USING THE STREAM VISUAL ASSESSMENT PROTOCOL (SVAP) AS A MONITORING TOOL TO ASSESS STREAM CORRIDOR CONDITIONS OVER TIME

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ABSTRACT: *A variety of stream assessment methods are available to assess and monitor stream corridor conditions throughout all phases of the watershed management process. Knowing the focus of a particular watershed management plan is critical when determining which assessment type to use. The Stream Visual Assessment Protocol (SVAP) is a qualitative multidisciplinary stream assessment method used to perform rapid visual assessment of several elements of overall stream corridor conditions. In this study, the SVAP was used in 2004 and 2008 on the same stream to document stream conditions over time in a watershed where there was an absence of major watershed changes. The following SVAP elements were assessed during both field campaigns: channel condition, riparian zone, bank stability, and water appearance. The objective of this study was to compare overall and individual element SVAP scores at multiple sites within one watershed over time to test the reliability of using the SVAP as a monitoring tool. Overall SVAP scores provide a measure of stream corridor conditions that considers biological, physical, and chemical stream characteristics. Individual element scores were compared to provide a potential link to specific watershed management plan goals. Results showed that overall SVAP scores were not significantly different over the four-year period. Analysis of individual SVAP element scores showed that the riparian zone and water appearance element scores were consistent over time, but channel condition and bank stability element scores were significantly different. Results of the analysis comparing overall SVAP scores over time indicate that the SVAP is a useful tool for watershed management plans that call for a cost-effective method of monitoring stream corridor conditions over time, including assessing the effects of stream restoration project implementation. However, the analysis of the individual SVAP elements yielded mixed results, indicating that linking individual element scores to specific watershed management plan goals may not be advisable.*

Keywords: *stream/river assessment; environmental monitoring; watershed management; stream/river restoration*

INTRODUCTION

The watershed management process typically includes the following phases: (1) getting organized, (2) problem and opportunity identification, (3) developing a restoration plan, and (4) implementing the restoration plan (e.g., Federal Interagency Stream Restoration Working Group (FISRWG), 1998; Shields et al., 2003; U.S. Environmental Protection Agency (USEPA), 2008). Stream corridor assessment and monitoring is often employed in multiple phases of watershed management, starting with problem and opportunity identification where stream assessment can be performed to define existing stream corridor conditions. If impairments are identified once baseline conditions have been established, management strategies can be developed that can improve watershed conditions (de Jesús-Crespo and Ramirez, 2011; FISRWG, 1998). On-going and post-project assessment and monitoring is important as watershed management teams move into the plan development and implementation phases of watershed management (USEPA, 2008; Shields et al., 2003; FISRWG, 1998). As the number of stream restoration projects increases and existing and new restoration methods are implemented, post-project monitoring becomes increasingly important (Palmer et al., 2007; Palmer and Allen, 2005; Bernhardt et al., 2005). Bernhardt et al. (2005) showed that the number of stream restoration projects in the U.S. increased exponentially since 1990 and that over $1 billion is spent on restoring streams each year. Moreover, post-project monitoring efforts vary geographically and the majority of projects do not include monitoring (Bernhardt et al., 2005); however, if monitoring occurs, it typically involves visual surveys of the site, photo documentation, and channel cross-section surveys (Palmer et al., 2007). Comparing pre- and post-project stream corridor conditions within the context of a project's stated goals would allow watershed managers to better judge project success or failure (Palmer and Allan, 2005) and further advance the science of stream restoration (Wohl et al., 2005).

A number of stream assessment methods are available to describe stream corridor conditions (see Niezgoda and Johnson, 2005; Fitzpatrick, 2001; NRCS, 2001a) and knowing the focus of a particular watershed management plan (e.g., habitat creation, streambank stabilization, water quality improvement, stormwater management) is important when determining which assessment type to use. Moreover, the availability of resources like time, money, and expertise must be considered (NRCS, 2001a). Stream assessment methods generally fall into the following categories: (1) habitat assessments, (2) stream classification, (3) geomorphic reconnaissance assessments, and (4) multidisciplinary assessments. These assessment methods can be either qualitative or quantitative in nature (Fitzpatrick, 2001; NRCS, 2001a). Qualitative stream assessments are designed for rapid analyses that are efficient both in terms of time and resources and they typically require a low to moderate level of training. In these assessments, metrics are scored qualitatively or measured by field observers and assessment usually takes 30 minutes or less at each site. Qualitative habitat and multidisciplinary assessments include the USEPA Rapid Bioasessment Protocol (RBP) (Plafkin et al., 1989), the Ohio EPA Qualitative Habitat Evaluation Index (QHEI) (Rankin, 1989), and the Natural Resource Conservation Service (NRCS) Stream Visual Assessment Protocol (SVAP) (NRCS, 1998) and the updated SVAP2 (NRCS, 2009). Conversely, quantitative stream assessments involve taking physical measurements of various parameters (e.g., channel cross-section surveys, collection and analysis of bed sediment samples, flow measurements, vegetation surveys, biological species collection). Quantitative assessment can take several hours to days to complete at a site and they require high levels of training. The U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program (Fitzpatrick et al., 1998) and the USEPA Environmental Monitoring and Assessment Program (EMAP) are examples of quantitative stream assessment methods (USEPA, 1997).

The SVAP is one method that can be used to collect qualitative information on the physical, biological, and chemical conditions within a reach of stream corridor. The SVAP was developed by the NRCS as a simple tool for landowners and conservation personnel to perform a rapid visual assessment of several elements of overall stream corridor conditions, including channel condition, degree of bank stability, riparian zone condition, degree of nutrient enrichment, appearance of stream water, presence or absence and extent of barriers to fish movement, presence or absence and extent of instream fish cover, presence or absence and condition of stream pools, and the presence or absence and extent of forest canopy cover over a stream (NRCS, 1998). Up to 15 elements can be evaluated in each stream reach, but users are encouraged to rate only the elements appropriate to the stream being assessed (de Jesús-Crespo and Ramirez, 2011; Bjorkland et al., 2001; NRCS, 2001b; NRCS, 1998). Individual element scores are averaged to provide an overall SVAP score for each reach assessed.

A number of studies have investigated the agreement between the SVAP and other qualitative assessment methods, including RBP and QHEI (Hughes et al., 2010; Ward et al., 2003; McQuaid and Norfleet, 1999). Hughes et al. (2010) compared results from RBP, QHEI, and SVAP assessments done in agricultural streams in ten U.S. states and found significant correlations between the results from all three stream assessment methods. Similarly, Ward et al. (2003) and McQuaid and Norfleet (1999) found significant correlations between RBP and SVAP assessment results from rangeland streams in California, and North and South Carolina streams, respectively. All three studies attributed the correlations to the fact that the assessments are evaluating similar stream conditions, which suggests that comparisons can be made between these assessment methods (Hughes et al., 2010; Ward et al., 2003; McQuaid and Norfleet, 1999).

Studies have also investigated the similarities between the qualitative SVAP and indexes based on quantitative stream assessments (de Jesús-Crespo and Ramirez, 2011; Hughes et al., 2010; McQuaid and Norfleet, 1999). Hughes et al. (2010) found statistically significant relationships between SVAP scores and the Quantitative Physical Habitat (QTPH) index, which is an index calculated from quantitative EMAP physical habitat characterization data. They also noted significant relationships between SVAP scores and macroinvertebrate and vertebrate Index of Biological Integrity (IBI) scores (Hughes et al., 2010), which was something that McQuaid and Norfleet (1999) did not find in their study. de Jesús-Crespo and Ramirez (2011) compared quantitative macroinvertebrate data with scores from the modified Hawaii Stream Visual Assessment Protocol (HSVAP) (NRCS, 2001b) from an urbanized watershed in Puerto Rico and found statistically significant similarities; however, they also found that water quality data were only weakly related to HSVAP scores.

The primary objective of this study was to compare overall and individual element SVAP scores at multiple sites within one watershed over time to test the reliability of using the SVAP as a monitoring tool. Overall SVAP scores provide a measure of stream corridor conditions that considers biological, physical, and chemical stream characteristics. Individual element scores were compared to provide a potential link to specific watershed management plan goals. If, for example, one objective of a project was to restore riparian vegetation and habitat, the riparian zone element scores could be compared before and after project implementation to evaluate success or failure of the restoration effort. If this study can demonstrate that SVAP scores are consistent over time in the absence of major watershed changes, then the SVAP could provide a cost-effective method to monitor stream corridor conditions over time, including assessing the effects of stream restoration project implementation.

METHODS

Study Area

Cayuga Creek originates in the Town of Lewiston, in western New York and the creek flows southwest into the City of Niagara Falls to its confluence with the Little Niagara River, which is upstream of Niagara Falls (Figure 1). The creek is 16 km long and has a drainage basin area of 91 km^2. Land use in the watershed is mixed, with the largest portion of the watershed being classified as agriculture (40%) followed by residential (21%), forest (11%), and commercial (10%) (Gould et al., 2009). The majority of agricultural land use is in the upper portion of the watershed, while the middle and lower portions of the watershed are characterized as residential and commercial, with increasing urbanization in the City of Niagara Falls (Gould et al., 2009).

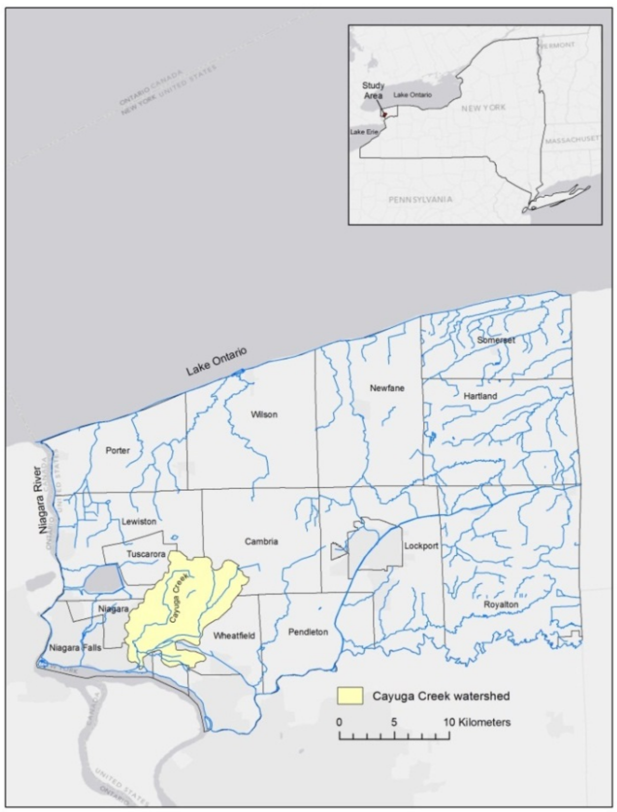

Figure 1. Map of the Cayuga Creek watershed, including towns in Niagara County, NY.

Cayuga Creek is tributary to the Niagara River, which has been designated by the International Joint Commission (IJC) as an Area of Concern (AOC). AOC designations result when one or more Beneficial Use Impairments (BUI) (e.g., degradation of fish and wildlife populations, loss of fish and wildlife habitat) are impaired. Cayuga Creek, and its main tributary, Bergholtz Creek, are also listed on the New York State 303(d) List of Priority

Waterbodies for organics, toxicity, nutrients and pathogens (New York State Department of Environmental Conservation (NYSDEC), 2010). As a result of impaired environmental conditions, Cayuga Creek has been the target of on-going watershed management planning activities by the Cayuga Creek Steering Committee (Frothingham, 2010). One product of the Steering Committee's work is the Cayuga Creek Watershed Restoration Road Map (CCWRRM), which identifies numerous potential stream restoration projects in the watershed (Ecology and Environment, Inc., 2009). However, none of the projects have been implemented thus far.

SVAP Procedures

In 2004 and 2008, SVAP field investigations took place in reaches of Cayuga Creek under lowflow conditions between late September and early November (Frothingham et al., 2009; Frothingham and Brown, 2005). Trained two- to three-person field crews scored the following elements in reaches of the creek during both assessments: (1) channel condition, (2) riparian zone, (3) bank stability, and (4) water appearance (Table 1). These four elements were assessed because previous research identified changes in land use (Gould et al., 2009) and water quality impairments (NYSDEC, 2010) in the creek. Typically, each reach was 12 times the bankfull channel width, although reaches were assessed separately if major changes in the conditions being assessed occurred over a shorter length of stream (NRCS, 1998). Elements were scored on a one (poor) to 10 (excellent) scale using the scoring descriptions provided in the SVAP manual (NRCS, 1998) (Table 1). Individual element scores were averaged to determine the overall SVAP score of each reach. In addition, a general description of each reach was documented in the field, the reach was sketched, and a digital photograph was taken. Channel width (lowflow and bankfull), depth (lowflow and bankfull), reach length, and dominant substrate type also were recorded on field sheets.

The length of each reach and, therefore, the total number of reaches assessed varied slightly between 2004 and 2008 (Table 2). A total of 44 stream reaches were assessed in 2004 (Frothingham and Brown, 2005) and 53 reaches were assessed in 2008 (Frothingham et al., 2009). As a result of the different reach lengths, it was not possible to compare overall and individual element SVAP scores in each reach as they were defined in 2004 and 2008; therefore, reaches were combined into eight sections using the reach length data and photo indexes from 2004 and 2008 (Frothingham et al., 2009; Frothingham and Brown, 2005) (Table 2; Figure 2). Stream Section 1 was located in the upper portion of the watershed and the sections progressed in the downstream direction (Figure 2). The reach element and overall scores were averaged for each section and compared.

Crews for both field campaigns received the same training, as this has been shown to improve the precision and accuracy of visually-based stream assessment protocols (Bjorkland et al., 2001; Hannaford et al., 1997). Training consisted of two components: (1) a two-hour session covered how to use the SVAP, including a review of the narrative scoring descriptions of each stream element and photos representative of at least poor and excellent element conditions, and in many cases, intermediate conditions, and (2) a group field trip to Cayuga Creek where crew members were given the opportunity to independently score elements in two reaches of the creek. Each crew had a SVAP reference sheet in the field that included short element descriptions with the element score ranges. Reference sheets were recommended by the modified HSVAP (NRCS, 2001b) and were easier to use in the field than the full 36-page SVAP manual (NRCS, 1998).

Data Analysis

Overall and element SVAP scores from 2004 and 2008 were compared using Mann-Whitney U tests, which were calculated using Microsoft Excel. A $\alpha=0.05$ significance level was used and the null hypothesis was that there was no significant difference between SVAP scores assigned in 2004 and 2008. This hypothesis stems from the fact that Cayuga Creek has been extensively studied and no major changes (e.g., major storm events, land use changes, stream channel modification) occurred during the four-year period between 2004 and 2008.

RESULTS

The 2004 and 2008 SVAP scores by study section for the overall and element scores are in Table 3. The 2004 and 2008 overall SVAP scores for all the sections were not statistically different at the $\alpha = 0.05$ level ($U = 15$, $p = 0.083$) (Table 3; Figure 3). All the overall SVAP section scores were low (≤ 7.4; a fair SVAP rating) (see Table 1) and 63% of the sections (Sections 3-4 and 6-8) had SVAP scores in both years that were less than 6.0, which is a poor SVAP rating.

Table 1. SVAP Element Descriptions and Scores (after NRCS, 1998)

Channel Condition			
Natural channel; no structures, dikes. No evidence of downcutting or excessive lateral cutting.	Altered channel; <50% of the reach with riprap and/or channelization. Excess aggradation; braided channel. Dikes or levees restrict floodplain width.	Evidence of past channel alteration, but with significant recovery of channel and banks. Any dikes or levees are set back to provide access to an adequate floodplain.	Channel is actively downcutting or widening. >50% of the reach with riprap or channelization. Dikes or levees prevent access to the floodplain.
10	7	3	1

Riparian Zone				
Natural vegetation extends at least two bankfull channel widths on each side.	Natural vegetation extends one bankfull channel width on each side. or If less than one width, covers entire floodplain.	Natural vegetation extends half of the bankfull channel width on each side.	Natural vegetation extends a third of the bankfull channel width on each side. or Filtering function moderately compromised.	Natural vegetation less than a third of the bankfull channel width on each side. or Lack of regeneration. or Filtering function severely compromised.
10	8	5	3	1

Bank Stability			
Banks are stable; banks are low (at elevation of active floodplain); 33% or more of eroding surface area of banks in outside bends is protected by roots that extend to the baseflow elevation.	Moderately stable; banks are low (at elevation of active floodplain); less than 33% of eroding surface area of banks in outside bends is protected by roots that extend to the baseflow elevation.	Moderately unstable; banks may be low, but typically are high (flooding occurs 1 year out of 5 or less frequently); outside bends are actively eroding (overhanging vegetation at top of bank, some mature trees falling into steam annually, some slope failures apparent).	Unstable; banks may be low, but typically are high; some straight reaches and inside edges of bends are actively eroding as well as outside bends (overhanging vegetation at top of bare bank, numerous mature trees falling into stream annually, numerous slope failures apparent).
10	7	3	1

Water Appearance			
Very clear, or clear but tea-colored; objects visible at depth 3 to 6 ft. (less if slightly colored); no oil sheen on surface; no noticeable film on submerged objects or rocks.	Occasionally cloudy, especially after storm event, but clears rapidly; objects visible at depth 1.5 to 3 ft.; may have slightly green color; no oil sheen on water surface.	Considerable cloudiness most of the time; objects visible to depth 0.5 to 1.5 ft.; slow sections may appear pea-green; bottom rocks or submerged objects covered with heavy green or olive-green film. or Moderate odor of ammonia or rotten eggs.	Very turbid or muddy appearance most of the time; objects visible to depth < 0.5 ft.; slow moving water may be bright green; other obvious water pollutants; floating algal mats, surface scum, sheen or heavy coat of foam on surface. or Strong odor of chemicals, oil, sewage, other pollutants.
10	7	3	1

Table 2. Study Sections

Section Number	2004 SVAP Section Length m (feet)	Number of Reaches Assessed in 2004	2008 SVAP Section Length m (feet)	Number of Reaches Assessed in 2008
1	779 (2,555)	8	820 (2,690)	13
2	593 (1,945)	6	524 (1,720)	7
3	251 (823)	3	239 (783)	4
4	378 (1,246)	5	428 (1,403)	6
5	578 (1,902)	8	681 (2,235)	8
6	353 (1,158)	4	472 (1,550)	4
7	313 (1,027)	3	472 (1,550)	4
8	749 (2,457)	7	793 (2,503)	7

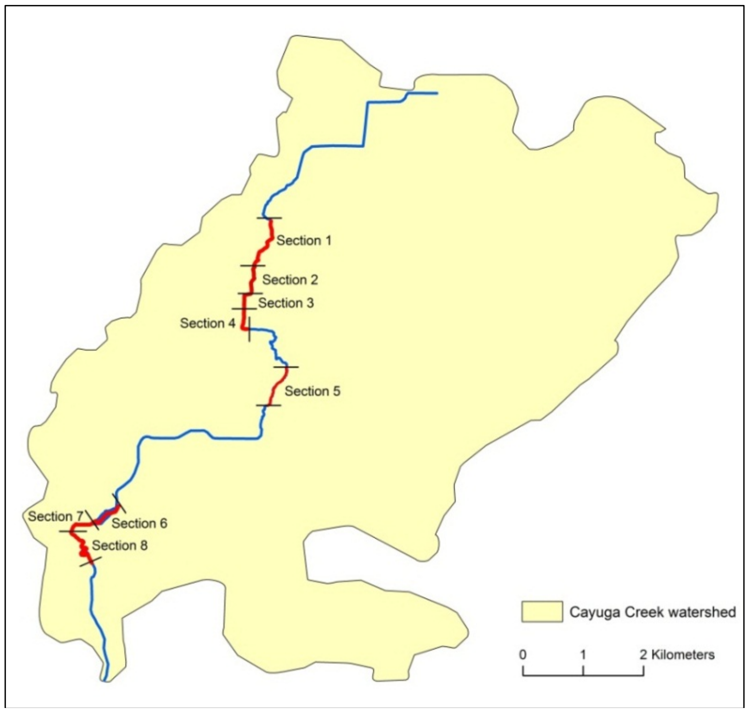

Figure 2. Cayuga Creek watershed map with study sections identified.

The 2004 and 2008 channel condition SVAP scores were significantly different ($U = 11.5$, $p = 0.028$) (Table 3; Figure 4). In Sections 1, 6, and 7 the average channel condition scores were relatively high (8.5, 8.3, and 7.7, respectively) and decreased in 2008 to low scores (3.8, 5.0, and 2.8, respectively) (see Table 1). Average bank stability scores were also significantly different ($U = 12$, $p = 0.038$) (Table 3; Figure 4). Most (75%) of the section bank stability scores were low (≤7.4) in both years; however, in Sections 1 and 2 the scores decreased from 7.6 and 8.0 in 2004 to 4.4 and 6.4 in 2008, respectively (see Table 1). Conversely, riparian zone and water appearance scores from 2004 and 2008 were not significantly different ($U = 30$, $p = 0.878$ and $U = 26$, $p = 0.574$, respectively) (Table 3; Figure 4). Overall, the riparian zone and water appearance section scores were low (≤7.4) (see Table 1) and similar in both 2004 and 2008.

DISCUSSION

The main objective of this study was to determine if the SVAP could be used to define stream corridor conditions over time. We tested this application by conducting the same assessment using the same methods in the same place, but with a four-year period between measurements under the assumption that any variability in scores would reflect the imprecision in the methodology rather than a systematic change in the stream itself. Results showed that the overall scores were not significantly different between 2004 and 2008 (Table 3; Figure 3), which was expected given the fact that major watershed changes did not occur between 2004 and 2008.

Table 3. Stream Visual Assessment Protocol Comparison Results by Section

		SVAP Score				
Section Number	**SVAP Year**	**Overall Score**	**Channel Condition**	**Riparian Zone**	**Bank Stability**	**Water Appearance**
1	2004	7.0	8.5	5.3	7.6	6.8
	2008	5.0	3.8	7.4	4.4	4.5
2	2004	6.8	8.5	6.5	8.0	4.0
	2008	6.6	7.0	8.6	6.4	4.4
3	2004	4.8	3.3	4.3	4.7	7.0
	2008	3.9	4.0	2.5	4.5	4.5
4	2004	5.3	4.6	3.4	5.2	8.0
	2008	4.5	5.0	2.8	4.3	5.8
5	2004	7.0	7.4	5.9	7.1	7.8
	2008	6.2	6.4	5.7	6.4	6.3
6	2004	5.3	8.3	7.3	5.8	2.0
	2008	5.2	5.0	7.9	5.4	2.5
7	2004	6.1	7.7	6.3	7.0	3.3
	2008	3.7	2.8	4.1	5.0	3.0
8	2004	5.8	7.0	6.0	6.9	3.4
	2008	5.4	4.1	6.4	5.9	5.0

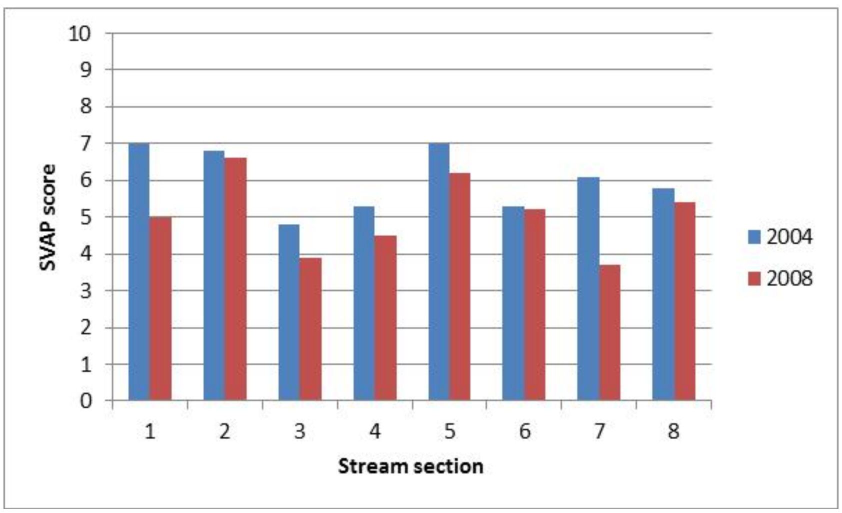

Figure 3. Overall Stream Visual Assessment Protocol scores for the stream sections in 2004 and 2008.

Individual element scores (e.g., channel condition, riparian zone, bank stability, and water appearance), however, showed greater variability (Table 3; Figure 4). Based on working in the watershed and a thorough review of the 2004 and 2008 field sheets and photo indices, we believe that the differences noted from the statistical analysis were not due to actual changes in stream corridor conditions, rather the differences are likely attributable to training and the relative ease of assessing each individual element. Other studies have attributed differences in SVAP scores to variability in crew member training and experience with stream assessments (Hughes et al., 2010; Bjorkland et al., 2001). The ease of assessing individual SVAP elements has been addressed in the updated SVAP2, as that protocol "was developed to provide more comprehensive descriptions of several scoring elements" (NRCS 2009, pg. i).

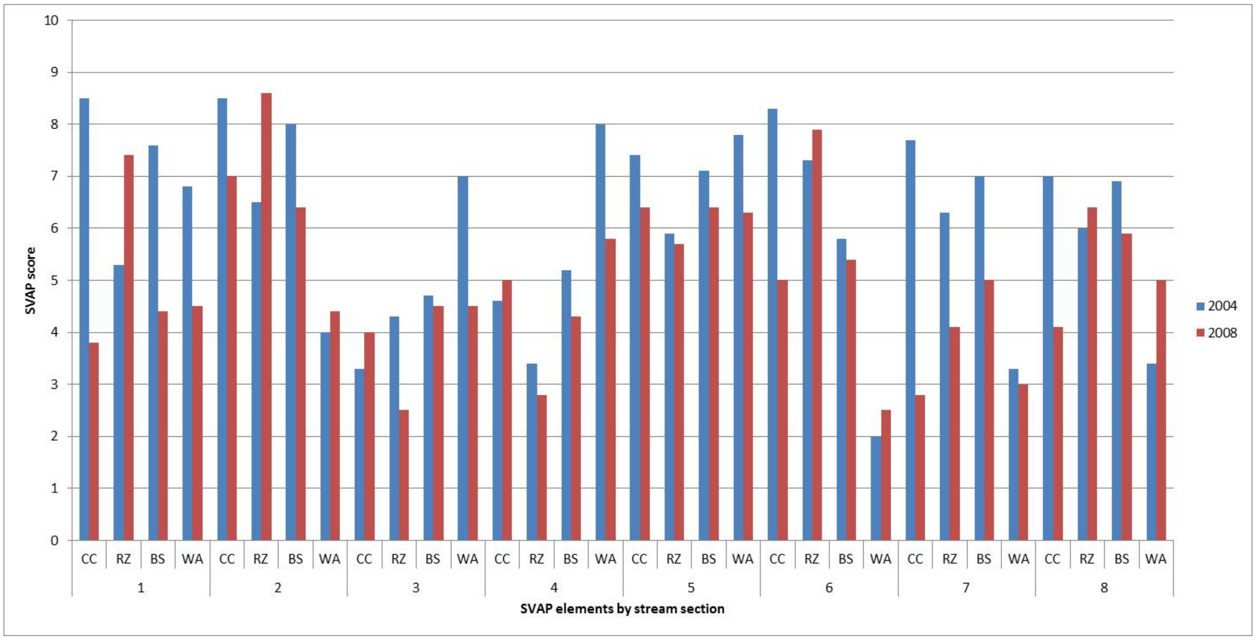

Figure 4. Stream Visual Assessment Protocol element scores for the stream sections in 2004 and 2008. CC = Channel Condition; RZ = Riparian Zone; BS = Bank Stability; WA = Water Appearance

Both the riparian zone and water appearance SVAP element assessments are based on detailed scoring descriptions with specific measures (width and water color, respectively) (see Table 1), making these elements relatively easy to assess. The riparian zone element assesses the width of the natural vegetation zone (or introduced vegetation that functions like native plants) from the edge of the bankfull channel out onto the floodplain (NRCS, 1998). Crew members were instructed in training to look for vegetation that could reduce the amount of surface runoff to the stream, help control erosion, dissipate energy during flood events, and provide shade, habitat, and organic matter. Specific vegetation widths are provided in the SVAP manual (see Table 1); for example, a high riparian zone score is given when vegetation extends at least two bankfull channel widths from the edge of the bankfull channel and lower scores result as the width is reduced to less than a third of the width of the bankfull channel (NRCS, 1998). Similarly, water appearance is based on water clarity and the SVAP manual provides specific scoring descriptions of water color (see Table 1). In fact, the SVAP manual states, "Clarity of the water is an obvious and easy feature to assess" in regard to water appearance (NRCS, 1998, pg.11). The water color scoring descriptions range from "very clear, or clear but tea-colored…no oil sheen or film on surface…no noticeable film on submerged objects or rocks" (high score) to "very turbid or muddy appearance…floating algal mats…heavy coat of foam on surface" (low score) (NRCS, 1998, pg.11).

Conversely, the channel condition and bank stability element scoring descriptions are not as detailed (see Table 1) and these elements assess complex channel processes that may require more training than needed for the other two elements. In fact, both the channel condition and bank stability elements were revised considerably in the SVAP2 manual (NRCS, 2009) to include more detailed descriptions. The channel condition SVAP element (NRCS, 1998) requires crew members to look for evidence of past channelization, presence or absence of riprap, and recovery of the stream from human impacts. Channel incision, widening, and deposition are also assessed using this element. The channel condition scoring description refers to "excessive aggradation" and "significant recovery of channel and banks" (NRCS, 1998, pg.7), but no specific measures of, for example, depth of bed material or sinuosity, are provided in the SVAP manual. A thorough understanding of channel planform patterns in natural versus modified channels and the ability to identify signs of recovery in a modified channel and channel incision are necessary to increase the accuracy of determining a channel condition score. The SVAP2 channel condition element is based the Channel Evolution Model (CEM) (Schumm et al., 1984; Simon 1989), which provides a more detailed description of how to identify channel instability based on current stream channel form. The bank stability SVAP element (NRCS, 1998) focuses on the elevation of the bank relative to the active floodplain and whether or not there is vegetation on the bank and, if so, whether or not the vegetation roots extend to the baseflow water elevation. Focusing on factors such as bank height, angle, and composition, plus the vegetation root depth and density in training would be valuable to better assess the bank stability element. In SVAP2, the name of this element has been revised to bank condition and the description focuses on bank protection by natural vegetation and riprap or other structures (NRCS, 2009).

Finally, the method specified by the SVAP for defining stream reaches (i.e., 12 times the bankfull channel width) makes year-to-year comparisons challenging because previously defined reaches can be difficult to relocate. The SVAP manual (NRCS, 1998) describes visual indicators of bankfull width, such as a break in slope on the bank, a change in vegetation, and debris along the bank, but accurately estimating bankfull width can be difficult (Shields et al., 2003). Moreover, having a fixed reach length will make quantitative analysis easier when comparing SVAP scores over time or from reach to reach. This study addressed the issue of varying reach lengths by combining reaches into stream sections. Additionally, field crews in 2008 were instructed to record GPS coordinates at the upstream end of each reach, so reaches could be identified in future assessments of the stream. Alternatively, a fixed reach length could be determined prior to data collection; for example, other studies using the SVAP defined fixed reach lengths that ranged from 20 to 200 meters (de Jesús-Crespo and Ramirez, 2011; Hughes et al., 2010; Ward et al., 2003; McQuaid and Norfleet, 1999).

CONCLUSIONS

Results of the analysis comparing overall SVAP scores over time indicate that the SVAP is an appropriate tool to monitor on-going and post-project stream corridor conditions. Overall SVAP scores were similar in 2004 and 2008 and were reflective of other studies that have found poor stream corridor conditions in Cayuga Creek (NYSDEC, 2010; Ecology and Environment, Inc., 2009). Thus, the SVAP is a useful tool for watershed management plans that call for a cost-effective method of monitoring stream corridor conditions over time, including assessing the effects of stream restoration project implementation. Moreover, the SVAP is similar to what currently is being done during post-project monitoring (e.g., visual surveys of the site, photo documentation) (Palmer et al., 2007), with the added benefits of using a standard method and having the SVAP scores for comparison purposes. The analysis of the individual SVAP elements yielded mixed results, indicating that linking individual element scores to specific watershed management plan goals may not be advisable. The SVAP manual provides straightforward, measureable scoring descriptions for the riparian zone and water appearance elements, which likely contributed to the 2004 and 2008 riparian zone and water appearance elements scores being the same over time. However, there were significant differences between the 2004 and 2008 channel condition and bank stability element scores despite the fact that there was an absence of major watershed changes. Some of the element description issues noted in this study have been addressed by the revised and updated SVAP2 (NRCS, 2009); however, the channel condition and bank stability/condition elements still require a more advanced level of understanding of channel processes. We recommend providing better, more detailed training to field crews on complex channel processes, which might result in more comparable results over time for these elements; however, this study was not designed to test that hypothesis.

One notable benefit of the SVAP is the ability to modify the protocol to better suit a particular geographic location and/or a specific watershed management plan (de Jesús-Crespo and Ramirez, 2011; Bjorkland et al., 2001; NRCS, 2001b; NRCS, 1998). Based on the problems associated with reach length encountered during this study, changing the definition of reach length is recommended for monitoring stream corridor conditions over time. A standard reach length could be selected based on what other researchers have done (de Jesús-Crespo and Ramirez, 2011; Hughes et al., 2010; Ward et al., 2003; McQuaid and Norfleet, 1999) or GPS coordinates could be recorded, which would give future field crews the ability to accurately locate each reach.

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