2.6 Riparian Vegetation Issues in Stream Management

General Concepts of Riparian Vegetation Ecology and Management

The role of vegetation in maintaining a healthy stream

Although people value trees and plants along a stream for their contribution to the beauty of streamside landscape, the vegetation in a watershed, especially in the *riparian* area, plays a critical role in providing for a healthy stream system. The riparian, or streamside, plant community serves to maintain the riverine landscape and moderate conditions within the aquatic ecosystem.

As rainfall runs off the landscape, riparian vegetation:

- Slows the rate of runoff
- Captures excess nutrients carried from the land
- Protects stream banks and floodplain from the erosive force of water
- Regulates water temperature changes

It also:

- Provides food and cover to terrestrial and aquatic fauna
- Conserves soil moisture, ground water and atmospheric humidity.

Vegetation's erosion and pollution prevention capabilities

Riparian vegetation serves as a buffer for the stream against activities on upland areas. Most human activities whether agriculture, development, or even recreation, can result in a disturbance or *discharge* which can negatively impact the unprotected stream. Riparian vegetation captures and stores pollutants in overland flow from upland sources such as salts from roadways and excess fertilizer from lawns and cropland. The width, density, and structure of the riparian vegetation community are important characteristics of the buffer that can be used to define the level of its functionality.

On bare soils, high stream flows can result in bank erosion and overbank flow can cause soil erosion and scour on the floodplain. The roots of vegetation along the bank hold the soil and shield against erosive flows. On the floodplain, vegetation slows flood flows, reducing the energy of water. This reduction in energy will decrease the ability of water to cause erosion and scour. Furthermore, as vegetation slows the water, the soil suspended in the water is deposited on the floodplain.

Vegetation's hydrologic influences

Vegetation intercepts rainfall and slows runoff. This delay increases the amount of precipitation that infiltrates the soil and reduces overland runoff. A reduction and delay in runoff decreases the occurrence of destructive flash floods, lowers the height of flood waters, and extends the duration of the runoff event. These benefits are generally most readily observed in forested watersheds like Stony Clove when compared with similar watersheds where urban development is the chief land use (Fig. 1). The reduction in flood stage and duration typically means less disturbance to stream banks and floodplains.

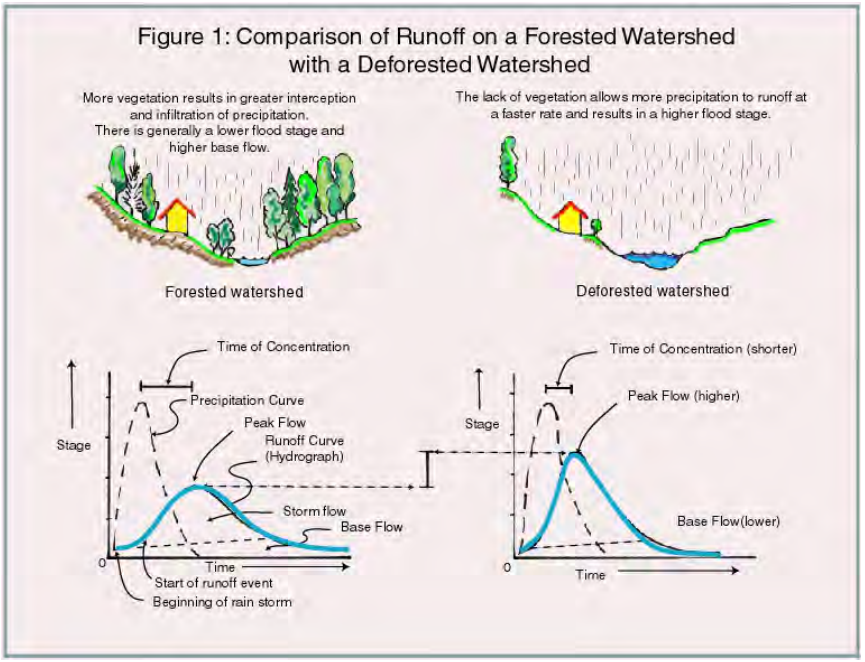


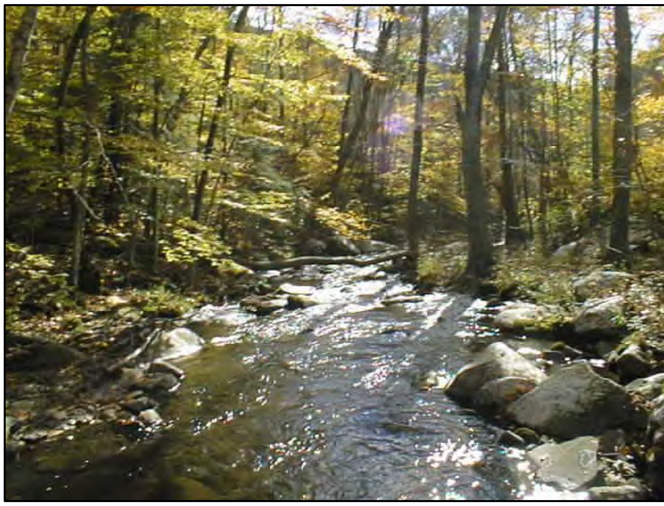
Figure 1 Illustration by P. Eskeli 2002, from <u>Watershed Hydrology</u>, P.E. Black, 1991, Prentice Hall, page 202, 214.

Ecological importance of vegetation in the riparian zone

Vegetation along a stream also functions to provide the climate, habitat, and nutrients necessary for aquatic and terrestrial wildlife. Trees shading a stream help maintain cool water temperatures needed by native fish populations. Low hanging tree branches and roots on undercut banks create cover for fish from predators such as birds and raccoons. Natural additions of organic leaf and woody material provide a food resource needed by terrestrial insects and aquatic macroinvertebrates (stoneflys, mayflies, etc.), the primary source of food for fish. Terrestrial wildlife depends upon vegetation for cover as they move from the upland community to the water's edge. A diverse plant community, one similar to the native vegetation of Stony Clove, provides a wide range of conditions and materials needed to support a diverse community of wildlife. If the vegetation is continuous within the riparian zone along the length of a stream, a corridor is available for wildlife migration. Connectivity between the riparian and upland plant communities enhances the ability of upland and riparian plant and animal communities to thrive despite natural or human induced stress on either community.

Characteristics of a healthy riparian plant community

A healthy riparian plant community should be diverse. It should have a wide variety of plants including trees, shrubs, grasses or herbs. The age of the plants should be varied and there should be sufficient regeneration of new plants to ensure the future of the community. A diverse community provides a multitude of resources and the ability to resist or recover from disturbance. An important difference between an upland plant community and a riparian community is that the riparian community must be adapted to frequent disturbance from flooding. Consequently, many riparian plants, such as willow, alder, or poplar can regrow from stump sprouts or can reestablish their root system if up ended. Furthermore, the seed of these trees may have a greater ability to germinate and establish in depositional areas, such as gravel bars and lower flood benches.



Diverse plant types
(trees, shrubs, grasses, herbs)
+
Diverse plant ages
(young and old)
+
Disturbance-adapted, moisture-loving plants
(accustomed to flooding & ice floes)

=

Healthy riparian buffers

Figure 2 A healthy riparian community is densely vegetated, has a diverse age structure and is composed of plants that can resist disturbance.

Riparian Vegetation in Stony Clove

Forest history and composition in Stony Clove

Catskill mountain forests have evolved since the ice age reflecting the changes in climate, competition and human land use. The first of these changes was the result of the climatic warming that occurred after the ice age which enabled warm climate adapted plant communities to replace the cooler climate communities. Following the retreat of the glaciers, the forest of Stony Clove gradually re-established and evolved from the boreal spruce/fir dominated forests, (examples of which can presently be found in Canada) to the maple-beech-birch northern hardwood forests (typical of the Adirondacks and northern New England) with the final transition of the lower elevations of the watershed to a southern hardwood forest dominated by oaks, hickory and ash (typical of the northern Appalachians). Dr. Michael Kudish provides an excellent documentation of evolution and site requirements of the region's forests in his book, The Catskill Forest: A History.

More recently, human activities have affected the forest either through the manipulation of regeneration for the maintenance of desirable species, the exploitation of the forest for wood and wood products or through development. Native American land management practices included the use of prescribed burning as a means of enabling the nut bearing oaks and hickories to remain dominant in the forest. European settlers contributing to the rising industrial economy in the 18th and 19th century greatly altered the landscape and forest cover through land clearing for agriculture, forest harvesting for construction materials, and hemlock bark harvesting for the extraction of tannin. The land cover in Stony Clove began to revert to forest with the local collapse of these economies in the 20th century and the acquisition of much of the land by the state for the Catskill Forest Preserve (Kudish, 2000). Please refer to individual Management Unit descriptions in Volume II Section 4 for more detailed information about past activities that affected the streamside and floodplain vegetation.

Previous land use has had a significant role in determining the type of vegetation found along the stream. Due to the steepness of the sides of the valley, the most intensive development activities were confined to the valley floor along the stream. Pastures and fields were created from cleared, forested floodplains. After abandonment, these old fields have experienced a consistent pattern of recovery, with species dominating the initial regrowth including sumac, dogwoods, aspens, hawthorns, and white pine. These species are succeeded by other light loving hardwood tree species such as ash, basswood and elm or in lower parts of the watershed, hickories, butternut, and oak. Hemlocks are largely confined to the steeper stream banks and slopes where cultivation or harvesting of hemlocks for bark was impossible. More recent housing construction has re-intensified activity along the stream and been accompanied by the introduction of non-native vegetation typical of household lawns and gardens.

Today, the Stony Clove watershed is largely forested. Upland forest cover types transition from the oak-ash-hickory forests at the bottom of the watershed, to a beech-maple forest in the middle elevations, to a maple-beech-birch in the headwaters. Balsam fir forest stands, remnant of the boreal, post-glacial forests and relatively unaffected by exploitation, can still be found at the crest of the watershed ridge. Riparian areas in Stony Clove are also largely forested, although the continuity of the forest is frequently interrupted by infrastructure, utility lines, residential land use and the remnants of the railroad right-of-way and abandoned agricultural lands.

The riparian forest

Typically, a riparian forest community is composed of those plant species that thrive in a wet or moist location and have the ability to resist or recover from disturbance. Generally, the riparian forest community is more extensive where a floodplain or wetland exists and the side slopes to the valley are more gently sloping. The plant associations found in forested floodplain communities may be exclusive to riparian areas, such as the case with the sycamore stands found along the Stony Clove creek as it enters its delta at Phoenicia. Where the valley side slopes are steeper, the riparian community may occupy only a narrow corridor along the stream and then quickly transition to an upland forest community. From a vegetation assessments in a nearby watershed, it was found that northern hardwood communities on steep slopes adjacent to the stream contained a mix of ash, poplar, elm, beech, yellow birch and some maple, whereas in upland northern hardwood communities, the yellow birch and maple became the dominant species. Soils, ground water and solar aspect may create conditions that allow the riparian forest species to occupy steeper slopes along the stream, as in the case where hemlock inhabits the steep, northfacing slopes along the watercourse.

Natural disturbance and its effects on the riparian vegetation

Riparian vegetation is disturbed by the forces of nature and development activities of those who live near the stream. Sources of natural disturbance include damage due to floods, ice floes, and to a lesser extent, high winds, pest and disease epidemics, drought and fire. Deer herds can also alter the composition and structure of the vegetation due to their specific browse preferences.

The 1996 flood created and reopened numerous high flow channels on Stony Clove Creek, reworked point bars, scoured floodplains and eroded formerly vegetated stream banks. Immediately following the flood, the channel and floodplains were scattered with woody debris and downed live trees. In the years since this event, much of the vegetation has recovered. Trees and shrubs flattened by the force of floodwaters have re-established their form. Gravel bars and sites disturbed in previous flood events became the seedbed for herbs and grasses. This type of natural regeneration is possible where the stream is stable and major flood events occur with sufficient interval to allow establishment. The effect of flood disturbance on vegetation along stable stream reaches is short term and the recovery/disturbance regime can be cyclical. If the disturbance of floods and ice are too frequent, large trees will not have the opportunity to establish. Typically, the limit that trees can encroach upon the channel is defined by the area disturbed by the runoff event that achieves bankfull flow (expected to occur on average every 1.3 years). While shrubs like willow and alder or herbaceous plants like sedges, which reestablish themselves quickly after disturbance, can grow in the bankfull channel, it is unadvisable to plant trees in this channel area.

Local geology and stream *geomorphology* may complicate the recovery process. A number of sites were found in Stony Clove where vegetation has not been able to reestablish itself on the high, steep bank failures created during recent flood events. On these sites it will be necessary to understand the cause of the failure before deciding on whether to attempt planting vegetation to aid in site recovery. In these instances, the hydraulics of the flowing water, the morphological evolution of the stream channel, the geology of the stream bank, and the requirements and capabilities of the vegetation must be considered before attempting restoration. Since the geologic setting on these sites is partially responsible for the disturbance, the period required for natural recovery of the site would be expected to be significantly longer unless facilitated by restoration efforts.

The ice break up in the spring, like floods, can damage the established vegetation along the stream banks and increase mortality of the young tree and shrub regeneration. Furthermore, ice floes can cause channel blockages which result in erosion and scour associated with high flow channels and overbank flow. Typically this type of disturbance also has a short recovery period.

Pests and diseases that attack vegetation can also affect changes in the ecology of the riparian area and could be considered a disturbance. The hemlock woolly adelgid (*Adelges tsugae*) is an insect, which feeds on the sap of hemlocks (*Tsuga spp*.) at the base of the needles causing them to desiccate and the tree to take on a greyish color. Stress caused by this feeding can kill the tree in as little as 4 years or take up to 10 years where conditions enable the tree to tolerate the attack (McClure, 2001). This native insect of Japan was first found in the U.S. in Virginia in 1951 and has spread northward into the Catskills including Stony Clove (Adams, 2002).

Figure 3 Hemlock woolly adelgid on the underside of a branch.

In the eastern United States, the adelgid attacks eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*Tsuga carolinianna* Engelman) and can affect entire stands of hemlock. Once a tree is infested, population trends for the insect are typified by a fluctuating density of the insect with some hemlock regrowth occuring in periods when population densities are lower. This regrowth is stunted and later attacked as the adelgid population increases. With each successive attack tree reserves become depleted and eventually regrowth does not occur. The native predators of hemlock woolly adelgid have not offered a sufficient biological control, but recent efforts to combat the insect include experimentation with an Asian lady beetle (*Pseudoscymnus tsugae* Sasaji) which is known to feed on the adelgid. Initial experimental results have been positive, but large-scale control has yet to be attempted. The US Forest Service provides extensive information about this pest at its Morgantown office "forest health protection" webpage: www.fs.fed.us/na/morgantown/.

With respect to stream management, the loss of hemlocks along the banks of Stony Clove Creek poses a threat to bank stability and the aquatic habitat of the stream. Wildlife, such as deer and birds, find the dense hemlock cover to be an excellent shelter from weather extremes. Finally, dark green hemlock groves along the stream are quiet, peaceful places that are greatly valued by the people who live in the Stony Clove. The Olive Natural Hertitage Society, Inc. is monitoring the advance of the hemlock woolly adelgid in the Catskills and is working in cooperation with NYS DEC on testing releases of *Pseudosymnus tsugae.* Initial results of the monitoring suggested a possible link between the presence of hemlock woolly adelgid on a site and the degree to which people use or access the site. Due to the widespread nature of the infestation, the use of chemical pest control options such as dormant oil would most likely provide little more than temporary, localized, control. The use of pesticides to control adelgid is not recommended in the riparian area due to potential impacts on water quality and aquatic life.

Without a major intervention (as yet unplanned), it is likely that the process of gradual infestation and demise of local hemlock stands by woolly adelgid will follow the patterns observed in areas already affected to the south. Reports from Southern Connecticut describe the re-colonization of hemlock sites by black birch, red maple and oak (Orwig, 2001). This transition from a dark, cool, sheltered coniferous stand to open hardwood cover is likely to raise soil temperatures and reduce soil moisture for sites where hemlocks currently dominate vegetative cover. Likewise, in the streams, water temperatures are likely to increase and the presence of thermal refuge for cool water loving fish such as trout, are likely to diminish. Alternatives for maintaining coniferous cover on hemlock sites include the planting of adelgid resistant conifers such as white pine as the hemlock dies out in the stand (Ward, 2001).

Human disturbance and its effects on the riparian vegetation

Although natural events disrupt growth and succession of riparian vegetation, human activities frequently transform the environment and, as a result, can have a long lasting impact on the capability of vegetation to survive and function. Presently, the most significant sources of human disturbance on riparian vegetation in Stony Clove includes the construction and maintenance of roadway infrastructure, the maintenance of utility lines and the development of homes and gardens near the stream and its floodplain.

Roadway and utility line influences on riparian vegetation

Due to the narrow valley and steepness of the valley walls, the alignment of NYS Route 214 in Stony Clove closely follows the stream alignment. Use and maintenance of the road right-of-way impacts the vigor of riparian vegetation. The narrow buffer of land between the creek and the road receives the runoff of salt, gravel, and chemicals from the road that stunt vegetation growth or increase its mortality. Road maintenance activities also regularly disturb the soil along the shoulder and on the road cut banks. This disturbance fosters the establishment of undesirable invasive plants. The linear gap in the canopy created by the roadway separates the riparian vegetation from the upland plant communities. This opening also allows light into the vegetative understory which may preclude the establishment of shade loving plants such as black cherry and hemlock.

Utility lines parallel the roadway and cross the stream at various points requiring the utility company to cut swaths through the riparian vegetation at each crossing, further fragmenting essential beltways for animal movement from streamside to upland areas. Although the road right-of-way and utility line sometimes overlap, at several locations along the stream, the right-of-way crosses through the riparian area separate from the road. This further reduces the vigor of riparian vegetation and prevents the vegetation from achieving the later stages of natural succession, typified by climax species such as sugar maple, beech and hemlock.

Residential development influence

Residential land use and development of new homes can have a great impact on the watershed and the ecology of the riparian area. Houses require access roads and utility lines that frequently have to cross the stream. Homeowners, who love the stream and want to be close to it, may clear trees and shrubs to provide access and views of the stream. Following this clearing, the stream bank begins to erode, the channel over-widens and shallows. The wide, shallow condition results in greater bedload deposition and increases stress on the unprotected bank. Eventually stream alignment may change and begin to cause erosion on the property of downstream landowners. Catskill stream banks require a mix of vegetation such as grasses and herbs that have a shallower rooting depth, shrubs with a medium root depth, and trees with deep roots. Grasses alone are insufficient to maintain bank stability in steeply sloping streams such as the Stony Clove Creek.

Figure 4 Mowing to the edge of the stream leads to bank failure. This bank has been reinforced with log cribbing.

Many people live close to the stream and maintain access to the water without destabilizing the bank. By carefully selecting a route from the house to the water's edge and locating access points where the force of the water on the bank under high flow is lower, landowners can minimize disturbance to riparian vegetation and stream banks. Restricting access to foot traffic, minimizing disturbance in the flood prone area, and promoting a dense natural buffer provide property protection and a serene place that people and wildlife can enjoy. Additional information on concepts of streamside gardening and riparian buffers can be found at the following web site produced by the Connecticut River Joint Commission, Inc: http://www.crjc.org/riparianbuffers.html. A list of native trees and shrubs "Native Trees for Riparian Buffers in the Upper Connecticut River Valley of New Hampshire and Vermont" developed by this group is provided in Volume III Appendix C.

Invasive plants and riparian vegetation

Sometimes the attempt to beautify a home with new and different plants introduces a plant that spreads out of control and "invades" the native plant community. Invasive plants present a threat when they alter the ecology of the native plant community. This impact may extend to an alteration of the landscape should the invasive plant destabilize the geomorphology of the watershed (Malanson, 2002). The spread of Japanese knotweed (*Polygonum cuspidatum*), an exotic, invasive plant gaining a foothold in Stony

Clove, is an example of a plant capable of causing such a disruption. As its common name implies, Japanese knotweed's origins are in Asia, and it was brought to this county as an ornamental garden plant. This plant spreads rapidly on disturbed sites and prefers the moist, open conditions of the stream edge and bank for colonization. After establishing itself, Japanese knotweed will shade out existing vegetation and form dense stands along the bank. The primary concern with this plant is that it will reduce the ability of a stream bank to resist erosion. Although the impact of a Japanese knotweed invasion on the ecology of the riparian area is not fully understood, this plant may also displace other life dependent on the native vegetation for shelter, food or cover.

Figure 5 Knotweed's leaf pattern.

Figure 6 Dense stand of knotweed.

Japanese knotweed spreads primarily by vegetative means. Often, earthmoving contractors, highway department crews or gardeners transfer small portions of the roots in fill or soil that gets dumped on a stream bank. These roots then grow into a new plant that soon becomes a colony. Once in the riparian area, high flows scouring the bank may spread portions of the root downstream where it establishes new colonies on disturbed sites or sediment deposits. The above ground portion dies back each fall and re-grows to a height of 6-9 feet tall each spring. The canopy of the dense stands of bamboo-like stalks, covered by large heart shaped leaves (Fig. 5), blocks out almost all light from reaching the soil (Fig. 6), thereby shading out other plants and leaving the soil bare.

Japanese knotweed is very difficult to control. The broad use of herbicides, while potentially effective following a protocol of repeated treatments by a professional certified applicator, does present risks due to the threat the chemicals pose to water quality and the fragile aquatic ecosystem. Mechanical control, by cutting or pulling, is labor intensive and requires regular attention to remove any re-growth. Biological controls are untested. The first step for residents and those who manage land and infrastructure in Stony Clove is to familiarize themselves with the appearance and habits of knotweed. Next, it is important for landowners and land managers to monitor its spread. Landowners should avoid practices that would destabilize the stream banks or weaken the natural riparian vegetation that can prevent its spread. Any fill material introduced to the riparian area should be tested for the presence of Japanese knotweed.

Any Japanese knotweed roots pulled or dug up from your property should be disposed of in a manner that will prevent it from spreading or re-establishing itself.

During the aquatic habitat assessment, the project team mapped the distribution of Japanese knotweed along the Stony Clove creek. This mapping exercise did not characterize the area covered by each colony, only the presence of a colony.

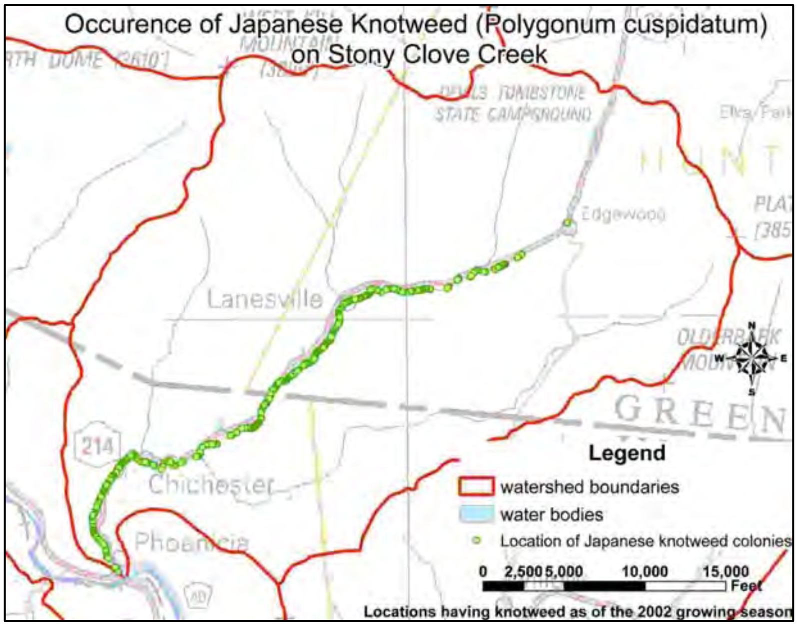


Figure 7 Occurrence of Japanese Knotweed along Stony Clove Creek

As is evident from the map, Japanese knotweed has colonized many sites along the Stony Clove mainstem (Fig 7). Without control efforts it is likely to continue to spread and fill in along the banks within a matter of a few years. For more information about the specific quality and composition of a particular riparian area, please refer to individual Management Unit descriptions in Section 4.

NYC DEP and Greene County Soil and Water Conservation District are working with Hudsonia to review current knowledge on Japanese knotweed and conduct basic research into its growth habits as part of an effort to develop management recommendations for its future control.

Assessment of the Current Condition of Riparian Vegetation

As part of the stream management planning process, physiognomic classes (e.g., open-canopy forest, shrub-brush, herbaceous) were mapped and the riparian vegetation assessed for the Stony Clove watershed. The purpose of this exercise was to provide the planning team with baseline information about communities present in the watershed, a description of the condition of vegetation in the riparian area, and recommendations related to the management of riparian vegetation along the stream. The development of the Stony Clove Streamside Planting Program, explained at the end of this section, demonstrates the use of this information to implement riparian vegetation management activities.

Mapping of physiognomic classes

Mapping of physiognomic classes was loosely based on the Vegetation Classification Standard produced by The Federal Geographic Data Committee. The mapping was confined to the riparian and near adjoining upland areas within 300 ft. of the mainstem of Stony Clove Creek. This classification was selected because it allows identification of those locations, such as herbaceous or cobble deposits, where the combination of channel morphology and riparian vegetation would indicate the greatest cost-benefit from riparian buffer plantings and bio-engineered bank stabilizations.

The mapping exercise included the approximate delineation of the classes through the photointerpretation of infra-red digital orthophotography acquired by New York State in the mid-1990's. A physiognomic class GIS data layer was created using heads-up digitizing techniques with ESRI's Arcview and Image Analyst softwares. The photo interpretation was field checked with class boundaries and classification amended based upon field observations. The vegetation maps resulting from this process accompany each management unit.

Summary of Findings

According to this ripairan vegetation assessment, closed deciduous (200+ acres) and herbaceous (120+ acres) are the largest physiognomic classes followed by closed coniferous (90 acres). This predominance of closed forest cover helps to provide a high degree of stability to the watershed. Forest cover slows storm runoff and the stream banks in much of the watershed have some woody vegetation to protect against bank erosion. Protection of the forest communities near the stream will help ensure long-term stream stability, but the effectiveness of stream protection provided by vegetative communities, differs based on their width, plant density, vegetation type and the stream's geomorphic characteristics.

Figure 8 Riparian vegetation (closed deciduous), protects stream banks and water quality, and provides habitat and food sources for fish and wildlife.

Although forested land covers a large portion of the watershed's riparian area, the extent of herbaceous cover is a concern. While herbaceous cover is better than no cover at all, plants with a variety of rooting depths (herbs, shrubs and trees) provide more extensive stream bank protection. Approximately 136 acres, or 18% of land cover is considered to have inadequate vegetative cover; this includes areas of herbaceous vegetation, cobble and cobble/herbaceous areas and exposed banks. Stony Clove's Streamside Planting Program, described in the next portion of this section, was initiated in 2003 to address these areas of inadequate vegetation.

Table 1 provides the results of the GIS vegetation assessment of the Stony Clove Creek including, the area and percentage of each land cover type. Classes listed in italics contribute to the total area of inadequate vegetation.

Table 1: Summary of Physiognomic Vegetation Classification		
Land Cover Type	**Area (acres)**	**Percent**
Closed Deciduous	204.16	27.08
Herbaceous	*128.60*	*17.06*
Closed Coniferous	91.26	12.10
Open Deciduous	80.08	10.61
Open Coniferous	79.95	10.60
Impervious	52.86	7.01
Deciduous Shrubbrush	35.92	4.76
Closed Mixed	31.89	4.23
Open Mixed	21.91	2.91
Gravel/dirt road	17.18	2.28
Cobble	4.46	0.59
Cobble/herbaceous	*2.89*	*0.38*
Water	1.78	0.24
Rip-Rap	0.76	0.10
Exposed Bank	*0.31*	*0.04*
Total Area	753.96	
Inadequate Vegetation	136.26	18.07

Stony Clove Streamside Planting Program

GCSWCD and NYCDEP used the above findings from the mapping of physiognomic classes in order to identify candidate stream reaches for inclusion in a streamside planting program. Project partners identified three main steps to establish this program.

1. *Identify priority sites* using information gathered during morphological and riparian vegetation characterization analyses to identify potential planting sites where improvement of the riparian vegetation is likely to be both effective and successful.

2. *Develop treatment designs* for participating prioritized sites using primarily native plants that address landowner aesthetics, ecological enhancement and water quality improvement or protection.

3. *Install the designs* and document the planting process and results for program replication and general education/outreach.

Besides addressing vegetation issues in the Stony Clove watershed, this planting program will provide valuable information and procedures for the enhancement of riparian areas in other Catskill Mountain watersheds.

Identifying Priority Planting Sites

On the Stony Clove, the NYC DEP and GCSWCD have utilized a set of geomorphic criteria for locating priority sites for streamside plantings. The planting efforts target two distinct areas of a stream reach: areas within the bankfull channel, and those areas beyond the bankfull channel within a 100 ft. riparian corridor. The following section describes the goals of each effort and methods used to identify sites where planting would have the greatest impact.

Planting efforts for In-channel Areas

In-channel plantings are a high priority in the Stony Clove Creek sub-basin because:

1. the dominant threat to water quality appears to be elevated suspended sediment loading from in-channel sources;

2. the dominant threat to aquatic habitat appears to be thermal impacts of anthropogenic alteration of both channel width, and of vegetative cover on the banks and in riparian zones;

3. the dominant threat to infrastructure appears to be catastrophic channel adjustments.

In general, plantings within the bankfull channel are intended to:

1. reduce over time the width/depth ratio (W_{bf}/D_{bf}) of the bankfull channel in an effort to increase sediment transport effectiveness at bankfull flow (Q), and/or

2. increase bank cohesiveness, and/or

3. improve aquatic habitat value by providing thermal shading and physical complexity.

Locations for these types of plantings are typically *aggradational* settings, where the goal of plantings is to narrow and deepen the channel, and to convert what are currently overwide bars into a vegetated low bench and, eventually, a floodplain. In Rosgen's schema, the goal is to accelerate the evolution of "C" channels within "F" channels where appropriate, or to prevent "C" channels from evolving into "D" channels (Fig. 9).

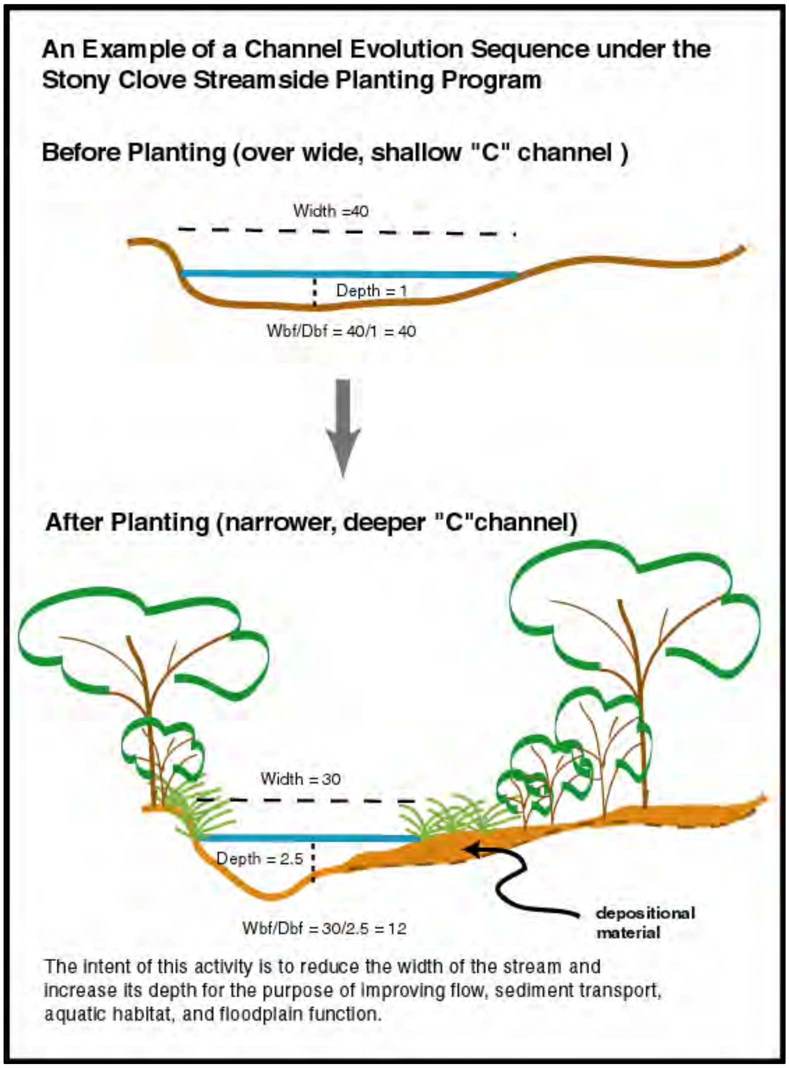


Figure 9 Vegetation assisted channel restoration

Identification of candidate sites began by excluding inappropriate sites. These include reaches that are likely to be *degradational*, as well as *entrenched* settings where narrowing and deepening the channel would still not result in the channel meeting the criterion for "Low Entrenchment" in Rosgen's classification process (i.e., "F" channels that have not evolved sufficient *belt width* within the entrenched channel to allow the development of a stable "C").

Sites considered for planting within the bankfull boundary meet all of the following conditions:

1. Stream reaches where *width/depth ratio* is amongst the highest on the stream. Watershed context has also been considered; e.g., priority is also given to management units with clusters of cross sections with high width/depth ratios, while reaches with very high width/depth ratio sections followed by reaches with very low width/depth ratio sections will require additional scrutiny of longitudinal

stability and the potential for *headcuts* to develop. Appropriate width/depth ratios will be determined from statistical data for the entire watershed.

2. The slope of any candidate reach must be less than 2 percent (the drop in elevation of the creek must be less than 2 ft. for every 100 ft. of channel length). This targets flatter sections of the stream.

3. The cross-sectional form of the stream and floodplain permits the development of a "Low Entrenchment" reach. The desired reach would have an entrenchment ratio or the floodplain width (W_{fp}) compared to bankfull channel width (W_{bf}) of greater than 2.2. Selection of entrenched stream reaches is not desirable because they have not developed sufficient beltwidth to create a new floodplain. From a Rosgen classification perspective, the objective is to allow development of "C" channels inside "F" channels. Selecting entrenched channels is unlikely to succeed since the shear stresses associated with bankfull flows is likely to raze plantings. Only where the bankfull flows can access the floodplain can the plantings succeed.

As in the case of upland plantings, bank failures at documented bank erosion monitoring sites are not candidates for vegetative restoration. These sites are experiencing severe erosion and will need channel and/or bank reconstruction before vegetation can be successfully established. Sites found to have occurrences of Japanese knotweed would receive priority consideration, all other considerations equal.

The process has resulted in the creation of a series of maps for each management unit including reaches that meet entrenchment ratio, slope and width/ratio and bank failure sites conditions. Project staff compiled a list of priority in-channel areas targeted for vegetative restoration using this series of maps and their best professional judgment. Finally a list of landowners' contact information was created for priority sites.

Planting beyond the bankfull channel

The objective of managing vegetation in the riparian corridor outside the bankfull channel boundary is three-fold.

1. increase rooting depth and density of vegetation in an effort to increase bank cohesion and control rates of lateral channel migration and channel enlargement.

2. limit the input of pollutants from upland sources into the streamflow from overland or interflow, and to trap and store pollutants from overbank flows.

3. promote the expansion of riparian areas supporting a more climax riparian vegetation community. In most instances, the native climax riparian vegetation in the Stony Clove is a forested community.

Priority sites for riparian plantings outside the bankfull boundary include all areas within a 100 ft. buffer of the stream currently characterized by herbaceous vegetation or non-vegetated, where the near bank has not been identified as a bank erosion monitoring site. This may also include joint plantings in rip-rap revetments. “Herbaceous” and “cobble” categories were chosen as the top priority land cover categories because they have the least streambank stabilization benefit, and because the goal is to promote buffers with the characteristics of the native climax terrestrial vegetation community found in reference riparian sites, which in most riparian locations will not be herbaceous (one exception may be E-channel dominated wetlands).

The process for identifying the planting sites included using the GIS riparian vegetation classification coverage - created through analysis of recent aerial photographs - to identify those areas other than forest or shrub/scrub cover within the 100 ft. buffer, outside the bankfull boundaries of the stream. The results of this analysis were compared with the GIS coverage of bank failures. All areas near bank failures were deselected as these sites are experiencing severe erosion and will need channel geometry adjustments before vegetation can be successfully established.

Figure 10 Joint plantings at this site would increase stream bank stabilization and improve fish habitat

The results of this de-selection were compared with coverage of reveted areas, to be targeted for joint planting. Joint planting involves placing of live stakes in the soil between the opening of previously installed rock rip-rap. It is intended to increase the effectiveness of the rock system by forming a living root mat underneath the rock and to improve the habitat and aesthetic value of the rip-rap.

Prioritization Results

This process has resulted in the creation of a series of maps based on management units depicting the most recent aerial photographs, herbaceous and cobble vegetation coverage, revetment areas, and bank failures. From these maps, the project staff identified 58 sites with inadequate vegetation for consideration for inclusion in the planting program. Each site was assessed and photographed and their condition was described. Based on the assessment, each site was assigned a priority level for potential vegetation planting. There were 19 high, 12 medium, 17 low and 10 very low priority sites. The site descriptions are provided as part of this plan in their respective management unit. A list of landowners’ contact information for priority riparian areas was compiled and landowners have been informed about the pilot planting program and invited to participate.

Developing Treatment Designs

The options for planting include, active stream channel plantings of grasses and sedges, streambank plantings of willow species, or floodplain plantings of native trees, such as green ash, poplar or other floodplain species. The type of planting depends on site characteristics, available funds and landowner participation in the program. Bioengineering activities may also be included in some designs.

Figure 11 Sedges are grass-like plants that grow at the edge of the water along stream banks. Their roots are very strong and their form helps reduce stream velocity at high flows.

The Watershed Agricultural Council and U.S. Forest Service have provided grant funds for this project, which includes preparation of modular designs that will be available for future use to design additional projects elsewhere in the Stony Clove as well as other watersheds.

Installing Designs

This step requires the cooperation of not only GCSWCD and NYCDEP, but also private landowners who interact daily with their streamside property. While success of streamside planting depends on natural conditions like stream dynamics and plant preferences, it also depends on informed, caring, and interested property owners who promote the growth of new vegetation and protect the functions of established vegetation.

As this is a pilot program, the participating landowners will be asked to provide access to the site for the purpose of monitoring the project and exhibiting planting practices to others. These efforts will be fully described and the project sites will be closely monitored to document changes that occur after project installation. If you are interested in conducting a similar program and would like specific documents, please contact GCSWCD at (518) 622-3620 or call NYCDEP at (845) 340-7519.

Riparian ecosystems are a vital component of watershed protection and resource conservation. Therefore, it is important to maintain and improve the riparian vegetation along the Stony Clove Creek and its' associated tributaries.