ASHOKAN WATERSHED STREAM MANAGEMENT PROGRAM

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Project Report:

Persistence of Large Woody Debris in Woodland Creek, Town of Shandaken, Ulster County, New York

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Executive Summary

This reports documents the data, findings and conclusion of a successful Student Conservation Association (SCA) internship based out of the Ashokan Watershed Stream Management office in Phoenicia, New York.

Large woody debris (LWD) is an integral component of stream and river systems and plays an important role in maintaining the ecological health of streams and long-term stability of stream systems. Large woody debris can change the shape of the stream channel, increase erosion or sediment deposition, or change the speed and direction of the flow of water. I identified three major factors contributing to the persistence of LWD accumulation. These included: 1) the size of the tree, bigger trees were the less likely to move; 2) the size of the river, increased discharge had a greater influence on moving and entraining LWD; and 3) the presence or absence of a rootwad. The rootwad contributed to the overall size of the tree, but also contributed to logs "locking" together and forming an accumulation. Woodland Creek was selected because its assessment in 2008 was the first the Ashokan Reservoir watershed to include the locations of LWD sites. First the 91 sites recorded in 2008 were identified and found that 67 persisted. At each of the 67 sites, the length and diameter of trees were measured. By collecting this data over several years, we could potentially find which factors are more likely to lead to the persistence of LWD and in what situations LWD becomes problematic.

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Background

Large woody debris (LWD) plays an essential role for the ecological health of streams and plays an important role for maintaining the long-term stability of stream banks and stream channels. Large woody debris can change the shape of the stream channel, increase erosion or sediment deposition, and change the speed and direction of the flow of water. The influence of these changes can dramatically affect the size and type of pools, bars, and amount of sediment transported throughout the stream. Large woody debris can help to stabilize or destabilize stream banks, make waterfalls, and create and protect fish habitat (Montgomery et al., 2003; Grunell et al., 2002).

Stream managers in the Ashokan Reservoir watershed located in the New York conduct periodic assessments of the streams and tributaries within the watershed, with an emphasis on identifying issues contributing to erosion or stream instability and those that are likely to be a contributor to stream geomorphology. The staff documents the presence of all LWD in the stream corridor during a rapid stream inventory assessment, and evaluates the potential geomorphic effect on the stream channel.

In wadeable streams and smaller rivers, LWD can effectively obstruct flows and alter channel hydraulics by enhancing the presence and depth of scour pools (Abbe and Montgomery, 1996). Stream studies in mountain streams indicate pools are often formed by or strongly influenced by the presence of LWD (Montgomery et al., 2003; Grunell et al., 2002; Francis et al., 2008; Abbe and Montgomery, 1996). The consequence from deposition of whole trees within the stream channel is that they tend to develop a scour pool upstream of the rootwad (Francis et al., 2008). Pools formed around LWD jams typically have larger and more variable depths than other types of pools (Montgomery et al., 2003).

Large woody debris can affect stream bank and channel morphology. The presence of LWD can influence a channel width by armoring the stream banks and maintaining relatively stable sections preventing the channel from over-widening (Montgomery et al., 2003). It can also negatively impact a section of a stream channel by directing flows into the bank, causing bank erosion and instable channel widening (JFNew, 2007; Abbe and Montgomery, 1996; Montgomery et al., 2003; Nakamura and Swanson, 1993). Large woody debris accumulations can form obstructions leading to sediment storage within a stream channel. In small to medium river channels, sediment accumulation was observed at LWD sites that extended across the entire channel (Grunell et al., 2002). Sediment deposition started from a LWD jam can be drastic enough to create major shifts in channel shape. Large woody debris accumulations may create steps dispersing energy from the stream causing sediment to fall, or the LWD may form jams blocking the flow of water causing sediment deposition (Montgomery et al., 2003). Large woody debris can protect sediment bars by diverting flows away from the bar. Under different circumstances LWD can accelerate erosion by shifting flows towards areas of deposition (Grunell et al., 2002). Sediment previously stored in a LWD jam can be made available to be transported downstream if the jam was removed. This can cause problem in downstream locations (Grunell et al., 2002; Montgomery et al., 2003 JFNew, 2007).

Large woody debris generally has little or no effect on local flooding when it is not joined with other debris. Historically, large woody jams were assumed to increase the occurrence of flooding, however research suggests a channel needs to be substantially blocked by LWD before there is any measurable effect on water height (JFNew, 2007). Researchers have demonstrated when several pieces of LWD are located within close proximity (less than two times the diameter in distance from the next piece), there is no greater impact on water levels than the one piece alone (JFNew, 2007). Therefore, the presence of LWD in a stream channel does not indicate the flooding potential was higher than in a channel without LWD (JFNew, 2007). For larger alluvial streams it is very unlikely that a mass of woody debris could cover a large enough area to affect flooding (Rutherfurd et al., 2002). An observed exception often occurs when LWD and other flood deposits obstruct bridges and culverts. In these cases, woody debris blocks the flow of water through bridges and culverts, and flood heights can be raised significantly.

Most issues arise when LWD forms larger masses, or jams. The beneficial and adverse effects of LWD have been studied in stable jams that resulting in changes to flow and sediment transport regimes (Montgomery et al., 2003). Research has shown the presence of a key member (central tree within the jam, often with a rootwad still attached) can create a stable LWD jam. Stable LWD jams can remain in stream channels for many years, even in extremely dynamic floodplains (Abbe and Montgomery, 1996). Stable jams change channel-bed morphology, trap additional woody material, and are unlikely to move downstream during bed-mobilizing, or bankfull, flows. Unstable jams can mobilize readily at bankfull flows, and have few if any lasting effects on channel-bed morphology (Abbe and Montgomery, 2001). The likelihood that a LWD jam (mainly tree trunks) will become stable, and therefore influence channel morphology, is a function of three factors: 1) The size of the tree, which affects the ability of the stream to move it; 2) the presence or absence of a rootwad, which contributes to the overall size of the tree, but also contributes to logs "locking" together and forming a larger mass, or accumulation; and 3) the bankfull width of the river, particularly at the location where the LWD is located, the narrower the river channel, the more likely that a piece of LWD will stay at that location and will have an influence on the stream.

Woodland Creek

Woodland Creek is located in Woodland Valley in the town of Shandaken, in Ulster County New York and is part of the Ashokan Reservoir watershed. Woodland Creek drains to Esopus Creek which runs into the Ashokan Reservoir. A sizeable portion of the upper reaches and mountain tops are part of the Catskill Park Forest Land which is owned by New York State's Department of Environmental Conservation. The drainage area of woodland creek Woodland Creek watershed area comprises of 20.6 square miles. Woodland Creek is the second largest tributary to the Esopus Creek (based on the total stream miles, drainage area, and discharge) and it is geomorphically representative of other tributaries in the watershed. The USGS calculates an average of 53.4 inches of precipitation a year with 35.4 inches of runoff annually. Forest covers 99.1% of the watershed (USGS, 2011).

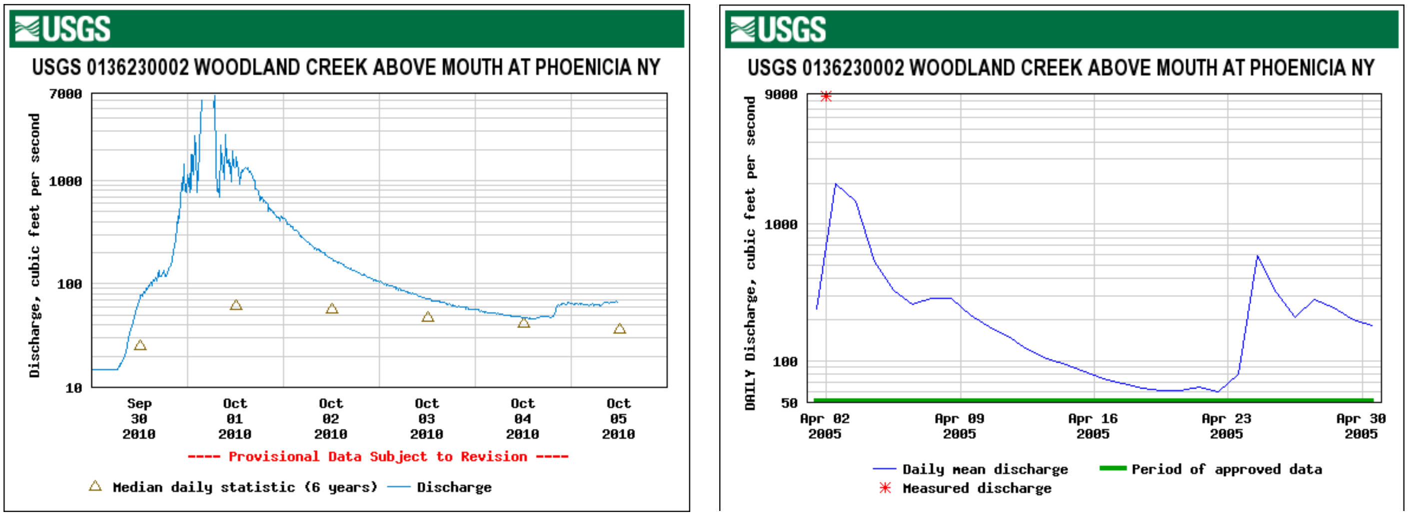
Hydrology

The peak annual discharge that occurred in Woodland Creek for water years 2003-2010 are listed in descending order in Table 1. The largest discharge (811 cfs) that occurred between the initial 2008 assessment and the 2010 assessment was a less than bankfull event on December 12, 2008 (Table 1), with a return interval (RI) of less than 1.25 years (data not available after September 30, 2009). The October 2010 (Figure 1A, Table 1) flood, however, had a peak discharge of 7,080 cfs with an estimated 25-year RI, and to mobilized the non-persistent LWD in Woodland Creek. The largest flood recorded in the Ashokan Watershed occurred in April 2005; the peak discharge in Woodland Creek was almost 9000 cfs (Figure 1B, Table 1) which corresponded to a 100-year RI (USGS, 2011).

Table 1: Highest Historical Peak Streamflow For USGS 0136230002

Date	Streamflow (cfs)
2005-04-02	8600
2010-10-01	7080
2003-09-28	5810
2003-12-11	3810
2005-10-08	2570
2008-10-25	1660
2007-04-16	1260
2007-10-27	1250
2010-08-23	987

Figure 1: Hydrograph from Woodland Creek USGS gauge for the period (A) September 20-October 5, 2010 and (B) April 2-April 30, 2005



Methods

Assessing LWD in streams is one step towards understanding and protecting stream integrity. Management of LWD in streams can protect and enhance stream quality while maintaining the designated uses of a stream. Large woody debris has also been shown to have a major effect on stream biota and is recognized as an important feature in forested stream ecosystems (Grunell et al., 2002; Warren et al., 2009). Consequently, a basic understanding of the processes that determine wood recruitment and stability can be used to develop some best management practices for LWD (JFNew, 2007). The Ashokan Watershed Stream Management Program initiated a study in Woodland Creek in 2010 to characterize woody debris features that would make LWD sites more likely to contain persistent (stable) LWD in the channel. Persistent LWD was observed as having an affect on the channel-bed morphology or did not move downstream during a bed-mobilizing flood event (Abbe and Montgomery, 2003). We developed an evaluation methodology to assess the factors related to persistence of woody debris in wadeable streams (Braudrick and Grant, 2000; Warren and Kraft, 2008; Montgomery et al, 2003; Haga et al, 2002, Gurnell et al. 2002; Abbe and Montgomery, 2003; JFNew, 2007; Rutherford et al., 2002; Abbe and Montgomery, 1996). These included:

- The ratio of length and diameter of a tree to the bankfull width of the stream at the location of the LWD.
- The presence of a key member with an attached rootwad
- The number of pieces of wood in the accumulation
- The presence of a pool associated with the LWD,

Woodland Creek in Woodland Valley was selected for this study because the creek was previously assessed in 2008 including GPS locations for LWD sites (Figure 2). In the summer of 2010, we revisited each of the LWD sites that had been identified in 2008. The length and diameter of every piece of LWD and bankfull width was measured at each site. A third assessment of LWD was conducted after a 25-year flood event occurred on October 1, 2010. During this assessment only the presence or absence of LWD was recorded.

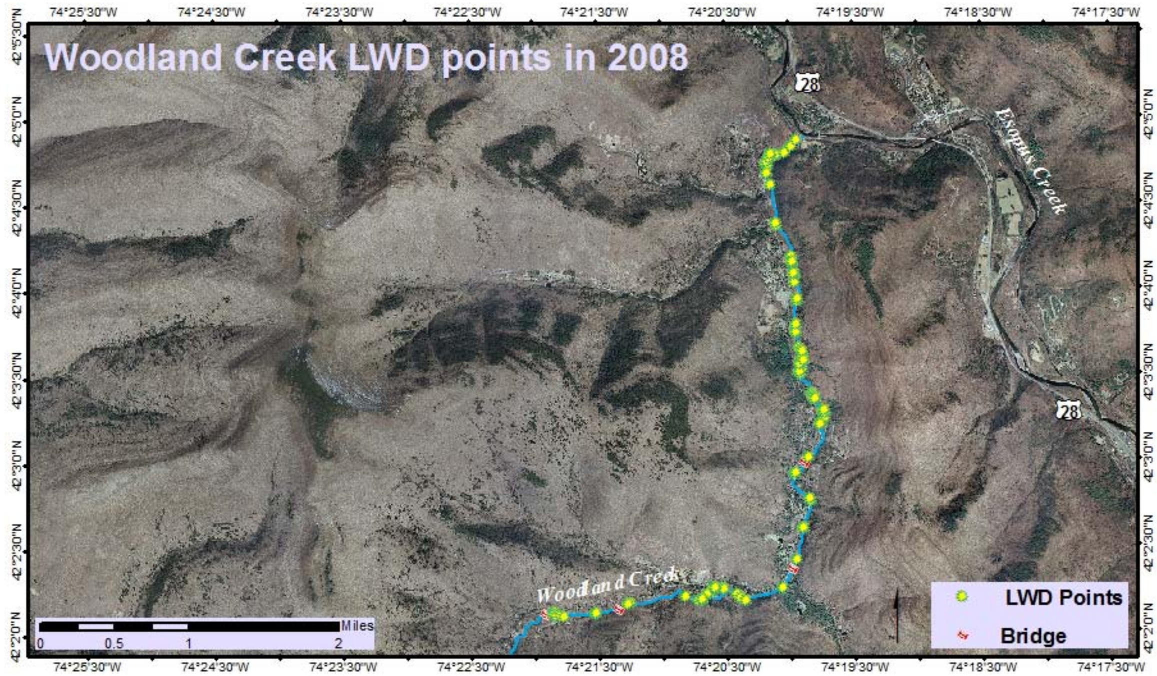


Figure 2: Locations of 91 LWD sites in Woodland Creek that were surveyed in 2008, aerial imagery from 2009 (courtesy of NYC DEP).

Results

The project intern relocated the 91 previously recorded and found that 67 of those sites still retained LWD. The LWD at all 67 sites were classified as persistent and assessed for the predicted factors listed earlier in the paper. After the October 1 flood the intern relocated the 67 sites and determined that 32 sites still retained LWD. Ninety piece of LWD remained at those 32 sites.

Effect of woody debris dimensions on persistence of LWD

Large woody debris usually persisted over time at sites where the length of the LWD was greater than 50% of the bankfull width.

The field survey done during the summer 2010 inventoried 164 pieces of LWD at 67 stream sites. The bankfull width averaged 66.4 ft (SD = 16.84 ft) at all sites and the length of all LWD averaged 44 ft (SD = 17.89 ft). The diameter of LWD averaged 0.83 ft (SD = 0.28 ft). Seventy percent (115 pieces) of the LWD sampled were greater than 50% of the bankfull width. Only 49 pieces of LWD had a length that was less than 50% of the bankfull width.

Effects of density on persistence of LWD

Large woody debris generally persisted over time at sites where two or more pieces of LWD constituted a jam.

Of the 164 LWD pieces identified, 80% are part of an accumulation of two or more pieces of LWD. The average jam contained 3.7 pieces of LWD (SD = 2.0). The most common jam contained two pieces of LWD (11 of the 29 sites). The next most common jam contained three pieces of LWD (10 of the 29 sites). The remaining eight jam sites are as follows; 3 sites contained 4 pieces of LWD, 3 sites contained 5 pieces of LWD, 1 site had a jam of 6 pieces, 3 sites contained 7 pieces of LWD, 1 site had 8 pieces and 1 site had a jam of 9 pieces.

Effect of rootwad on persistence of LWD

The presence of a rootwad attached to a piece of LWD lead to, but did not guarantee, persistence.

Large woody debris persisted over time at sites where rootwads were present. Of the 164 pieces of LWD identified103 pieces (63%) had an attached rootwad, with the average rootwad width of 8 ft (SD = 5.1 ft) and an average height of 5.5ft (SD = 3.1 ft). Of the 103 pieces of LWD with a rootwad attached 49 (47.5%) pieces of LWD with an attached rootwad were oriented downstream, meaning the branches would face downstream and the rootwad would be upstream. 44 of the 103 (42.7%) pieces of LWD with an attached rootwad were oriented perpendicular to stream flow. Only 10 of the 103 (9.8%) pieces of LWD with an attached rootwad were oriented upstream, meaning the branches would be pointing upstream and the rootwad would be downstream.

Effect of LWD on presence of a pool

From this study, it could not be determined, if the presence of LWD lead to an increased chance of the formation of a pool.

Of the 164 pieces identified as being persistent only 58 pieces (35%) were associated with a pool. Of the 58 pieces 45 (77%) had an attached rootwad to the LWD. Of the 45 pieces of LWD with a rootwad attached 18 (40%) were oriented perpendicular to the stream flow, 22 (49%) were oriented downstream of the stream flow, and only 5 (11%) were oriented upstream.

Effect of a flood event on LWD jams

Large woody debris persisted after a significant flood event at sites with a debris jam (at least two LWD pieces).

After the October 2010 flood, LWD persisted at 32 of the original 67 sites and LWD was lost from 35 sites; 90 pieces of LWD were retained at the 32 persistent sites. Of the 90 pieces remaining after the flood, 76 were part of an accumulation of 2 or more pieces. About 84%, or 27 of the 32 persisting sites, originally contained a jam of 2 or more LWD pieces; only 5 sites or about 16% contained only 1 piece of LWD and persisted through the flood event. About 46% or 16 of the 35 sites that lost LWD had a jam of 2 or more LWD pieces before the flood; about 54% or 19 of the 35 of the lost sites contained 1 piece of LWD.

Implications

In Woodland Creek, multiple pieces of woody debris that were more than 50% longer than bankfull width and retained their rootwads helped LWD persist through bankfull and flood events. The presence of a rootwad alone was not sufficient to guarantee persistence. Additional factors, such as sediment deposition (occurring upstream or downstream of the rootwad), or roots partially attached to the bank (holding it in place) helped LWD to persist at study sites.

Whether LWD persisted over time and through different flow events at any site depended on whether there was, or was not, a jam or a single piece of LWD. Jams of two or more pieces of LWD increased persistence. In addition, orientation of single pieces of LWD in the channel also made a difference in persistence; LWD that was closer to the stream banks, parallel to flows, spanning the channel, and at least partly above bankfull stage appeared to enhance persistence of LWD through bankfull and flood events.

<u>Additional Observations and Recommendations</u>

This project started with one focus and evolved considerably throughout the study period. Subsequent studies may improve upon these pilot efforts by:

- tagging each LWD piece (for effective tracking and identifying the same piece during future surveys),
- inventorying all LWD across the entire length of the stream several times (to assess the net gain or loss of LDW in the system),
- measuring bankfull features both above and below the LWD jams (to determine if there are any bankfull features, such as widening, that could from the LWD),
- recording each piece of LWD's location in the stream channel (to determine if the location of the LWD in the stream channel leads to persistence),
- recording when the accumulation is behind standing live trees or behind a boulder (to determine if it helps remain persistent even through flood conditions).

Currently the staff at the Ashokan Watershed Stream Management Program uses a data dictionary in the field. The data dictionary lists all possible data that should to be observed and recorded during field assessments. One revision to the current data dictionary should be made for LWD is how the orientation angle is recorded. Instead of a continuous field the orientation angles should be categorical. Four categories for orientation might be, <20° or parallel to stream flow, between 20°-40°, >40°, and perpendicular to stream flow. Currently, the orientation of LWD to the bank is estimated to the nearest degree, which is difficult to measure or estimate accurately in the field.

More importantly, a better definition of LWD is needed to ensure consistency among data. The definition of LWD should be included in the data dictionary and carried into the field by all staff. Limiting LWD to pieces that occur in the bankfull stream channel, and not in the flood plain, might also save time during assessments.

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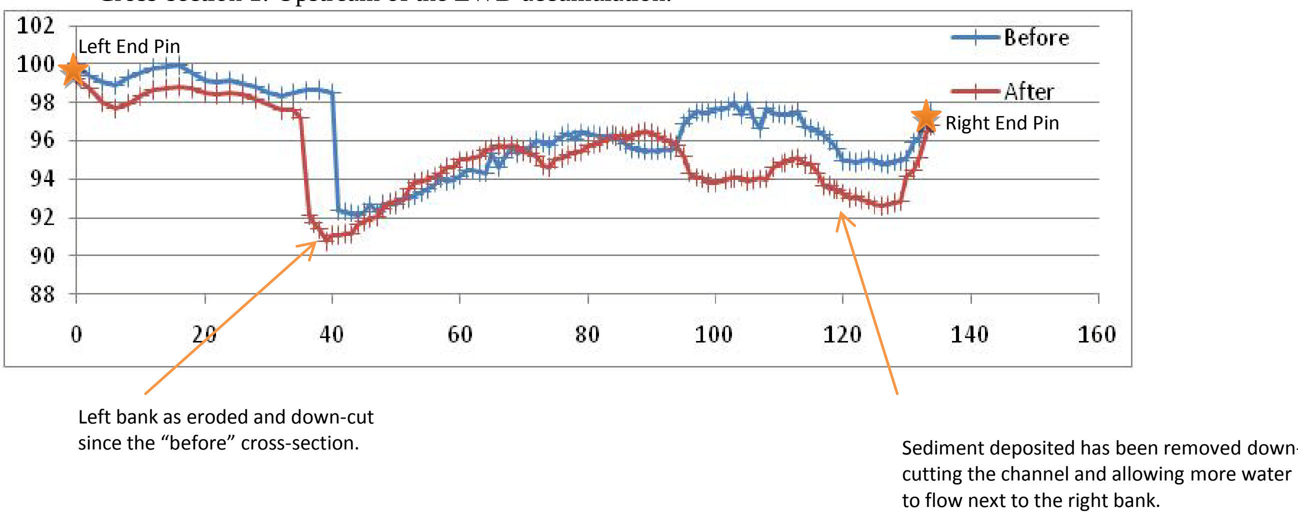
Case Study:

Figure 3: Two monumented cross-sections at the photomonitored site on Woodland Creek before and after October 1, 2010.

Cross-section 1: Upstream of the LWD accumulation:



Cross-section 2: Downstream of the LWD accumulation: