AN EVALUATION OF THE STREAM VISUAL ASSESSMENT PROTOCOL FOR THE LITTLE TENNESSEE RIVER WATERSHED

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Abstract. Stream and riparian habitat are essential factors in the health of riverine flora and fauna, which are a part of the complex interactions that occur in stream ecosystems. Knowing how riparian and stream habitat change over time is important to understanding the health of these systems for both the survival of plants and animals and for human health. The Little Tennessee River has many branches that cover a vast area stretching from Rabun County in north Georgia through Macon and Swain counties in North Carolina and into Tennessee, which makes its existence and health vital to a large population of people. The Little Tennessee Watershed Association (LTWA) carries out biomonitoring throughout the Little Tennessee River basin to address water quality issues in Little Tennessee River and its tributaries. In response to land use pressures resulting from residential and commercial development and agriculture, the LTWA is implementing a program using a simple assessment tool known as the Stream Visual Assessment Protocol (SVAP) to collect stream quality data within the watershed based on physical characteristics. The LTWA will use this information to enhance the spectrum of approaches for protecting and improving stream health. As a pilot project of this program, we assessed ten sites within the upper Little Tennessee watershed to gain an understanding of current conditions. In addition, we determined the feasibility of using the protocol with the general public and suggest possible improvements to the protocol.

Key words: Little Tennessee Watershed Association; Little Tennessee River; riparian habitat; stream habitat; Stream Visual Assessment Protocol (SVAP); Upper Little Tennessee Watershed.

INTRODUCTION

Diversity and quality of stream and riparian habitat are important indicators of the overall health of a stream. Stream health directly correlates with habitat complexity (Gorman and Carr 1978). Aquatic animals prefer habitat that offers some sort of instream cover for protection of their eggs, feeding requirements, and many other reasons. Habitat diversity is very important because each aquatic species prefers a distinct type of cover (Gorman and Carr 1978). Land use in and around the riparian buffer and the interface between the stream and the surrounding land can greatly affect the habitat complexity and in turn, the diversity of aquatic wildlife. Many fish and insect species prefer habitat below overhanging vegetation. The removal of such vegetation decreases fish populations (Jones et al. 1999). Riparian vegetation also produces detritus that provides up to 90 percent of the organic matter necessary to support headwater stream communities (Cummins and Spangler 1978). The removal of riparian vegetation reduces the amount of available organic matter in addition to decreasing the strength of the buffer that helps to filter out sediment, pollutants, and harmful nutrients from agriculture (Jones et al. 1999). It also decreases the amount of canopy cover that helps to keep the water temperature stable. Such sedimentation, pollution, and nutrient enrichment decrease the diversity of aquatic communities (Jones et al. 1999).

The Little Tennessee River flows 135 miles from Rabun County in north Georgia through Macon and Swain counties in North Carolina and into Tennessee, where it joins the Tennessee River. The 1,100 square mile watershed is considered one of the most intact in the eastern United States. With about 88% of the region covered with mountain forest, protecting many of the headwater streams, the watershed boasts some of the highest levels of aquatic diversity and endemism in the Southeast (Desmond 2003). However, like all developed watersheds, the Little Tennessee faces a growing number of threats to its health, namely the large amount of livestock grazing and farming in or near riparian zones and/or floodplains and increasing development pressure from residential and commercial development. Livestock manure deposition in or near flood plains, riparian grazing, and instream livestock bathing have negative effects on aquatic communities. Riparian grazing and instream livestock activity has been observed as a major cause of stream sedimentation, and manure presence causes respiratory stress to fish and macroinvertebrate communities by forming a coating on their gill structures (Strand and Merritt 1999). The increase in nitrogen levels due to livestock manure and urine can also adversely affect the respiration of aquatic organisms. It is because of these threats that streams need to be monitored with visual assessment in addition to biological assessment in order to better pinpoint the causes of habitat loss, lack of aquatic biodiversity, and overall lack of stream health. The information obtained from using the SVAP protocol will be helpful in formulating a mitigation plan for problem areas in the watershed.

The Little Tennessee Watershed Association (LTWA) is a non-profit organization founded in 1993 when concerned individuals met to discuss the health of the Little Tennessee River. The mission of the LTWA is to protect and restore the waters of the upper Little Tennessee Watershed to maintain aquatic biodiversity and habitat conditions, as well as water quality for the use of people living in the area. The LTWA works in conjunction with local governmental agencies, environmental non-profits, and volunteers to execute numerous projects and initiatives under their Water Quality and Water Quantity programs. One of the main tasks that the LTWA performs is biomonitoring (LTWA 2003). Indeed, the LTWA has data from 1990, before the organization was founded, collected by the Biomonitoring Program Director, Dr. William McLarney. These data include samples of fish and, in some cases, benthic macroinvertebrates at 154 sites in the Upper Little Tennessee Watershed. Dr. McLarney used the Index of Biotic Integrity (IBI) to collect data at each of these sites, resulting in a 20-year dataset used to help monitor threats over time and better understand changing conditions within the Upper Little Tennessee watershed (McLarney 2007). Such long-term data also help LWTA advocate for changes to local governmental policies and practices that protect the watershed and improve water quality.

In this paper, we will report results from visual assessments of ten sites in the upper Little Tennessee Watershed. We conducted sampling using the Stream Visual Assessment Protocol (SVAP), which was modified for use within the Little Tennessee River basin. This assessment is useful for, among other things, determining changes in streams after a disturbance, understanding conditions for resource use, and forming resource inventories and reports (Bjorkland et al. 2001). Scientists developed the first draft of SVAP in 1996 after a survey was conducted by the Natural Resources Conservation Service's (NRCS) Water and Climate Center, in which they asked NRCS state biologists about stream ecological assessments and the need for technical support. After finding that biologists desired to be more active in stream ecological assessments and wanted additional technical support, a tiered system of assessment methods was developed. The simplest method created in this system was the SVAP, which is a conglomeration of existing assessment procedures (Bjorkland et al. 1998). This protocol was designed as a quick assessment to be used by individuals who are unfamiliar with conducting stream assessments. NRCS workers perform the assessment with landowners in order to both assess the stream and teach the landowner about the conservation of aquatic resources (Bjorkland et al. 2001).

As it pertains to the Little Tennessee, criteria for the assessment included 13 categories important to the overall health of the stream environment. In addition to reporting the results of the stream assessment, we will also discuss areas of improvement for the protocol in order to create a single standardized visual assessment protocol. This LTWA SVAP will soon be used by landowners and other citizens throughout the watershed to help pinpoint problem areas of poor physical habitat quality.

METHODS AND MATERIALS

General Procedure

We collected data from ten sites within the upper Little Tennessee watershed over the course of two months, using a modified version of the Stream Visual Assessment Protocol (SVAP). Sites included locations on Tellico, Watauga, Rabbit, Ellijay, Skeenah, Tessentee, Mud, Betty, and Mill Creeks (Fig. 1)

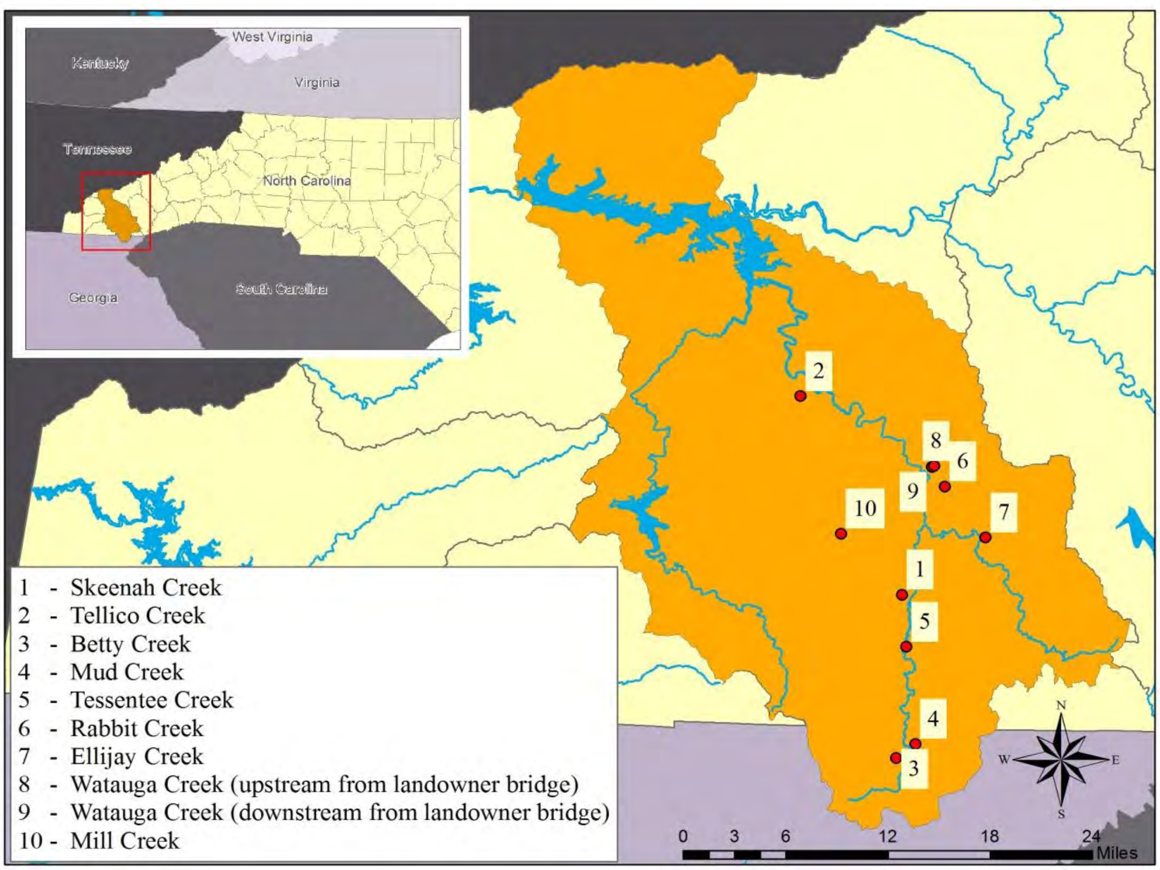

FIG. 1. Map showing SVAP site locations in the Little Tennessee River watershed.

At each site, we entered the stream wearing waders provided by the LTWA, and walked the designated reach carefully observing our surroundings. We specifically evaluated the channel condition, possible hydrologic alteration, riparian zone, bank stability, water appearance, nutrient enrichment, barriers to fish movement, instream fish cover, pools, insect and invertebrate habitat, canopy cover of stream reach, manure presence, and riffle embeddedness using a hard copy SVAP guide provided by LTWA. These guides included pictures for most categories to help the user determine a proper score for the stream. We gave each category a score from 1 to 10, with 10 being the best and 1 being the worst, and recorded the information on modified data sheets, which were printed on *Rite in the Rain*® all-weather paper (Appendix A). We also recorded date, time, dominant substrate, weather conditions, and general observations, noted on the modified data sheets. Finally, we used a digital camera to take photographs of most of the sites and logged the GPS coordinates at the entrance to each stream reach and a track of the reach using a Garmin 60CS GPS unit.

Criteria for Assessment

We assigned scores for stream condition based on the following information:

Channel Condition: This category refers to the sinuosity of the stream and whether or not the stream has been straightened. If a stream describes a nearly perfect straight line, it has been channelized. You can often spot these reaches on topo maps, where they are shown in magenta (W. McLarney, Biomonitoring Program Director, LTWA, pers. comm.). Older channelized streams may be characterized by grassy instead of woody vegetation along stream banks (Bjorkland et al. 1998). Streams with channels that were natural, with no structures, dikes, or down-cutting, received a score of 9 or 10. To receive a score of 6 to 8, there had to be evidence of recovery from past channel alteration. All dikes or levees were set back so that the stream had suitable access to the flood plain. If the stream reach was braided, had less than fifty percent of riprap and/or channelization, showed aggradation (stream bottom or flood plain raised in elevation because of deposition of material), and was restricted from the flood plain, then it received a score of 3 to 5. Streams with more than 50% of the area with riprap and/or channelization, that had active down-cutting or widening, as well as being restricted from the flood plain by dikes and levees, received a score of 1 or 2 (LTWA 2009).

Hydrologic Alteration: Natural hydrologic conditions are important to maintaining the shape and function of the stream channel, which is important for maintaining the physical habitat for flora and fauna. Natural conditions include bankfull flows (Fig. 2) and access to the flood plain for flooding events (Bjorkland et al. 2001). So, streams earned either a 9 or 10 when there were no dams, dikes, or areas of water withdrawal along a reach. Additionally, there were no structures limiting the stream from reaching the flood plain, with no evidence of

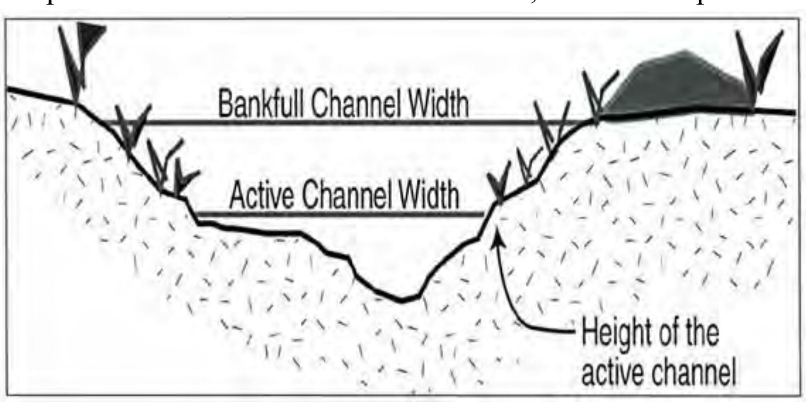

FIG. 2. Bankful and Active Channel Depiction (Taylor and Love 2003)

the channel incision. Streams that flooded once every three to five years with no channel incision and habitat that was not negatively impacted by water withdrawals received a score of 6 to 8. If flooding occurs once every six to ten years with the stream having limited channel incision, or if withdrawals from the stream negatively affects stream habitat during low flow periods, the stream received a score of three to five. To receive a 1 or 2, the stream had to experience no flooding, be deeply incised, or have structures that prevent the stream from having flood flow. Alternatively, the stream would also receive these scores if withdrawals had caused the loss of low flow habitat or if floods only occurred on a one-year rain event or less cycle (LTWA 2009).

Riparian Zone: This zone is the area extending from the edge of the active channel (Fig. 2) out onto the flood plain on both sides of the stream (Bjorkland et al. 1998). If this zone had natural vegetation extending at least two active channel widths, which is the width of the stream at bankfull discharge, on either side, then the stream received a score of 9 or 10. Scores of 7 and 8 were given to streams that only had natural vegetation extending one active stream length on either side of the stream, or if there was only one active channel width of vegetation within the entire flood plain. If the vegetation extended half the active channel length the stream received a score of 5 or 6. Streams with vegetation extending only a third of the stream length on either side, or if the riparian zone function was significantly compromised because of its condition, then a score of 3 or 4 was assigned. Streams deserving of a 1 or 2 had natural vegetation extending less than a third of the active channel length on either side of the stream. Additionally, these streams would not show regeneration of vegetation or the filtering function was severely compromised (LTWA 2009).

Bank Stability: This element refers to the possibility of soil from the upper and lower portions of stream banks being deposited in the stream. Although some bank erosion is normal, excessive erosion is unhealthy and indicates degraded riparian zones and areas of instability (Bjorkland et al. 2001). Streams with stable banks, which were low (at flood plain level), with at least 33% of the surface area in outside bends protected by roots extending to the base flow elevation, received a 9 or 10. Scores of a 6, 7, or 8 were given to streams that had less than 33% of the surface area in outside bends protected by roots that extended to the base flow elevation. If the stream had banks that were usually high, meaning that flood events were restricted to one year out of five, or even less, with actively eroding outside bends, characterized by falling mature trees, then it was assigned a 3, 4, or 5. These streams may have also had slope failures. Streams were assigned a 1 or 2 if they had the same conditions as the last section, in addition to having straight areas in or near the reach, with outside bends actively eroding, with many mature trees falling over into the stream annually, and much evident slope failure (LTWA 2009).

Water Appearance: This category refers to the turbidity, the amount of suspended particles and organic matter, of the stream (Bjorkland et al. 1998). If the stream was either very clear or tea colored, which allowed objects to be visible 3 to 6 feet below the water, with no evidence of oil sheen on the surface or film on inundated rocks or other objects, then it was given a score of 9 or 10. Streams receiving a 6, 7, or 8 had somewhat cloudy water with objects visible at 1.5 to 3 feet below the surface of the water. Water in these streams may have had a slightly green appearance, but still had no oil sheen present on the water's surface. Streams that were considerably cloudy most of the time, with objects visible at 0.5 to 1.5 ft below the surface received a 3, 4, or 5. These streams may have also had slow areas that in some cases appeared pea-green, had inundated objects covered with green film, and possibly smelling of ammonia. Streams received a 1 or 2 if they were extremely cloudy or muddy most of the time. Objects in these streams were only visible at less than 0.5ft. The water moved slowly and was possibly bright green in color with obvious pollutants. These streams may have had floating algal mats, surface film, oil sheen, or foam, or may even have had a chemical, oil, or sewage scent (LTWA 2009).

Nutrient Enrichment: Among other factors, this element was determined by the amount and types of vegetation in the water. Having too much decaying vegetation in the stream promotes the development of excess algal and macropyhte growth (Bjorkland et al. 2001). Streams with a clear appearance along the reach with no macrophytes, and little algal growth were assigned a 9 or 10. If the stream was only fairly clear and possibly slightly green with moderate algal growth on stream substrate, then it received a score of a 6, 7, or 8. If the water in the stream moved slowly with the presence of green macrophytes, other than *Podostemum*, with significant algal growth, then the stream received a 3, 4, or 5. Lastly, streams receiving a score of 1 or 2 were green, gray or brown in color with dense areas of macrophytes that impeded the water's progress. These streams also had severe algal blooms, which created thick algal mats in the stream (LTWA 2009).

Barriers to fish movement: The presence of fish and their reproduction is important to the riverine environment, so the presence and absence of barriers is important to stream health assessments (Bjorkland et al. 1998). Therefore, streams with no barriers received a score of 9 or 10. Streams that had, or were suspected of having, seasonal withdrawals that consequently were a barrier to fish movement received a 6, 7, or 8 depending on the severity of the situation. If drop structures, culverts, dams or other diversions that had more than a one-foot drop within three miles of the reach were present, then the stream received a 3, 4, or 5. This information was usually determined by driving upstream and downstream of the stream reach. Streams in which drop structures, culverts, dams, or other diversions were greater than one foot within the reach were assigned a score of 1 or 2 (LTWA 2009).

Instream Fish Cover: This category refers to the amount of fish habitat that is available in the stream, which is important to the stability of fish communities (Bjorkland et al. 2001). Types of instream fish cover specifically mentioned in the LTWA's SVAP included logs and large woody debris, pools, riffles, undercut banks, overhanging vegetation, boulders, thick root mats, and dense macrophyte beds. However, the protocol does allow for the counting of other sources of fish cover by having an "other" category. Streams with more than seven cover types were given a 9 or 10, while those with 6 to 7 cover types available were given a 7 or 8. Streams with 4 to 5 cover types received a 5 or 6, while those with 2 to 3 cover types were given a 3 or 4. Streams with one to no cover types were given either a 1 or 2 (LTWA 2009).

Pools: Pools are deep or shallow areas of slow moving water that can provide cover for fish (Bjorkland et al. 1998).Streams abundant in pools that had more than thirty percent of their bottoms obscure because of their depth, or had pools that were at least 3ft deep received a score of 9 or 10. If pools were not abundant and 2ft deep with 10 - 30% of their bottoms obscure because of their depth, then they received a score of 6, 7, or 8. Streams with shallow pools that had 5 to 10% of their bottoms obscure because of their depth that were less than 2ft deep were given scores of 3, 4, or 5. If pools were absent, or the entire bottom was discernible then the stream received a 1 or 2 (LTWA 2009).

Insect/Invertebrate Habitat: Stable substrate is important to the colonization of insect and invertebrate habitats in streams (Bjorkland et al. 2001). Insect and invertebrate habitat was defined as being fine woody debris, leaf packs, submerged logs, boulders, undercut banks, cobbles, and coarse gravel. However, the SVAP does allow for the addition of other undefined insect cover types by listing "other" as an option. Streams with at least five good quality habitats were given a 9 or 10. Streams with 3 to 4 good quality habitats received 6, 7, or 8. If the stream only had 1 to 2 good quality habitats then it received a 3, 4, or 5. Streams with one to zero habitat types were given a 1 or 2 (LTWA 2009).

Canopy Cover of Stream Reach: This element refers to the amount of sunlight that reaches the water's surface. Too much light will increase stream temperature and promote algal growth (Bjorkland et al. 1998). Therefore, streams with more than 75% of the water surface shaded in the reach and within 2-3 miles of the reach received a 9 or 10. If the stream was shaded more than 50% in the reach or 75% in the reach and poorly shaded within 2-3 miles of the reach, then the stream received a 6, 7, or 8. Streams in which the reach was only shaded 20-50% were given a 3, 4, or 5. If less than 20% of the water within the reach was shaded, then the reach received a 1 or 2 (LTWA 2009).

Manure Presence: Human and animal waste changes the chemical make-up of the stream such that the trophic scale of the aquatic biological community is altered. Additionally, untreated human waste is an extreme health risk (Bjorkland et al. 2001). If there was no evidence of livestock in or near the riparian zone, then the stream received a 9 or 10. If there was evidence of livestock access to the riparian zone, for example cattle gates leading into the water, then the stream was given a score of 6, 7, or 8. When there were waste storage structures located on the flood plain of the stream and there was evidence of occasional manure in the stream, a score of 3, 4, or 5 was given. In the worst case, a stream received a 1 or 2 if there was evidence of a significant quantity of manure on the banks or in the stream, or if untreated human waste was being discharged directly into the stream (LTWA 2009).

Riffle Embeddedness: Scores for this category were determined by kicking substrate located above a riffle in the stream and counting the amount of time it took for the sediment to clear from the point of disturbance. If no cloud of sediment was produced and the water remained clear, the stream received a score of 9 or 10. Streams where the sediment cloud persisted for 2 seconds were given a 7 or 8. If the sediment persisted for five seconds, the stream received either a 5 or 6, while streams with sediment persisting for 8 seconds received a 3 or 4. Steams where large sediment was completely buried in fine sediment, and riffles, which were once naturally present, were now absent received a 1 or 2 (LTWA 2009).

After we surveyed the ten stream reaches, we shared information using a comparison data sheet (Appendix A) and discussed findings, determining whether we missed any outstanding factors, or whether any scores should be changed. In cases where scores were changed, we crossed out previous assessments and wrote in the new scores beside the earlier mark. We averaged category scores by the number of observations, then to create an overall visual assessment rating, scores were averaged among observers. Based on the SVAP score for each stream reach, we classified the streams on scale of *very poor* to *excellent*, where *very poor* scores 1 to 2.2, *poor* scores 3.1 to 5.3, *fair* scores 6.1 to 7.0, *good* scores 7.7 to 8.5, and *excellent* scores 9.6 to 10. Gaps between the scoring tiers were reserved for judgment of the observer, so we could use or own judgment on whether to round up or down based on the overall visible condition of the stream. We depicted these rankings on maps (Appendix A).

Analysis

The LTWA is concerned about usability of this protocol by the public. In order to evaluate the efficacy of this protocol, we looked at differences among categories. We calculated the variance between our scores for each category in order to see which category is the most difficult to agree upon using the following equation:

$$\sum \frac{2\sqrt{(x_n - \mu)^2}}{n}$$

x_n = individual observer value
μ = Mean value of the that category for the stream
n = sample size

We averaged these variance values to produce a mean of the variances for each category. Although the variance would be more effective with more observer scores, this analysis would help us to pinpoint and discuss possible problem areas of the protocol.

RESULTS

The results show that two (20%) of the streams surveyed have a rating of *poor*, seven (70%) have a rating of *fair*, and one (10%) has a rating of *good*. These scores are shown in Table 1. The site locations are depicted in Fig. 1.

Tellico Creek scored the highest with an overall score of 7.25. The channel was altered very little, and its riparian zone was intact, diverse, and free of pollution sources such as manure or agricultural runoff. The water seemed clear with little sign of excess nutrient enrichment, and there were many opportunities for fish and macroinvertebrate habitat, with the exception of a deficit in deep pools. This is an example of a *good* stream for the watershed. Mud Creek scored the worst with an overall score of 4.75. Its primary substrate consists of silt and sand, and the channel is relatively straight with little elevation change. Just below a shallow culvert, sits a concrete drop-off which poses a large barrier to fish movement. Riparian zones on over half of each bank are mostly bare providing no buffer for the agricultural runoff from the two adjacent fields. What little vegetation exists has low diversity and appears to be fairly recently planted. The streambed was littered with trash, and there are not many opportunities for fish and macroinvertebrate habitat. This is an example of a *poor* stream that would benefit from plans for mitigation.

TABLE 1. Stream visual assessment protocol scores for ten stream reaches in the watershed.

Site	Numerical Score	Reach Rating
Skeenah Creek	6.63	FAIR
Tellico Creek	7.25	GOOD
Betty Creek	5.7	FAIR
Mud Creek	4.75	POOR
Tessentee Creek	4.8	POOR
Rabbit Creek	6.85	FAIR
Ellijay Creek	6.5	FAIR
Watauga Creek	6.7	FAIR
Watauga Creek	6.1	FAIR
Mill Creek	6	FAIR

Notes: All sites were surveyed by two observers except site 1 (Skeenah Creek), which was surveyed by four, and site 5 (Tessentee Creek), which was surveyed by three observers. These results are visualized in maps found in Appendix A.

The mean score for each category was calculated. These means ranged from 4.92, for riparian zone, to 8.24, for insect/invertebrate habitat. We calculated variance among scores for each site and averaged per category observed to draw conclusions as to which criteria are the most objective and difficult to judge. For most sites, n(number of observers)=2, except n=4 at Skeenah Creek and n=3 at Tessentee Creek. Variance ranged from 0.15, for nutrient enrichment, to 0.65, for water appearance, with a mean of variance for all categories of 0.37.

TABLE 2. Variance among observer scores for each category.

Category	Variance among scores
Channel Condition	0.33
Hydrologic Alteration	0.56
Riparian Zone	0.37
Bank Stability	0.38
Water Appearance	0.65
Nutrient Enrichment	0.15
Barriers to Fish Movement	0.21
Instream Fish Cover	0.55
Pools	0.30
Insect/Invertebrate Habitat	0.33
Canopy Cover	0.29
Manure Presence	0.26
Riffle Embeddedness	0.38
Total Mean Variance	0.37

DISCUSSION

The LTWA SVAP seems to be a successful tool for creating a quick and easy-to-follow survey of southern Appalachian stream and riparian habitat quality. By design, it yields consistent numerical results which, when combined with biological sampling data, can be helpful in pinpointing exact sources of problems with water quality in a stream. Most categories on the protocol are easy to score and provide effective feedback for areas that must be addressed when considering quality of instream habitat.

The LTWA protocol worked toward pinpointing problem areas in the watershed, but several improvements can be made for it to be more affective and simpler to follow for volunteer landowners and the general public. For SVAP to be a uniform protocol, it must be outlined in one legible and easy-to-follow document that can be given to all participating parties. In the LTWA SVAP, there are simple typographical errors that can easily be fixed.

The artistic depictions for each scoring category are helpful for the SVAP evaluator. Drawings and paintings provide better reference than photographs because areas of importance to the observer can be highlighted, and minor, distracting details can be left out. These depictions give an observer a better idea of the elements on which they need to concentrate in a way that cannot be conveyed by words or photographs (Hodges 2003). Some categories however, were lacking in these drawings. For example, the bank stability category had no pictures, but asked the evaluator to determine whether or not 33% of banks in outside bends were protected by roots. Without some sort of image to which they can refer, this is difficult to judge. SVAP should also consider using fractions instead of percentages in their descriptions as it would likely be easier for the average citizen to judge. Hydrologic alteration, manure presence, and riffle embeddedness were only missing one or two pictures each, yet having these would be helpful for an observer in giving a proper score.

Our results indicate that some of the categories of SVAP generally produce more variable scores than others. Using more evaluators for each stream reach could help in reducing, or at least pinpointing the cause of variance in SVAP, but the variances found in our data should be taken into account when considering the final version of the LTWA SVAP. The highest variances were found in water appearance, hydrologic alteration, and instream fish cover.

Water appearance is probably the most subjective category in the protocol which would explain the high variance of 0.65, almost double the mean total variance, between evaluator scores. Perhaps this is difficult to judge because many of the streams evaluated never got beyond 3 feet deep, forcing the evaluator to make a guess. With a protocol aimed at non-experts, guesses like these are not necessarily educated and will cause high variation in scores.

Hydrologic alteration is a controversial category. In order to properly assess it, one must acquire some basic knowledge of the flooding history of the stream. A landowner may have this knowledge, but typically a volunteer will not, hence a variance of 0.56, 0.19 above the mean total variance, between observer scores. Although this is an important factor of the overall stream health, errors in scoring may skew the overall SVAP score to inaccuracy. It is because of this that we suggest the hydrologic alteration category be removed from the LTWA protocol, but making it an optional category based on the evaluator's local knowledge should be considered.

The high variation in scores of instream fish cover (0.55) can be explained by evaluators using different scoring systems. Detailed scoring instructions should be included in the protocol in order to standardize the scoring methods of evaluators. These instructions should include a half point system for counting a type of fish and insect/invertebrate habitat that is found but not common within a reach. It should also explain whether the scorer should start at zero and add points based on good qualities, or start at 10 and subtract points for bad observed qualities. This standardization will make the SVAP a much more effective tool for the LTWA.

Many of the streams in the Little Tennessee River basin have an abundance of thick mats of foam that could possibly indicate phosphate enrichment (Fig. 3). Nutrient enrichment is difficult to evaluate in mountain streams because the water generally moves quickly and such foam mats can be created by turbulence when no nutrient enrichment has occurred. Also due to the fast moving water, the green, algal tint that would normally indicate nutrient enrichment is not always displayed. Many times, these harmful nutrients can occur in Appalachian streams but rarely settle long

FIG. 3. Foam in Mill Creek near Memorial-Patton United Methodist Church.

enough to create visible indicators (C. Pringle, Distinguished Research Professor, Odum School of Ecology, University of Georgia, pers. comm.). Due to the ambiguity of this category for visual assessment, we suggest it also be removed from the LTWA SVAP, with an option for considering it a factor in visually obvious enrichment scenarios. Perhaps steps may be taken toward yearly or bi-yearly chemical analysis of streams in the watershed to evaluate nutrient enrichment.

Once revised and standardized, the LTWA Stream Visual Assessment Protocol will be a much more effective tool in judging stream health. It will provide local landowners and the general public with a chance to actively pinpoint problem areas and eventually increase the quality of the water in their watershed. Participating citizens will be able to take pride in the steps they took toward better water quality in one of the most intact and species-rich watersheds in the eastern United States.

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APPENDIX A

Color-coded SVAP ratings per site – 8 separate maps (digital archive on attached CD).

APPENDIX B

Revised SVAP Data Sheet for field use (digital archive on attached CD).

APPENDIX C

SVAP Comparison Data Sheet for field use (digital archive on attached CD).

APPENDIX D

Older version of LTWA SVAP information pamphlet for evaluators (digital archive on attached CD).