisional (Excel tables: SEMSpp-6349, SEMAbiotic-6349). It is concluded that shallow emergent marshes are indeed very uncommon along the Esopus, Stony Clove and Woodland Valley, and where present, are generally of low quality with exotics and invasive species as 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 in the study area. To this end, efforts should be made to secure access permission for surveys of the high-potential marsh located near Sleepy Hollow campground.

Assuming that the current suite of biotic and abiotic conditions along the Esopus, Stony Clove and Woodland Valley remain unstable, shallow emergent marshes, currently rare in this valley, will likely continue to remain low quality and small in extent. Any hydrological change and/or change in beaver activity, however, may change the trajectory of these marshes and result in either an increase or an eradication of these small wetlands along the Esopus, Stony Clove and Woodland Valley.

PROVISIONAL REFERENCE TYPES

Appalachian Oak-PineForest Species Composition

Only one plot (ESF23) of this type was sampled, but its PQRS of 30 and wFQI of 23.9 place it into the good reference category. This plot is a maturing to mature mixed forest with an open groundlayer and some development of vertical structure. Both tip-ups and multiple standing snags over 30cm are present. This forest area is bordered by a driveway and road and has some indications that some of the canopy *Pinus strobus* may be remnants from a former plantation.

The tree canopy layer (32 m) is fairly open with 64% cover. This forest is dominated by *Pinus strobus* (35%), *Quercus rubra* (15%), and *Fraxinus americana* (11%); lesser canopy associates are *Acer rubrum* var. *rubrum* (3%) and *Prunus serotina.* The tree subcanopy layer (24m) is well developed with 30% cover and dominated by *Betula lenta* (15%), *Quercus rubra* (5%), *Acer rubrum* var. *rubrum* (4%), *Betula alleghaniensis* (4%), and *Pinus strobus* (4%). The sapling layer (4 m) is moderately well-developed with 15% cover and *Ostrya virginian*a (8%), *Prunus serotina* (3%), *Acer saccharum* var. *saccharum* (2%), *Fagus grandifolia* (2%), and <1% of *Betula lenta.*

The tall seedlings layer (0.8 m) is poorly developed with only 3% cover and 1% each of *Prunus serotina*, *Fraxinus americana*, *Carpinus caroliniana* ssp. *virginiana*, while <1% of *Betula lenta*, *Ostrya virginiana*, *Acer saccharum* var. *saccharum* are also present. The short seedlings layer (0.3 m) averages 4% cover with *Fraxinus americana* (2%), *Acer pensylvanicum*, *Acer rubrum* var. *rubrum*, *Acer saccharum* var. *saccharum*, *Carya* sp., *Ostrya virginiana*, *Pinus strobus*, *Prunus serotina*, *Quercus rubra* as the most abundant species.

Tall and short shrub layers are absent. The dwarf shrub layer (0.4 m) is very sparse with 1% cover of *Cornus alternifolia* and <1% each of *Rubus occidentalis* and *Lonicera canadensis.*

The herbaceous layer (0.4 m) is somewhat sparse, averaging 7% cover with *Solidago caesia* var. *caesia* (2%), with 1% each of *Eurybia divaricata*, *Carex laxiflora* and *Carex swanii*, in addition to <1% each of *Ageratina altissima* var. *altissima*, ***Alliaria petiolata***, *Apocynum androsaemifolium*, *Arisaema triphyllum* ssp. *triphyllum*, *Athyrium filix-femina* ssp. *angustum*, *Carex appalachica*, *Carex debilis* var. *rudgei*, *Carex pensylvanica*, *Actaea pachypoda*, ***Epipactis helleborine*****,** *Galium* sp., *Luzula multiflora* ssp. *multiflora*, *Maianthemum canadense*, *Maianthemum racemosum* ssp. *racemosum*, *Monotropa uniflora*, *Polystichum acrostichoides*, *Solidago hispida*, ***Taraxacum officinale*****,** ***Veronica officinalis***, and *Dryopteris marginalis.*

The non-vascular layer is very sparse with 1% cover of mosses. The unvegetated surface has 90% cover and is comprised of litter and duff (80%), wood >10cm (7%), sticks (2%), <1% of bare soil, and large rocks.

The FQI and abiotic information for this plot can be found in Excel tables: AOPFSpp-6293 and AOPFAbiotic-6293. Based on the PQRS and wFQI (Excel tables: PQRSAshokanPlots.xlsx and NaturalCommunityPlotFQI.xlsx) we include this as a provisional reference example of NVC type CEGL006293 *Pinus strobus – Quercus* (*rubra, veluntina*) *–Fagus grandifolia* Forest.

Backwater Slough Species Composition

Only two plots, ESO08 and ESO10, of this type were sampled. Plot ESO08's PQRS score of 21.5 placed it into the excellent reference community category. Its plant species composition included exclusively native species, but was fairly simple with no emergent aquatic species present. Other habitat features such as submersed logs and rocks were also absent from the plot. This example was on the small side with good to excellent floodplain characteristics prior to the 2011 flood during Hurricane Irene, but it had only a moderate landscape factor score. It was hoped that better potential reference examples would be documented during 2012 plot sampling, but the excessive channel movements along all of the study area streams combined with excessive scouring and channel aggradation and degradation seems to have eliminated the existing vegetation from many if not most of the previously existing examples of this community type.

The herbaceous layer (0.1 m) is sometimes present averaging <1% cover with *Myosotis scorpioides*, *Lythrum salicaria*, *Glyceria striata*.

A non-vascular layer is often present and dominated by submerged filamentous (3%).

The floating aquatic layer is sometimes present averaging 1% cover of *Lemna minor*.

The submerged aquatic layer is variable in its coverage with 0-50% cover. It averaged 25% cover with *Myriophyllum verticillatum* (15%), and *Elodea canadensis* (10%).

The unvegetated water surface has 50% cover,and standing covered the entire plot substrate. Other unvegetated components and their average cover are Bare Soil (50%), Rock (11%), and Wood (1%).

Cobble Shore Wet-Meadow

One one cobble shore wet meadow plot was sampled (ESOM03). It was a very small but excellent floristically with a wFQI of 27.3 Its PQRS of 27.5 placed it in the good reference category for open wetlands.. Until other examples are found, this plot can serve as a very good provisional reference for the riparian variant of NVC type CEGL004286 *Justica americana* Herbaceous Vegetation.

The short shrub layer (0.8 m) is very sparse with only <1% cover of *Salix* sp.

The herbaceous layer (0.6 m) has 90% cover and is strongly dominated by *Carex torta* (85%); minor associates include 1% each of ***Myosotis scorpioides*** and *Carex aquatilis* var. *aquatilis,* and <1% each of *Agrostis stolonifera, Ambrosia artemisiifolia, Equisetum arvense, Euthamia graminifolia,* ***Galeopsis tetrahit*** **var.** ***tetrahit,*** *Galium obtusum, Glyceria canadensis, Impatiens capensis, Agrostis scabra,* ***Myosoton aquaticum,*** *Onoclea sensibilis, Poa* sp., *Polygonatum* sp., ***Raphanus raphanistrum, Rumex obtusifolius,*** *Scirpus* sp., *Solidago gigantea, Symphyotrichum puniceum* var. *puniceum*.

The unvegetated surface has rock-cobbles (85%), rock-pebbles (8%), and water (7%) as its most abundant components.

The FQI and Abiotic information for this plot can be found in Excel tables: CSWMSpp-4286 and CSWMAbiotic-4286.

Riverside Sand/Gravel Bar Description

Only two plots of riverside sand/gravel bar were sampled: one each of the NVC types CEGL005106 *Leersia oryzoides - Glyceria striata -* (*Schoenoplectus* spp., *Impatiens capensis*) Herbaceous Vegetation (plot ESO09), and CEGL00847 *Polygonum cuspidatum* Temporarily Flooded Herbaceous Vegetation (plot ESF40). The plant species composition and abiotic characteristics of ESO09 have been provided (Excel tables: RSGBSpp-5109 and RSGBAbiotic-5109). These examples of this community type are marginal and although plot ESO09 has been selected as a reference, it should be considered provisional. Additional surveys to document and describe this type along the Esopus, Stony Clove, and Woodland Valley are needed; catastrophic flooding from Hurricane Irene seem to have destroyed many of the potential occurrences, but the community may recover in the future if the stream channels stabilize.

Riverside Sand/Gravel Bar Species Composition (Average of two plots sampled)

The tree canopy layer (25 m) is sometimes absent, averaging 10% cover with *Populus deltoides* (7%), *Fraxinus pennsylvanica* (3%), and *Platanus occidentalis* (3%).

The tall shrub layer (2.8 m) is very sparse with 1% cover of *Salix sericea* (1%) and <1% of ***Rosa multiflora***.

The short shrub layer (0.9 m) is also sparse, averaging 2% cover of *Salix petiolaris* (1%), and <1% each of *Salix lucida* ssp. *lucida*, *Salix sericea*, and ***Rosa multiflora***.

The liana layer (7 m) is sometimes absent, averaging 1% cover of *Vitis riparia* (1%) and <1% of *Echinocystis lobata*.

The short vine layer (1.5 m) is also sometimes absent, averaging <1% cover with *Vitis riparia* as its only recorded species.

The herbaceous layer (1.1 m) has 73.5% cover and ***Fallopia japonica*** (49%), Phalaris arundinacea (5%), Leersia oryzoides (5%), ***Lythrum salicaria*** (5%), ***Myosoton aquaticum*** (2%), ***Myosotis scorpioides*** (2%), ***Alliaria petiolata*** (1%), *Persicaria sagittata* (1%), *Persicaria pensylvanica* (1%), *Glyceria grandis* var. *grandis* (1%), *Eleocharis obtusa* (1%), *Bidens frondosa* (0.5%), *Persicaria hydropiperoides* (0.5%), *Bartonia virginica* (0.5%), *Galium palustre*, ***Galeopsis tetrahit* var. *tetrahit***, ***Trifolium pratense***, *Epilobium coloratum*, *Elymus virginicus* var. *virginicus*, ***Daucus carota***, *Carex* sp., *Juncus tenuis*, *Ambrosia artemisiifolia*, ***Agrostis stolonifera***, ***Agrostis capillaris***, ***Centaurea scabiosa***, ***Medicago lupulina***, *Plantago* sp., *Phryma leptostachya*, ***Phleum pratense***, *Rumex* sp., *Scirpus atrocinctus*, *Scirpus hattorianus*, *Glyceria striata*, ***Melilotus albus***, *Onoclea sensibilis*, ***Silene vulgaris***, ***Leucanthemum vulgare***, *Lepidium virginicum* var. *virginicum*, *Symphyotrichum lanceolatum* var. *lanceolatum*, ***Ranunculus repens***, and *Impatiens capensis* as the most abundant species.

The floating aquatic layer averaged 2% cover of an unknown aquatic species.

Riverside Sand/Gravel Bar Discussion/Recommendations

Plot ESO09 was one of two riverside sand/gravel bars sampled and the only one of the 5106 NVC type. The other plot, ESF40 (CEGL8472), had extremely poor species composition. Plot ESO09's PQRS of 30 placed it in the good reference category for open wetlands, and makes it afair reference for open uplands (a more typical classification for riverside sand/gravel bars), although this plot appears to be a wet variant. Its wFQI score of 11.7 is somewhat low, as is its $w\bar{C}$ of 1.9. Both are apparently low due in large part to the high cover of exotic and invasive species occurring within the plot in combination with prevalent weedy native species. However, these scores are much higher than those of ESF40, which had an wFQI of 3.5, a $w\bar{C}$ of 1.0, and a PQRS score of 48, placing it in the poor reference category for both wetlands and uplands. The good quality PRQS score of Plot ESO09 is attributed to its 1) excellent hydrologic regime, 2) lack of disturbance within the plot, 3) excellent hydrological connectivity with the floodplain, and 4) good soil/geological condition, soil structure and floodplain interactions. Its degrading factors include the very small size of the natural community where it occurs, substantial departure from reference vegetation conditions particularly related to the high percentage of exotic and invasive species present, and its proximity to a paved road.

Conclusions/Summary

The more than 40-mile stretch of riparian habitat along the Esopus, Stony Clove and Woodland Valley offers opportunities for good reference "expressions" of many of the major natural riparian community types encountered. One hundred and six plots were sampled across approximately 13 natural community types (Table 2). Beech-maple mesic forests, hemlock-northern hardwoods,floodplain forests, and cobble shores were the most commonly encountered natural communities along the Esopus, Stony Clove and Woodland Valley. Maple-basswood rich mesic forest, and shrub swamps were seen less frequently along the Esopus, Stony Clove and Woodland Valley (Table 2). Other natural communities such as shallow emergent marshes, riverside sand/gravel bars, cobble shore wet meadow and Appalachian oak-pine forest were encountered so rarely that sample sizes were too small to allow the selection of final references and to develop more than preliminary 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 and within distance to and elevation above the stream channels particularly along the Stony Clove and Woodland Valley. Two tools, Plot Quality Rank System and Florsitic QualityIndex, 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 (Excel table: PQRSAshokanPlots.xlsx) of the Plot Quality Rank System (PQRS), plot ranks fell within all categories ranging from “excellent” to "poor" (see Sechler 2010), with average or better overall quality for the adequately sampled types (Table 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 Esopus, Stony Clove and Woodland Valley riparian area, and if it is to be used similarly in other watersheds for riparian reference studies.

The Floristic Quality Index (wFQI) results showed a wide range of values from 0.0 (cobble shore) to 34.2 (floodplain forest) (Excel table: NaturalCommunityPlotFQI.xlsx). 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 Esopus, Stony Clove and Woodland Valley, with cobble shores, shrub swamps, and shallow emergent marshes by far containing the most exotic plant species.

Beech-maple mesic forests within the watershed occur primarily as part of large matrix forests on the lower slopes of the Catskill Preserve lands bordering the study area., The results of the Plot Quality Rank System and Plant Stewardship Index reflect generally good to excellent quality examples of the beech-maple mesic forest along the Esopus, Stony Clove and Woodland Valley, and several plots qualify as "references" for this natural community.

In contrast,floodplain forests were scattered along creeks throughout the study area, with small examples occurring throughout various stretches of the Esopus, Stony Clove, and Woodland Valley. Floodplain forests were in overall fair to good condition, with some disconnection to the natural landscape, typically small in size, and contained many exotic plants such as garlic mustard (*Alliaria* *petiolata*). These were the main factors contributing to the lower quality floodplain forests (Excel table: PQRSAshokanPlots.xlsx). However, several floodplain forest plots were of high enough quality to serve as "references" for this natural community along the Esopus, Stony Clove and Woodland Valley.

Hemlock-northern hardwood forest examples along the Esopus, Stony Clove and Woodland Valley were generally in good to excellent condition, with good connection to the natural landscape, few to no exotic plants, and fair to good size (PQRSAshokanPlots.xlsx). Several of these plots qualify as "references", reflecting good to excellent expressions of these natural communities.

In addition, examples of shrub swamps in general were in fair to good condition, with few disturbances and a good connection to the natural landscape (Excel table: PQRS_Ashokan). However, the FQI scores lowered the overall quality of these shrub swamps due to the number of exotic plant species found.

Small examples of cobble shore natural communities were very frequently found along the Esopus, Stony Clove and Woodland Valley, and, in general, were in fair to poor ecological condition but 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 Esopus, Stony Clove and Woodland Valley, new substrate 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, Plots WVAN03 and ESAN04 had a wFQIs of 11.4 and 10.5 respectively, by far the highest of the cobble shore plots. These examples, despite being small in size, had few exotic species and thus may serve as a natural community reference for cobble shores. However, it is recommended that other options be explored, including searching for larger, more vegetated cobble shores in adjacent watersheds that are dominated by native species.

The same criteria may be true for shallow emergent marshes, which were infrequently encountered along the Esopus, Stony Clove and Woodland Valley. The best "expression", plot WVOM04, was small and contained too many exotic plant species to be considered as more than a provisional reference for this natural community type. We recommend that additional searches be conducted within the Esopus, Stony Clove and Woodland Valley riparian area, and in adjacent watersheds to find larger examples of shallow emergent marshes that are dominated by native species.

Other factors not within the realm of this study may also be important in determining which riparian community examples to use as references for the Esopus, Stony Clove and Woodland Valley. Factors such as microclimate, frequency of flooding, and sediment input and output individually and collectively drive vegetation patterns in riparian zones (Hughes *et al.* 2005). The variability and unpredictability of these dynamic, riparian 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. Natural communities that occur on slopes above the stream channel, 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 Esopus, Stony Clove and Woodland Valley, such as shrub swamps and floodplain forests, are perhaps more unique to this particular watershed. The Esopus, Stony Clove and Woodland Valley 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(Cornell Cooperative Extension of Ulster County 2007). The narrow valleys of the Stony Clove and Woodland Valley, steep mountain sides, and high energy and flashy character of the Esopus, Stony Clove and Woodland Valley are 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.

Table 4: Average Plot Factor Rank by Reference Natural Community Type

Natural Community type	# Plots	Average Plot Rank Score	Overall Quality
Beech-Maple Mesic Forest	15	27.87	Good
Cobble Shore	15	23.93/31.63*	Good/Fair
Floodplain Forest	18*	39.28**	Good
Hemlock-Northern Hardwood Forest	21	24.79	Excellent
Maple-basswood rich mesic forest	6	28.25	Good
Shallow Emergent Marsh	3	30.17	Fair
Shrub Swamp	6	34.84	Fair

*Cobble shores were scored with and without the applicable floodplain metrics to provide context relative to the condition of the floodplain were each shore occurred. **One sapling dominated successional plot was excluded from the calculation of the mean score due to its lack of scoring in the canopy tree related categories.

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