SIMPLE ALTERNATIVE METHODS FOR THE BIOLOGICAL COMPONENT OF WATERSHED ASSESSMENTS

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Abstract. Bioassessments have become useful tools for understanding and rating stream health. The most widely used bioassessments analyze macroinvertebrate communities in order to reach conclusions about water quality. Many state agencies have designed protocols for macroinvertebrate bioassessments and non-government organizations also have adopted their own protocols that are simplified but still effectively measuring stream health. We will compare results from two simplified bioassessment protocols to those produced by the Georgia EPD bioassessment protocol. Our objectives are to determine whether or not the simplified methods produce the same quality data and some inference as that of the EPD methods. We also look at seasonal differences in results to determine whether time of sampling influences results. Currently, our data is limited to four sampling sites in Statham, GA that have been sampled over the fall and winter seasons. We intend to add 11 more sites for fall and winter, and also include spring samples for all 15 sites. Assessment scores varied little over the five sites, and with this limited data set there are inconsistencies of ratings between the two simplified methods compared to the EPD methods. We have also not yet produced any evidence of water quality ratings being affected by sampling in different seasons. Previous studies have shown that at least one of the simple methods produces results consistent to more complex methods, and that macroinvertebrate community structure does undergo seasonal changes. Due to the insufficient amount of data collected at this time, we are unable to reach solid conlusions.

INTRODUCTION

Water quality problems are best managed at a watershed scale where point and non point pollution entering all connected bodies of water in a localized drainage area can be addressed (GA EPD 2005). Watershed monitoring should be stratified to observe how various land uses and point discharges effect stream quality (Fore et. al.1996, Karr 1990, Muenz et. al. 2005, Risse et. al. 2004, Stoneburner et. al.1976). The Georgia EPD requires that all cities and counties that hold water withdrawal or wastewater discharge permits, conduct an extensive Watershed Protection Plan (WPP) and follow up every two years on the progress of this plan through a Watershed Assessment (WA) (GA EPD 2005). These assessments are required by EPD to be carried out at the expense of the communities' Wastewater Treatment Facilities (GA EPD 2005).

Through the WA, the chemical, physical, and biological factors are assessed relative to reference stream conditions (GA EPD 2005). A large part of the biological assessment is composed of the collection and identification of macroinvertebrates present at the sample site (Barbour et. al. 1999). Inferences can be made about the overall health of the stream by relating the life histories of present or absent macroinvertebrate species to stream conditions (Barbour et. al. 1999, Cairns et. al. 1971, Firehock et. al.1995, Fore et. al. 1996, Muenz et. al. 2005). Currently, the Standard Operating Procedure (SOP) for the macroinvertebrate bioassessment requires minimal sample collection, highly randomized and specified sorting techniques, and also a low taxonomic resolution of macroinvertebrate which requires a high level of skill for identification. Because of these high standards, the bioassessment portion of WA's becomes very costly.

It is possible that alternative procedures for biological assessments could produce equivalent relative ratings and require less time, training, and expense. A popular bioassessment used throughout the US is The Adopt-A-Stream (AAS) macroinvertebrate sampling protocol (GA DNR 2000). This Protocol requires less sampling effort, generalized sorting techniques and is designed to be used by people with limited knowledge in the science of aquatic entomology (GA DNR 2000, Muenz et. al. 2005). An additional method used for biological assessments based on macroinvertebrate communities is termed the Sequential Comparison Index (SCI), which is also a simplified method using macroinvertebrates to rate stream health (Cairns et. al.1668 and 1971, Stoneburner et. al. 1976).

In this study, water quality ratings derived from the bioassessment portion of the EPD Watershed Assessment Protocol, AAS and SCI will be evaluated and compared. These findings may show simple methods can be used and the costs of treatment facilities can be reduced, lightening workloads while continuously ensuring reliable water quality data, resulting in additional effort and money to be put towards other issues such as the progress of the WPP. Our objectives will be to compare seasonal samples taken according to the AAS procedure to that of the annual sample from EPD to determine if season impacts bioassessment scores. Also, we will compare scores calculated from the 3(AAS, SCI and EPD) procedures and determine if there is a correlation between the complex EPD procedure and the two simple procedures.

BACKGROUND

Bioassessments are important for evaluating water quality because they are able to detect human impacts that have lasting effects on the biological integrity of the stream that may go unnoticed using only physical and chemical monitoring (Barbour et. al. 1999, Cairns et. al. 1971, Firehock et. al.1995, Fore et. al. 1996, GA DNR 2000, Muenz et. al. 2005). Bioassessments enable resource managers to directly measure time integrated conditions of the stream (Karr 1990). Aquatic macroinvertebrates are often the preferred tool for measuring the biological portion of the stream assessment for a number of reasons (Barbour et. al. 1999). They are ubiquitous as they are not limited by light (as are microorganisms) or space (as are fish). Macroinvertebrates are always present in measurable quantities during baseflow conditions except under the most extreme conditions. The most useful attribute to using macroinvertebrate as a tool of measurement for water quality is the ease of obtaining and preserving samples. Aquatic macroinvertebrates encompass a large variety of species that occur in a wide range of wet habitats, life histories and tolerances to disturbed conditions (Barbour et. al. 1999). For these reasons, the community structure of these macroinvertebrates can provide clues to the functioning of the stream ecosystem as a whole (Karr 1990, Barbour et. al. 1999, Stoneburner 1976).

The types of macroinvertebrates that are predicted to be present at a site in undisturbed conditions are characteristic of the ecoregion in which they live (GA EPD 2004). The ecoregion classification is based upon many environmental factors that influence an area such as, geology, altitude, latitude, annual precipitation, and native vegetative cover (Johnson 2000, GA EPD 2004). This concept implies that the absence of macroinvertebrate species at a site may not always be due to human-induced or natural disturbances (GA DNR 2000).

Adopt-A-Stream is a nationwide program that strives to bring learning experiences in natural resources to communities with a focus on stream and riverine ecosystems. This program has developed a procedure for monitoring the physical, chemical and biological conditions that is usable by the average person after attending a short training seminar. Once the seminar has been completed, volunteers are able to monitor streams they are concerned for on their own time, or have an opportunity to become certified to report measurements taken during monitoring to DNR for official documentation (GA DNR 2000). The AAS provides volunteers with a 60 page procedure and a list of equipment which is easy to obtain, affordable by the average person, and relatively simple to use (GA DNR 2000). The bioassessment portion of the AAS protocol measures water quality based on species richness of the macroinvertebrate community that is assessed through a composite sample from multiple stream habitats.

Sequential Comparison Index is a method that also provides water quality ratings based upon the number of taxa collected while tying in the contribution each taxa gives to the entire community composition of the sample (Cairns 1968). This is a method for analyzing data and can therefore be used without regard for sampling protocol. Sampling procedures used in this study will follow the AAS and this index will be applied to those samples for simplicity.

METHODS

Fifteen sampling sites are located in the piedmont ecoregion of Georgia. Four of the 15 sites are located in Barrow County, GA (Figure 1) and the remaining eleven are within Franklin County, GA (Figure 2).One of the 15 sites was determined to be a high gradient rocky bottom stream, while the rest were decided to be muddy bottom according to the AAS protocol. Eleven of the sampling locations were classified as streams and four were classified as wadeable rivers. The 15 sites visited were chosen because they had previously been sampled and scored according to the scale set by EPD protocol (Table 1) which will be compared to the results of this study.

The AAS macroinvertebrate protocol was followed for the collection of macroinvertebrate samples and also stream quality assessment. The sampling method is determined once the stream substrate is evaluated and classified as being muddy bottom or rocky bottom (GA DNR 2000). With muddy bottom streams, three habitats will be sampled with a dip net. The dip net is used to collect seven scoops from vegetated margins, four scoops from woody debris/organic matter, and three scoops from coarsest substrate of the streambed. With each scoop from vegetated margin and woody debris habitats, the frame of the net is used to dislodge organisms by disturbing the sample area which is one square foot per scoop. It is important to keep the net facing upstream and care is taken so the net is not tilted in a manner that allows any of the sample material to be carried away with the current. The coarsest area of the stream bed is sampled by securing the dip net in the streambed, facing up-current, and using footwork to disturb the bed in a square foot area. It is also recommended to gently rub larger rocks clean with hands. It is best to empty the sample contents in the net into a sieve bucket between each scoop. Also, thoroughly rinse the sample to remove as much sediment as possible while in the sieve bucket. Once all habitats have been sampled accordingly, the contents in the sieve bucket are transferred to a labeled, one gallon, Ziploc freezer bag not exceeding 2/3 full. Multiple bags may be used if needed and must be labeled with site and date. With the bag secure, it is placed into a second Ziploc bag and a labeled waterproof and alcohol-proof tag is also placed into the second bag. The double-bagging is recommended to reduce leaks which can occur. Organisms are fixed in a 70% alcohol solution and stored in a cooler as soon as possible.

With rocky bottom streams, the method is very similar, but altered slightly. From riffle areas, three scoops, four square feet each, are sampled, similar to the coarse streambed method for muddy bottom streams. The dip net is placed securely on stream bottom and the stream bed is kicked up over a four square foot area. Along with the riffle habitat, four handfuls of partially decomposed leaf packs are obtained and placed in the sieve bucket. The sample is rinsed, bagged, and preserved as before.

Along with biological assessment, it is important to record chemical conditions of the water at the time of sampling. For this study, air temperature (^{o} C), water temperature (^{o} C), pH, dissolved Oxygen (mg/L and %), and specific conductivity (µS/cm) were measured with a portable multiprobe water analyzer (Quanta by Hydrolab Corporation, Austin Texas) calibrated prior to sampling. A turbidimeter (Hach portable) was used to determine turbidity of samples taken mid depth and midstream of free-flowing water. A Hach Fish Farming Kit was used to determine total hardness (mg $CaCO_3$/L) and alkalinity (mg/L). These methods are modified from the AAS chemical monitoring protocol but are common tools used to quantify chemical characteristics on site.

The macroinvertebrates are moved to the lab instead of streamside sorting recommended by AAS, and two methods are used for sorting. The first method used is the AAS macroinvertebrate procedure. To begin, the sample is sorted by removing and rinsing large intact leaves and twigs, being careful not to lose any macroinvertebrates. The remaining sample is transferred to a white pan and closely examined with forceps to remove macroinvertebrates until a count of 200 is reached. The 200 specimens are divided into three containers ¾ filled with 70% ethyl alcohol with the first 100 specimens designated to the first container, and 50 specimens for both the second and third containers.

The first 100 macroinvertebrates are identified using AAS Macroinvertebrate Field Guide for Georgia Streams. Following the AAS protocol, the number of individuals present in each family is indicated by letters A, B and C. Each of the three categories is assigned a value based on tolerance/intolerance, and the number of families observed in a category is multiplied by this value. All three categories are summed to produce a final rating which is fitted into range of numbers that distinguish between excellent, good, fair, and poor water quality (Table 2).

To begin the SCI assessment, the first 100 specimens are randomly mixed by swirling the container and the contents are poured into lined, white pan (Cairns et. al. 1968 and 1971). The random placement of the specimens will allow one to divide the sample into “runs”, so a ratio of runs to total specimens can be computed. Runs are determined by the comparison of two specimens chosen at random, with two specimens similar in shape being grouped into one run and differing specimens are separated into differing runs. The first specimen chosen is designated as “1” and is placed in “run 1”. If specimen number “2” is similar in shape to specimen “1”, then it is also placed in “run 1”. If specimen “3” is different in shape than the previous two, then it is placed in the next run, “run 2”. This is continued until all 100 specimens are accounted for. The procedure is then repeated after the next 50 macroinvertebrates from the site sample are added and mixed to the first 100 to give a total of 150 specimens. Finally the procedure is again repeated with the examination of all 200 specimens collected in the sample. To determine water quality through this method, the number of runs are divided by the total number of specimens from each trial and then averaged. Finally, this number is multiplied by number of taxa observed (based on shape) in the entire sample. Healthy streams will produce results of twelve or greater and polluted streams result in numbers below eight (Table 3).

The results from both AAS and SCI will be compared to results determined by the EPD Bioassessment Protocol and will also be compared by season. A pairwise T-test will be applied to scores to determine any significant differences between seasonal samples (Table 4).

RESULTS

Currently, the Statham sites are the only fully processed sites for the seasons of fall and winter, and data is limited to eight processed samples. Unfortunately, scores for these four sites showed little variation (all sites fell in the “fair” to “good” category by the EPD method). Within this limited data set, there was no correlation in index scores for these eight sites between both EPD vs. SCI and EPD vs. AAS methods (Figure 3 and 4). Both

AAS and SCI bioassessments rated water quality more favorably when compared to the EPD bioassessment. Three of the sites were placed in the "Fair" Category by EPD, and during fall and winter both AAS and SCI placed the same three streams in either the "good" or "excellent" categories. At this same site, the AAS ratings were different from the other two indices, determining "fair" water quality in the fall and "excellent" water quality in the winter.

The data between the three methods for rating water quality are difficult to compare due to their scale differences. The EPD has the largest scale being from one to 100 and scores are divided into five categories. AAS differentiates between four categories and has a scale between 0 and >22 with an undefined maximum. SCI is the simplest by having three categories but also has an undefined maximum with the scale ranging from 0 to >12. Because of these differences, T-tests were not applicable to the data for the comparison of the three index methods to each other.

Addressing seasonality, the four sites observed over fall and winter showed no differences in scores between all three indices (Table 5). A pairwise T-test was run between the two seasons for each simple index method (Table 6 and 7). All three tests showed no differences between scores calculated from fall and winter, indicating that seasonal sampling does not impact water quality scores, but spring samples have not yet been compared. Although there was no difference between index scores calculated from changing seasons, water chemistry data did show some seasonal differences (Table 8). ANOVA was used to analyze and compare all water chemistry data collected from the 15 sites during fall, winter and spring. Air and water temperatures were similar in the winter and spring seasons, but fall was significantly different from both winter and spring. Dissolved oxygen (mg/L) was similar only between fall and spring. A significant difference between spring to fall and winter was indicated for specific conductivity (µS/cm). The mean pH significantly differed between winter and spring. Turbidity (NTU) was only different between fall and spring. Bothe alkalinity (mg/L) and total hardness (mg $CaCO_3$/L) were consistent through all three of the sampling seasons. Strictly from the results presented here, the lack of seasonal difference in macroinvertebrate samples is not in correlation with water chemistry, as water chemistry does show some changes by season.

Table 1. Rating intervals for calculated scores using EPD Index for bioassessment.

EPD	
Rating	**Score**
Very Poor	>95
Poor	75 through 95
Fair	25 through 75
Good	5 through 25
Very Good	<5

Table 2. Rating intervals for calculated scores using AAS Index for bioassessment.

AAS	
Rating	**Score**
Poor	<11
Fair	11 through 16
Good	17 through 22
Excellent	>22

Table 3. Rating intervals for calculated scores using SCI Index for bioassessment.

SCI	
Rating	**Score**
Poor	<8
Fair	8 through 12
Good	>12

Table 4. Explanation of seasonal sampling intervals

Season	Time Period
Fall	August - October
Winter	October - February
Spring	March - May

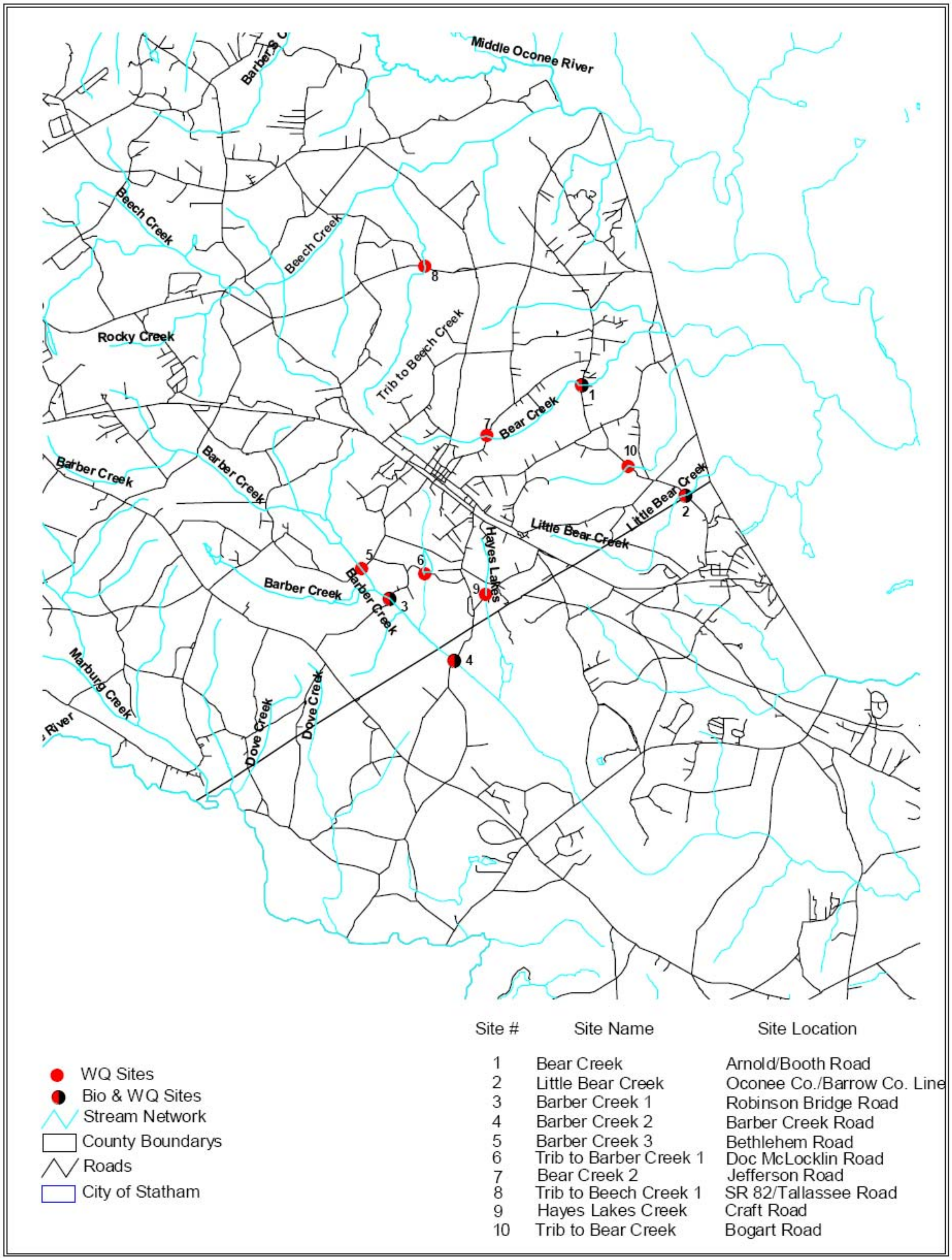

Figure 1. Sampling sites in Barrow County (denoted by red and black circle).

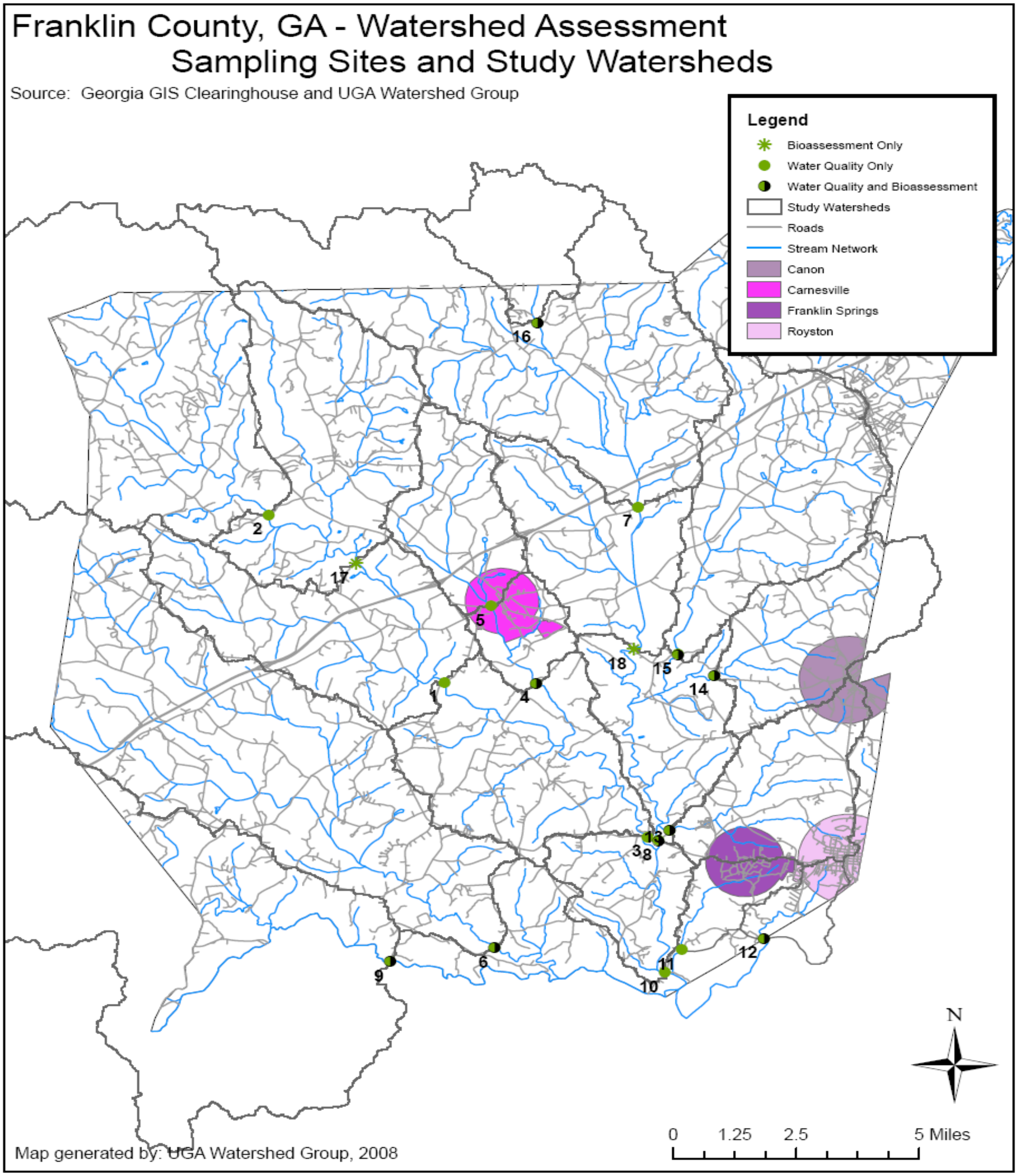

Figure 2. Sampling sites in Franklin County (denoted by green and black circle).

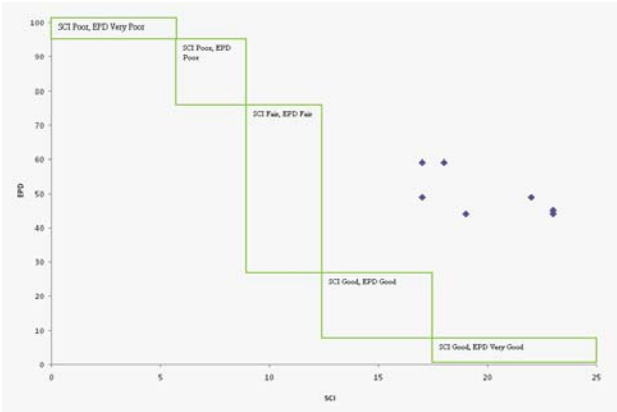

Figure 3. AAS water quality scores and categories for fall and winter vs. EPD annual water quality scores and categories from four Statham, GA sites.

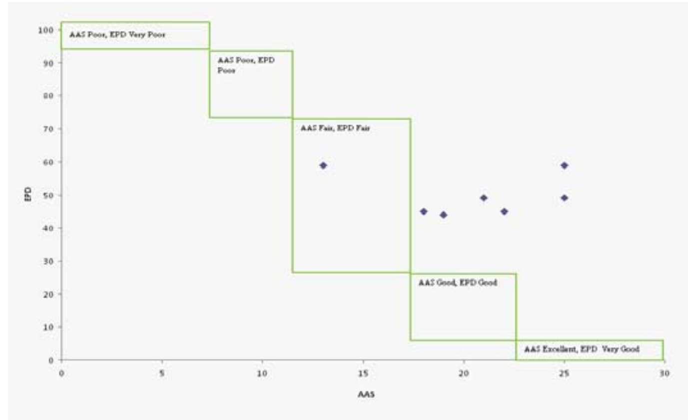

Figure 4. SCI water quality scores and categories for fall and winter vs. EPD annual water quality scores and categories from four Statham, GA sites.

Table 5. Index scores and corresponding categories determined by AAS, SCI and EPD methods for biological assessment from four Statham, GA sites during three sampling seasons.

Site	date	AAS		SCI		EPD	
		Score	Category	Score	Category	Score	Category
Bear Creek	Fall	19	Good	23	Good	44	Fair
Bear Creek	Winter	19	Good	19	Good	44	Fair
Little Bear Ck	Fall	21	Good	22	Good	49	Fair
Little Bear Ck	Winter	25	Excellent	17	Good	49	Fair
Barber Ck	Fall	18	Good	23	Good	45	Fair
Barber Ck	Winter	22	Good	23	Good	45	Fair
Barber Ck at BC Rd.	Fall	13	Fair	17	Good	59	Good
Barber Ck at BC Rd.	Winter	25	Excellent	18	Good	59	Good

Table 6. Water chemistry for Statham, GA and Carnesville, GA sites measured at three sample seasons.

		Air Temp C	Water Temp C	Conductivity (μS/cm)	pH	DO (mg/L)	DO (%)	Turbidity (NTU)	Alkalinity (mg/L)	Total Hardness (mg $CaCO_3$/L)
Bear Creek At Arnold Rd.										
	Fall	22.03	19.27	50	6.57	15.06	194.3	15.60	17.10	17.10
	Winter	2.75	6.27	54	6.94	10.55	86.5	9.99	25.65	59.85
	Spring	17.16	12.91	52	6.65	9.12	87.4	27.60	25.65	17.10
Bear Creek at Jefferson Bogart Rd.										
	Fall	22.09	20.04	47	6.04	8.07	106.6	-	17.10	17.10
	Winter	2.75	5.61	52	6.92	10.77	87.2	3.04	25.65	34.20
	Spring	13.70	11.00	45	9.77	6.66	90.1	7.20	25.65	17.10
Barber Creek at Robertson Bridge Rd.										
	Fall	20.79	19.94	76	6.53	8.03	103.2	49.80	42.75	34.20
	Winter	8.04	5.51	57	7.76	10.45	84.0	23.40	25.65	51.30
	Spring	18.11	16.41	56	6.70	8.05	84.1	12.50	34.20	17.10
Barber Creek at Barber Creek Rd.										
	Fall	20.83	20.18	73	6.80	15.74	203.9	6.71	51.30	51.30
	Winter	5.16	7.16	63	7.13	10.36	86.8	9.99	25.65	59.85
	Spring	18.18	15.56	62	6.81	8.54	84.8	11.90	42.75	34.20
Tom's Creek at Sheriff Rd.										
	Fall	20.78	18.99	84	7.16	9.76	123.4	20.50	42.75	51.30
	Winter	4.91	4.24	88	7.24	10.91	84.9	16.90	34.20	34.20
	Spring	25.65	17.40	80	6.80	8.42	89.1	19.10	42.75	34.20
MFK Broad R. at Goolsby Rd.										
	Fall	20.82	20.37	60	7.00	7.56	97.2	15.80	34.20	34.20
	Winter	10.66	8.46	64	7.10	11.37	98.5	7.40	42.75	34.20
	Spring	-	-	-	-	-	-	-	-	-
Stephen's Creek at Aderhold Rd.										
	Fall	21.79	19.66	86	7.14	12.72	161.4	8.53	51.30	42.75
	Winter	4.11	4.85	82	7.41	10.56	83.5	14.00	34.20	34.20
	Spring	25.01	18.02	79	7.03	8.31	89.0	11.10	51.30	34.20
Unawatti Creek at Jackson Bridge Rd.										
	Fall	20.49	21.50	67	7.35	9.84	132.2	10.20	51.30	34.20
	Winter	17.85	4.91	67	7.23	12.58	100.0	11.90	59.85	34.20
	Spring	18.00	14.74	76	7.22	9.91	99.1	9.20	42.75	34.20
NFK Broad R. at Jackson Bridge Rd.										
	Fall	21.20	19.59	89	6.97	13.19	138.7	15.80	34.20	34.20
	Winter	10.51	5.60	69	7.14	13.26	107.0	7.00	42.75	34.20
	Spring	-	-	-	-	-	-	-	-	-
Double Branch Creek at New Franklin Church Rd.										
	Fall	19.06	17.86	48	7.14	5.90	74.9	13.10	25.65	17.10
	Winter	10.66	6.24	46	7.08	12.79	105.0	8.80	34.20	17.10
	Spring	15.00	13.23	47	7.15	10.13	97.9	12.60	34.20	17.10
NFK Broad R. at Hwy 51										
	Fall	18.68	18.75	61	7.79	7.47	96.3	10.90	34.20	34.20
	Winter	12.53	7.39	6	8.54	13.42	113.2	8.00	42.75	34.20
	Spring	-	-	-	-	-	-	-	-	-
Rice Creek at Rice Mill Rd.										
	Fall	20.69	18.19	46	7.05	7.43	93.7	5.75	25.65	17.10
	Winter	15.16	4.93	58	7.06	13.66	108.1	4.40	25.65	25.65
	Spring	25.00	14.92	51	7.15	9.82	98.4	6.20	25.65	17.10
NFK Broad at Hwy 106										
	Fall	21.36	20.42	70	7.50	8.33	109.4	11.90	25.65	34.20
	Winter	11.61	10.42	71	6.74	10.76	97.3	10.10	51.30	34.20
	Spring	-	-	-	-	-	-	-	-	-
Nails Creek at Carey Town Rd.										
	Fall	21.50	18.95	65	7.35	7.35	94.1	11.30	42.75	34.20
	Winter	14.62	6.32	64	7.26	12.07	99.1	10.20	42.75	34.20
	Spring	-	-	-	-	-	-	-	-	-
Hannah Creek at Sam Bruce Rd.										
	Fall	20.44	19.14	143	7.43	10.70	138.5	6.96	34.20	34.20
	Winter	13.14	8.90	109	6.96	11.65	101.8	2.70	34.20	17.10
	Spring	-	-	-	-	-	-	-	-	-

CONCLUSIONS

When interpreting this data, it must be kept in mind the data points are few and there are limited conclusions to be drawn at this point in the study. There are currently eight fully processed samples from four Statham, GA sites sampled for fall and winter. We expect to see more developed trends as the remaining samples are processed and more data points are added. Methods for comparing varying protocols have been developed and require more detailed information on data quality objectives (DQO) than is provided in this study (Diamond et. al. 1996,Barbour et. al. 1999, Herbst 2006). The most popular of these methods is termed performance-based method systems (PMBS). The PMBS has proven in other studies to be a useful tool in solving comparability problems similar to what is being encountered in this study. Lin's concordance correlations have also been used to compare results from multiple assessments (Herbst 2006, Lin 1989, Zar 1999). Methods such as these may need to be applied to this for further understanding of our results.

The EPD sampling protocol uses annual samples taken during a sampling season limited from November to February which is during the same time fall and winter samples would be taken following the AAS protocol. The AAS protocol assumes that seasons have an effect on index scores while the EPD protocol assumes one sampling season is sufficient for determining index scores. The pairwise T-tests calculated for finding seasonal trends concluded there were no significant seasonal differences between fall and winter samples. This would imply that it may not be necessary to sample in both fall and winter and the EPD method is just as effective. T-tests were also used to compare water chemistry measurements and concluded that season does have a significant impact in the fall, winter and spring. The underlying assumption that water quality can be rated using macroinvertebrate communities is based on the impacts water chemistry parameters (such as temperature, conductivity, and analyte concentrations) have on macroinvertebrate health. With this line of thinking, one would predict a seasonal change in water chemistry would result in a seasonal change in macroinvertebrate communities. Seasonal changes in index scores could also be affected by seasonal life history changes of the macroinvertebrates. In springtime many of the aquatic larvae emerge into adults who live a terrestrial life and will not be found in samples collected after this has taken place. This would greatly affect species richness which is measured in all three methods used in this study and would most likely result in significant differences between spring from fall and winter. Many other factors may affect seasonal differences such as precipitation pattern, location and land use in the watersheds. With this many factors that are known to change seasonally and impact aquatic life, we are surprised to find that even with only eight samples, there was not a significant difference. Because there were seasonal differences in water chemistry parameters with all 15 sites included and fall, winter and spring measurements collected, there may be a more significant difference between seasons in the macroinvertebrate samples once all samples are processed.

At this point in the study we remain inconclusive to whether the AAS and SCI procedures produce similar results to those produced by following the EPD procedures. Also, our data has unexpectedly shown that seasonal sampling does not have an effect on simple index ratings. We keep in mind that there is much work to be done with our samples providing much more information which may solidify our current conclusions or may lead us to other conclusions. Also, numerous methods are available for comparing protocols measuring different metrics at different scales. These methods would be helpful to this study in providing additional information to draw conclusions from. It would also be helpful to integrate reference sites into the study with varying levels of known disturbances. This would help for understanding what is happening at the lower end of the water quality scales that have not been measured yet. The AAS macroinvertebrate protocol was designed for the purpose of indicating possible water contamination by local volunteers (GA DNR 2000, Winn et. al. 2005). The SCI was designed for wastewater treatment facilities as a quick, simplified way of measuring water quality for monitoring purposes (Cairns et. al. 1968, Stoneburner et. al. 1976). EPD designed it's macroinvertebrate protocol to be thorough and accurate over long time scales for watershed management (GA EPD 2005). What they were all designed for is to measure water quality based on present macroinvertebrate communities and it is still unclear whether all three predict consistent and comparable results of stream conditions.

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