2. Hydrology and Flood History

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Chestnut Creek. Photo taken by Lori Kerrigan, SCSWCD.

2. Hydrology and Flood History

a. Introduction

Hydrology, the study of water cycles in the landscape, includes a characterization of how the watershed and stream network cycle rain and snow over time as runoff and streamflow. By studying these characteristics we can gain some insight into how the watershed reacts to flood events, and learn more about human interaction with the dynamic Chestnut Creek system.

b. Chestnut Creek Statistics

According to the United States Geological Survey (USGS), the Chestnut Creek drainage encompasses 20.9 square miles of watershed area and empties into the Roundout Reservoir (USGS.gov). Streams in Chestnut Creek basin are primarily perennial streams, that is, they flow year-round except in extreme drought conditions. The drainage pattern in the watershed is dendritic (branching tree-like form), typical of Catskill Mountain watersheds otherwise uncontrolled by geologic factors.

c. Streamflow

There are two general categories of streamflow of interest to stream managers: storm flow (flood flow) and base flow. For additional information, see Volume I, Section III.C. Introduction to Stream Processes and Ecology. Storm flow appears in the channel in direct response to precipitation (rain or snow) and/or snowmelt, whereas base flow sustains streamflow between storms or during subfreezing periods. A large portion of storm flow is made up of overland flow; the runoff that occurs over and slightly below the soil surface during a rain or snowmelt event. This surface runoff appears in the stream relatively quickly and recedes soon after the precipitation event. The role of overland flow in the Chestnut watershed is variable, depending upon the time of year and severity of the storm or snowmelt. In general, higher streamflows are more common during spring due to rain and snowmelt events, and during hurricane season in the fall. During the summer months, vegetation has the highest demand for water, which delays and reduces the amount of runoff reaching streams during a rain storm. During the winter months, water is held in the landscape as snow and ice, so precipitation events do not generally result in significant runoff to streams. However, a sudden thaw or "rain on snow" event produces runoff that is not taken up by vegetation, and that can't sink into the ground (if frozen), so these events can produce significant flooding.

USGS maintains a continuous recording stream gage on the Chestnut Creek in Grahamsville, which provides invaluable stream flow information. The stream gage (USGS ID. # 01365500) is located in Grahamsville, just downstream from the confluence of Red Brook with Chestnut Creek, and drains 20.9 square miles of watershed area. This gage measures stage, or height, of the water surface at a specific location, updating the measurement every 15 minutes. These values can be converted to a flow magnitude (the USGS develops this relationship, called a "rating curve", for each of its stream gages), or the volume of water flowing by that point, usually measured in cubic feet per second (cfs). This way, the flow in the Chestnut Creek at this location can be determined at any time just by knowing the current stage. Additionally, we can make use of the historic record of constantly changing stage values to construct a picture of the response of the stream to rain storms, snow melt or extended periods of drought, to analyze seasonal patterns or flood characteristics.

As an example of what we can learn from gage data, compare two graphs for Chestnut Creek gage over the period from July 31, 2003 through August 7, 2003 (Figures 1 & 2). These graphs are called "hydrographs", and usually show a change in stream stage or flow over time. Figure 1 illustrates changes in stage during one week in the summer of 2003, showing the response of the stream stage for each of the rain storm events. Changes in stream flow, or discharge, clearly reflect stream response to storm events during the same time period in Figure 2. Each spike on the graph represents an increase in stream flow in response to rain storms – stream level rises (called the "rising limb" of the hydrograph) and falls as the flood recedes (called the "falling or receding limb" of the hydrograph).

We can see there was probably a rain storm around late August 3 that resulted in the stream rising about half a foot, and increasing in discharge by more than 60 cfs, from less than 20 cfs to about 80 cfs. We can also see that the stream recovered somewhat from this storm during the next day, but was hit by another storm before it could drop all the way back to its previous level. The stream always rises and peaks following the precipitation event, because it takes time for precipitation to hit the ground and run off to the stream. Knowing the timing of a rain storm, we could also calculate the response time of Chestnut Creek at the gage location, and determine how the stream responds to the rain storm both in timing as well as in magnitude of the resulting flood.

We can also analyze a longer time period to see seasonal trends or long-term averages for the entire length (period) of the gage record. The daily average flow annual hydrograph for August 2002 through August 2003 shows higher flows than average during this period of time, comparing median values from 50 years of record (purple line) with daily flows of this particular year period (blue line) (Figure 3). Stream flow was affected by ice from January through March 2003, so there is a corresponding gap in data during the period in which stage could not be measured. We can see the long term record shows higher flows in fall (hurricane season) compared to winter (water held in ice and snow), and higher flows in spring (snow and ice melt) compared to summer (drought conditions with vegetation using a lot of water). Though this year was wetter than average, we can see a similar overall seasonal pattern comparable to the long-term record.

d. Chestnut Creek Flood History

Annual peak streamflow is the highest instantaneous stream flow recorded for a particular 12-month period (usually from October 1 through September 30, or the "hydrologic Water Year"). Most peak flows for the Chestnut Creek gage from 1939 through 2001 occurred during the months of December, March, and April, though peak flow can occur at any time during the year (Figure 4). The range of

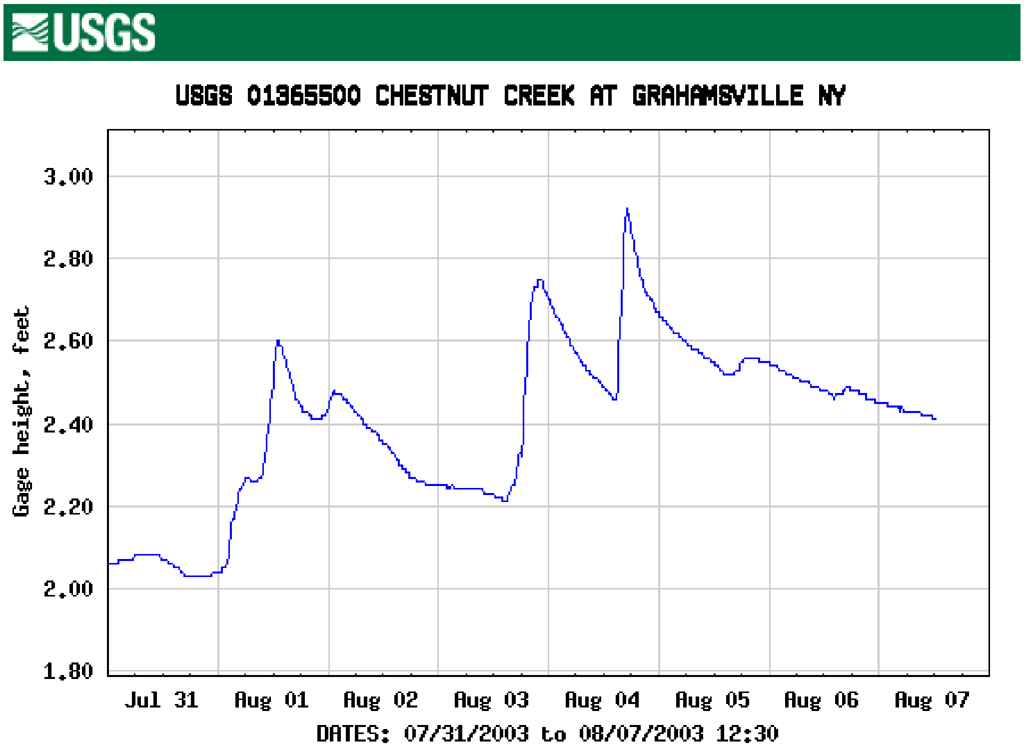

Figure 1. Stream gage height hydrograph for USGS 01365500, Chestnut Creek at Grahamsville, from July 31, 2003 to August 7, 2003. Source: USGS.gov

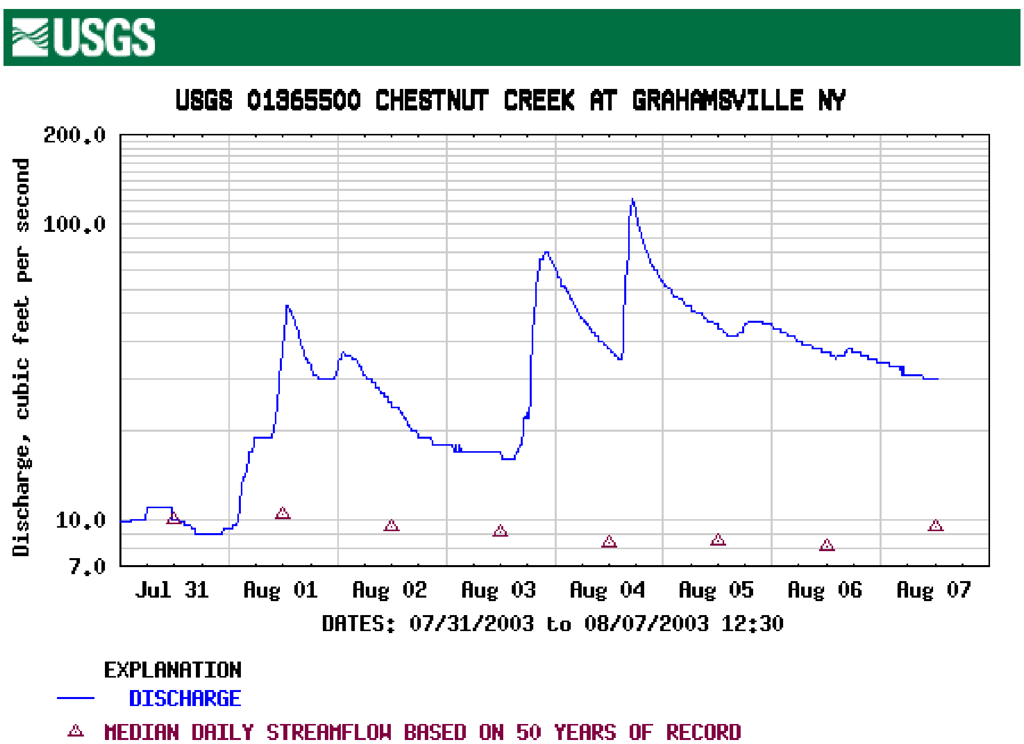

Figure 2. Stream discharge (cfs) hydrograph for USGS 01365500, Chestnut Creek at Grahamsville, from July 31, 2003 to August 7, 2003. Source: USGS.gov

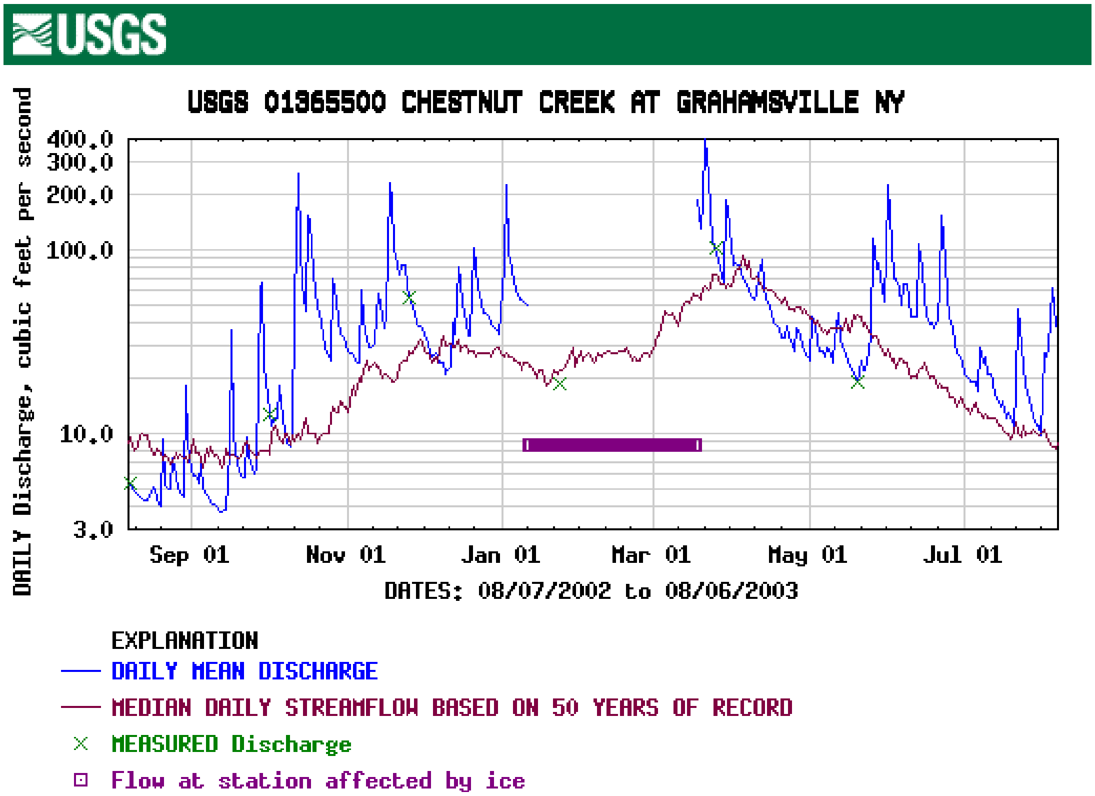

Figure 3. Daily discharge of Chestnut Creek from August 1, 2002 to August 1, 2003. Source: USGS.gov

annual peak flows shows the dramatic range of floods that have been recorded on Chestnut Creek in the last 60 years, and can assist stream managers in estimating the range of future flood behavior.

Stream flows that exceed stream channel capacity or a certain stage are called floods. Flooding can occur in response to runoff associated with spring snowmelt, summer thunderstorms, fall hurricanes, and winter rain-on-snow events, and can range from minor events to raging torrents that wipe out bridges and carve new channels. USGS has a standard method for creating a flood frequency distribution from flood peak data for a gage.

Flood frequency distribution shows flood magnitudes for various degrees of probability (likelihood). This value is most often converted to a number of years, the "recurrence interval" or "return period", for example, the flood with 20% chance of occurring or being exceeded in any single year corresponds to what is commonly referred to as a "5 year flood" (just divide 1 by the % probability to get the recurrence interval in years). This simply means that on average, for the period of record, this magnitude of flood will occur about once every 5 years. This probability is purely statistical; the probability remains the same year to year over time for a particular size flood, but many years may go by without one, or it may occur several times in one year.

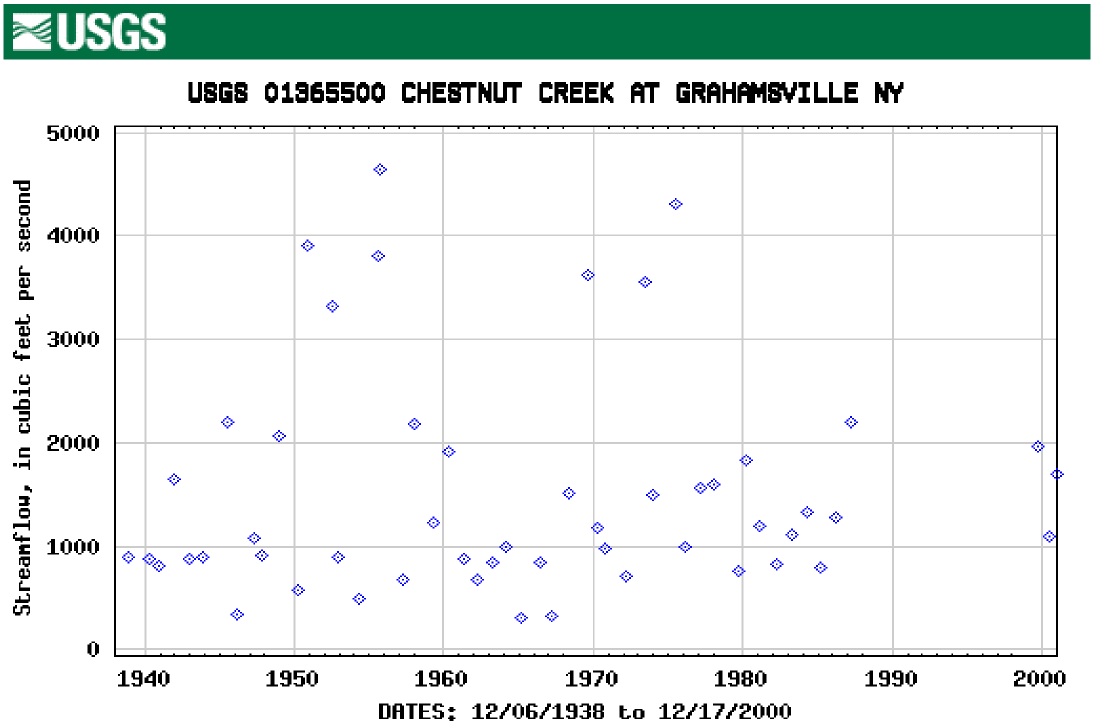

Figure 4. Annual maximum stream flow at USGS 01365500, Chestnut Creek at Grahamsville, for the period of record, 1939 - 2001. Source: www.usgs.gov

e. Conclusion

By studying the information recorded by the USGS gaging station on Chestnut Creek we can gain some insight into how the stream reacts to flood and drought events. Many agencies rely on evaluation of the likelihood of stream flooding in order to effectively manage the resource, plan developments or anticipate infrastructure or property damages and reconstruction needs.

3. Riparian Vegetation Issues in Stream Management

a. Natural Disturbance and its Effects on Riparian Vegetation
b. Human Disturbance and its Effects on Riparian Vegetation
   i. Roadway and Utility line influences on riparian vegetation
   ii. Residential development influence
c. Invasive Plants and Riparian Vegetation
d. Forest History and Composition in Chestnut Creek

Photo taken by Lori Kerrigan, SCSWCD.

3. Riparian Vegetation Issues in Stream Management

Streamside vegetation provides numerous benefits to water quality, to local landowners, and to aquatic and terrestrial plants and animals. Riparian buffers facilitate stream stability and function by providing rooted structure to protect against bank erosion and flood damage. Vegetated riparian zones act as a buffer against pollution and the adverse impacts of human activities. Streamside forests also reduce nutrient and sediment runoff, provide food and shelter, and moderate fluctuations in stream temperature. Finally, they improve the aesthetic quality of the stream community.

The extent of benefits depends on width of the riparian zone and its species diversity (Photo 1). For example, the only benefit addressed by a 25 foot buffer may be bank stabilization while a buffer over 200 feet includes a whole range of water quality and ecological benefits. In addition, a buffer that contains a variety of species and types (trees, grasses, shrubs, herbs) offers the best protection. An area with diverse species would be more likely to continue to function properly than a simpler community if one species was eliminated (more discussion will follow with the issue of wooly adelgid and Eastern hemlock). Whereas, if only one or a few species covers a streambank and disease or pests attack it, the buffer would quickly disappear. In addition, different types of plants offer a variety of root depth and strength to stabilize stream banks in shallow to deep soils.

Photo 1. A healthy riparian community is densely vegetated, has a diverse age structure and is composed of plants that can resist disturbance. View upstream from XS-56.

Native plants in the riparian zone share a common characteristic; they have the ability to resist or recover from disturbance, namely from repeated inundation by floodwaters. The riparian forest community generally is more extensive where a floodplain exists and valley walls are more gently sloping. Where valley side slopes are steeper, the riparian community may occupy only a narrow corridor along the stream and then transition to an upland forest community. 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, north facing slopes along the watercourse.

The following section introduces the basic threats to this important ecological area. This section also presents more detailed information about the past and present condition of Chestnut Creek's riparian vegetation.

a. Natural Disturbance and its Effects on Riparian Vegetation

Natural disturbances can greatly affect the vigor of streamside vegetation. These natural disturbances include floods, ice or debris 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 vegetation due to their specific browse preferences.

The effect of flood disturbance on vegetation along stable stream reaches is short term and the recovery/disturbance regime can be cyclical. Following a large flood, the channel and floodplains can be scattered with woody debris and downed live trees (Photo 2). In following years, much of the vegetation recovers. Trees and shrubs flattened by the force of floodwaters re-establish their form. Gravel bars and sites disturbed in previous flood events become 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 re-establishment. If floods and ice floes are too frequent, large trees do not have the opportunity to establish.

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

Sometimes, stream managers may seek to speed or augment the recovery process, but

Photo 2. View showing channel wide debris jam.

local geology and stream geomorphology may complicate this process. Hydraulics of flowing water, morphological evolution of the stream channel, geology of the stream bank, and the requirements and capabilities of vegetation must be considered before attempting restoration. Since 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.

Pests and diseases that attack vegetation also impact the riparian area. In the eastern United States, the wooly adelgid (*Adelges tsugae*) attacks eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*Tsuga carolinianna* Engelman) and can affect entire stands of hemlock, an important riparian species (Photo 3). The stress caused by the adelgid's feeding can kill a tree in as little as 4 years (McClure, 2001). Once a tree is infested, insect density fluctuates with hemlock regrowth. This regrowth is stunted and is later attacked as the adelgid population increases. With each successive attack the reserves of the

Photo 3. Hemlock wooly adelgid appear as fuzzy white spots on underside of the branch.

tree become depleted and eventually regrowth does not occur.

With respect to stream management, loss of hemlocks along the banks of Chestnut Creek poses a threat to bank stability and in-stream habitat. Wildlife find excellent cover from harsh weather within dense hemlock stands. Finally, dark green hemlock groves are quiet, peaceful places that are greatly valued by people who live in the valley. Without a major intervention (as yet unplanned), it is likely that the process of gradual infestation and the demise of local hemlock stands will result in re-colonization by black birch, red maple and oak (Orwig, 2001). This transition from a dark, cool, sheltered coniferous stand to open deciduous hardwood cover is likely to raise soil temperatures and reduce soil moisture for sites where hemlocks currently dominate the vegetative cover. Likewise, in streams, water temperatures are likely to increase and the presence of thermal refugia for cold water fish species such as trout are likely to diminish.

Many obstacles inhibit natural resource managers from controlling or even containing the wooly adelgid. Due to the widespread nature of the infestation it is unlikely that use of chemical pest control options such as dormant oil would provide little more than temporary localized control. Use of pesticides to control adelgid is not recommended in the riparian area due to the impact on water quality and aquatic life. 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: http://www.fs.fed.us/na/morgantown/. Other alternatives for maintaining coniferous cover on hemlock sites include planting adelgid resistant conifers such as white pine as the hemlock dies out in the stand (Ward, 2001).

b. Human Disturbance and its Effects on Riparian Vegetation

The distinction between natural and human disturbances is important to understand. While the effects of floods, ice floes, pests and disease can cause some widespread damage to riparian vegetation; most often the effects are temporary. In time, vegetation regenerates and repopulates streambanks. On the contrary, human activities frequently significantly transform the environment and, as a result, can have a longer lasting impact on the capability of vegetation to survive and function (Photo 4). Human disturbances include construction and maintenance of roadway infrastructure, development of

Photo 4. View of eroded left bank on DEP property. Material undercut and slumping.

homes and parking lots, and introduction of non-native species in the riparian zone.

i. Roadway and Utility line influences on riparian vegetation

Use and maintenance of impervious surfaces, such as roads, impact the vigor of riparian vegetation. Narrow buffers that run between roads and streams receive runoff containing salt, gravel, and chemicals from the road that stunt vegetation growth or increase stress and mortality. Road maintenance activities also regularly disturb the soil along the shoulder and on road cut banks, welcoming undesirable invasive plants. The linear gap in the canopy created by roadway and utility lines separates riparian vegetation from upland plant communities. This opening also allows light into the vegetative under story which may preclude the establishment of shade loving plants such as black cherry and hemlock.

ii. Residential development influence

Residential land use and development of new homes may have the greatest 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 also love the stream and want to be close to it, may clear all the trees and shrubs along the stream to provide access and views of the stream, replacing natural conditions with an unnatural mowed lawn that provides no benefits to stream health or local wildlife. Following this clearing, the stream bank may begin to erode and the stream may become over-widened and shallow. This wide, shallow condition results in greater bedload deposition and increases stress on the unprotected bank. Eventually, stream alignment may change and begin to cause stream migration impinging on the property of downstream landowners. Catskill stream banks require a mix of vegetation having a range of rooting depths such as grasses and herbs which have a shallower rooting depth, shrubs with a medium root depth, and trees with deep, thick roots. Grasses alone are insufficient to maintain bank stability in most cases.

Many people live close to the stream and have access to the water without destabilizing the bank. By carefully selecting a route from the house to the water's edge and locating access at a point where the force of water on the bank in high flow is lower, a landowner can minimize disturbance to riparian vegetation and the stream bank. 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.htm.
Riparian gardeners must know the appropriate species for streamside areas to identify species that are tolerant of frequent inundation and the force of high flows.

c. Invasive Plants and Riparian Vegetation

Sometimes attempts to beautify a home with new and different plants will introduce 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). A few invasives, Japanese knotweed (*Fallopia japonica*) and multiflora rose (*Rosa multiflora*) are currently gaining a foothold along Chestnut Creek. Though many invasives are also exotic (non-native), certain native plants may take over if introduced inappropriately.

As its common name implies, Japanese knotweed's origins are in Asia, and it was brought to this county as an ornamental garden plant (Photo 5). This plant grows and spreads rapidly on disturbed sites and prefers moist, open conditions common to developed or cleared stream edges and banks. After establishing itself on a site, Japanese knotweed shades out existing

Photo 5. Broad heartshaped leaf pattern of Knotweed (Janet Novak, 2001).

vegetation and forms large, dense stands. Stream managers suspect that knotweed roots do not provide the same high level of bank stabilization as do native tree, shrub and grass roots, especially if knotweed is the only species present. In addition, ecologists fear that this plant may also displace local wildlife dependent on native vegetation for shelter, food or cover. The canopy of dense stands of bamboo-like stalks, covered by large heart shaped leaves, blocks out almost all light from reaching the soil, thereby shading out other plants and leaving the soil between plants bare that would otherwise contain grasses or herb species in a natural vegetative community.

Most researchers believe that Japanese knotweed spreads primarily by vegetative means. Often, earthmoving contractors, highway department crews or gardeners transfer small portions of roots in fill or soil that get dumped on a stream bank or other construction project. These roots initiate growth of a new colony. Another means of spread occurs when high flows scouring the bank move roots downstream where they can establish new colonies on disturbed sites or sediment deposits.

NYC DEP and Greene County Soil and Water Conservation District (GCSWCD) are currently supporting Hudsonia to review the state of the science on Japanese knotweed and to conduct basic research to understand its growth habits, with the intent to develop management recommendations for its future control.

Another invasive, Multiflora rose (a thorny perennial shrub with compound leaves) was introduced to the area in the 1930's (Photo 6). This plant was promoted as a 'living fence' to farmers, because its arching stems can take root at the tip, forming dense thickets. The plant's persistent seeds provide an edible resource, and thick stems provide shelter to pheasant, quail, and songbirds. In recent years the rose has been planted along highways to serve as a crash barrier.

Although the white, spring-blooming Multiflora rose has some uses and attraction, landowners are quickly learning about its negative characteristics. Since it adapts to a wide range of soil, moisture, and light conditions, Multiflora rose spreads quickly and forms impenetrable thickets that thwart native species growth and attempts to control it. Multiflora rose is most commonly spread by seed through birds and other wildlife, thriving in fields, forest edges, stream banks, and roadsides. Disturbed areas are particularly vulnerable to invasion by multiflora rose, which impedes natural succession by preventing native species establishment.

Photo 6. Multiflora rose compound leaf (Samuel Roberts Noble Foundation, Inc. 2003).

Japanese knotweed and Multiflora rose are very difficult to control. Herbicides, while partially effective, are not a viable option in many locations due to the threat these 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 regrowth. The first step for residents and those who manage land and infrastructure is to familiarize themselves with the appearance and habits of invasive species such as these. Next, it is important for landowners and land managers to monitor its spread. Landowners should avoid practices that would destabilize stream banks or weaken natural riparian vegetation that can prevent invasives from spreading. Any fill material introduced to the riparian area should be tested for the presence of these species or obtained from a reliable source. Any Japanese knotweed or Multiflora rose 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 such as burning or deep burial.

The following sections describe how various natural and human disturbances have influenced the state of riparian vegetation that we see today along the Chestnut Creek. Recognizing some historic influences is helpful in order to more fully understand present conditions.

d. Forest History and Composition in Chestnut Creek

Catskill mountain forests have evolved since the last ice age, reflecting changes in climate, competition and human land use. Upon icemelt, plants adapted to warmer temperatures began to migrate north, replacing those species with a cold weather preference. The forests of Chestnut Creek gradually re-established and evolved from boreal spruce/fir dominated forests, (examples of which can presently be found in Canada) to maple-beech-birch northern hardwood forests (typical of the Adirondacks and northern New England) with the final transition of lower elevations of the watershed to a southern hardwood forest dominated by oaks, hickory and ash (typical of the northern Appalachians).

One of the earliest recorded natural disturbances was the March 20th blowdown in 1797. Regional high winds felled trees from Delaware county, to the Towns of Rockland and Neversink (Kudish, 2000). There have been several serious floods in the Chestnut Creek area in the past. One of the most massive occurred in 1928 and is still remembered by residents of the Town of Neversink (Volume I, Section IV.A. Community History and Current Condtions). While not as ferocious as the Great Flood of 1928, the flood of 1975 damaged roads, homes and seriously eroded many stream banks.

More recently, human activities have affected forests either through manipulation of regeneration for maintenance of desirable species, exploitation of the forest for wood and wood products or through clearing for development. Native American land management practices included the use of prescribed burning as a means of enabling nut bearing oaks and hickories to remain dominant in the forest. In response to the rising industrial economy, European settlers 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. These activities may have allowed the migration of some southern hardwood species (e.g. sycamore, shagbark hickory, gray dogwood) travelling up the Hudson Valley. Land cover in Chestnut Creek began to revert back to forest with the local collapse of these economies in the 20th century (Kudish, 2000) (Volume I, Section IV.A. Community History and Current Conditons).

Although a specific assessment of the condition of vegetation along Chestnut Creek was not conducted, stream managers made important observations during the stream assessment survey of the mainstem of Chestnut Creek and Red Brook and Pepacton Hollow tributaries. A series of historic aerial photographs from 1963-2001 supplement field observations. See Volume II, Section I. Chestnut Creek Stream Management Unit Descriptions for specific trend observations.

The Chestnut Creek riparian area can be characterized as a mix of small wooded buffers with mature trees, shrubs, and herbaceous plants, mowed lawns with scattered trees and shrubs, and reaches along steep hillslopes and terraces with mature forest (Photo 7). In riparian areas

Photo 7. View looking downstream from below XS-124. Mowed lawn is shown on the left, densely vegetated riparian buffer is shown on the right.

where wooded buffers are present, the width varies from 25 feet to 350 feet. On average, these areas are less than 100 feet wide. Japanese knotweed and Multiflora rose occupy a small portion of the Creek's streambanks, though they have potential for continued spread. Wooly adelgid is infesting hemlocks in the upper reaches of Chestnut Creek.

Where riparian functions are not limited by human activities, vegetation along Chestnut Creek generally appears to support conditions for a stable stream. This does not mean that there is no room for improvement. Many reaches have adjacent parking lots, equipment storage areas, and roads with little or no space for buffers. Along developed properties riparian vegetation has been affected by clearing, routine yard maintenance, and other land use activities. Although floodplain vegetation was deemed as adequate for providing general stability watershed wide, areas with a relatively low rooting depth to bank height provide minimal vegetative stability.

Various beneficial or potentially harmful riparian characteristics within each individual management unit were documented during the 2001 Stream Assessment Survey (Tables 1 & 2). For a more detailed description of riparian condition in a particular unit, please refer to its specific section (Volume II, Section I. Chestnut Creek Management Unit Descriptions and Volume II, Section II. A. Watershed Recommendations for Best Management Practices).

Table 1. Summary of beneficial riparian characteristics by Management Unit. (2001 Stream Assessment Survey, SCSWCD personnel)

MU#	Floodplain Forests	Small Wooded Buffers	Steep Hillslopes with Mature Forests
MU1		x	x
MU2			
MU3			x
MU4			x
MU5		x	x
MU6		x	
MU7	x		
MU8			
MU9			

Table 2. Summary of potentially harmful riparian characteristics by Management Unit. (2001 Stream Assessment Survey, SCSWCD personnel)

MU#	Mowed Lawns, Scattered Trees	Adjacent Roads & Parking Lots	Wooly Adelgid	Japanese Knotweed	Multiflora Rose
MU1	x		x		
MU2	x				x
MU3					
MU4	x	x		x	
MU5	x	x		x	
MU6	x	x			x
MU7	x				
MU8					
MU9					

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