Stream Condition Index: Understanding and Use of this Biomonitoring Tool for Florida Streams and Rivers

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Sarah Mixon, Soil and Water Science Department, University of Florida

ABSTRACT

To provide environmental consultants and other interested stakeholders with a broad overview of stream biomonitoring used in Florida; this paper reviews the application of the Stream Condition Index (SCI). As one of the primary bioassessment tools that is currently used by the Florida Department of Environmental Protection (FDEP), the SCI is a numerical metric from a biomonitoring method used to establish general stream health based on the relative abundance of specific stream invertebrates. When used in conjunction with an in-stream Habitat Assessment (HA), the FDEP has determined that SCI is a relatively accurate and cost-effective tool for assessing flowing streams and rivers in Florida. Part of this evaluation of an overall SCI was based on other independent measures of stream health, using individual metrics chosen by correlations to the Human Disturbance Gradient (HDG). HDG integrates HA scores, hydrologic modification scores, watershed land use, and surface water quality. SCI has been refined since its first use in the 1990's. The SCI scores established from these assessments are one of many tools that help the FDEP report to the U.S. Environmental Protection Agency regarding the pollution status or impairment of Florida waters. These monitoring tools help advance our understanding of the ecosystems being monitored, allowing a properly trained operator to ascertain whether or not pollutants or other adverse anthropogenic conditions have degraded a system. This information is critical when assessing the ongoing performance of nutrient reduction programs such as Total Maximum Daily Loads and Best Management Practices for a particular stream or river. While the future use of SCI is ongoing, Florida stream assessments may depend on budgetary and other factors. The training of field scientists in SCI methods appears to be a reasonable investment that would allow consistent, long-term monitoring of stream health in Florida.

INTRODUCTION

Florida is a highly populated state with significant agricultural, urban, and industrial land uses. Florida also has a major tourism industry associated with its wide range of valuable natural habitats. These natural resources are important to Florida and its economy, and the need for their protection has become increasingly recognized. Surface water quality in these systems is routinely threatened by nonpoint source (NPS) pollution generated by human influences. In Florida (and across the nation), the investigation of NPS water pollution has become a priority for many water resource managers (Barbour et al., 1996). The Florida Department of Environmental Protection

(FDEP) is the governmental entity held accountable for keeping Florida's waters in good condition.

As a provision of the U.S. Federal Clean Water Act, states are required to define designated uses for specific water bodies and to develop criteria to protect them (Karr, 1991). A well-recognized tool to help with the problem of NPS pollution is biomonitoring. Stream Condition Index (SCI) is an essential biomonitoring tool used as an indicator of stream or river health (Barbour et al., 1996). Anyone who monitors water quality, is involved in stream restoration, or is interested in a stream's general 'health', would benefit from understanding and utilizing the SCI. For example, with adequate training and practice, farmers with an interest in their cattle's drinking water, or water managers attempting to restore a stream to its full environmental value, could use the SCI as a tool to help determine the general health of water bodies they maintain or for which they are responsible. At a minimum, stakeholders benefit from a better understanding how these monitoring tools work.

Before development of biomonitoring methods, chemical monitoring of pollutants was the primary method for locating and managing pollutants in most water bodies. With time, the emphasis has shifted from primarily chemical monitoring, towards inclusion of direct measurements of the condition of the water bodies' biological assemblage (Yoder and Rankin, 1998). This shift has occurred because traditional water quality evaluations (e.g., chemical analysis of grab samples) have been viewed as inadequate, largely because chemical NPS pollution may be transient and unpredictable. Moreover, degradation of stream biota may be due to coincident physical habitat disturbance (Barbour, 1996), which chemical analyses do not capture. To evaluate overall stream impairment, SCI is one of several biological assessment tools currently being used, and has been considered a fundamental tool in Florida assessments for at least two decades.

The methodologies for assessing biological condition involve reference (aka *natural* or *relatively unimpaired*) sites that are either site-specific or regional. In the case of the site specific reference approach, the reference site is typically an upstream reach of comparable physical setting to the downstream site (e.g., below some impact), or a paired reach of similar physical setting to the one being assessed (USEPA, 2006). An average is then taken of the biological conditions downstream, which is compared to the expectations derived from the site-specific reference. This method works well in some areas because the water quality and habitat types are strongly associated. Some disadvantages of this approach, however, include a limited capacity for extrapolation, logistical issues with mobile taxa, limited statistical power, pseudoreplication issues, and the comparatively high level of effort needed for assessing a state-wide set of test sites, (Huges et al., 1986, Barbour et al., 1995, Bailey et al., 1998, Reynoldson and Wright, 2000).

In contrast to the site-specific reference approach, the regional reference site approach takes a resource class and marks out the least impaired sites. There are two common biological indices: the multimetric index, and the river invertebrate prediction and classification system score (RIVPACS-type) (Write et al., 2000). Each is developed using a population of least impaired sites (USEPA, 2006). The multimetric approach chooses metrics that well-differentiate between reference and test sites. Reference sites are usually chosen based on attributes such as in-stream habitat, surrounding land cover, and water chemistry. These criteria work well for determining human influence and can help identify and remove sites that have been impaired (USEPA, 2006). The RIVPACS-type method develops a list of likely taxa for each test site based on how closely related they are to the reference site.

Regardless of the approach, once the reference site population is established it is often used as the basis for listing criteria found in the 303(d) requirements of the Clean Water Act (CWA), (USEPA, 2006). For the purpose of this paper we will be talking about the multimetric approach of SCI as applied in Florida.

Non-point source pollution is sometimes short lived and varied in time, with the pollutant being either removed from the water column via physical and biological processes, or exported with downstream flow. Because processes such as nutrient uptake may operate at relatively short duration time scales, an instantaneous water grab sample for chemical analysis might not effectively characterize pollution problems in a stream. Because a grab sample is a snapshot in time and place, the presence or effect of the pollutant may not be evident by this type of monitoring. On the other hand, resident stream biota functions as natural and continual monitors of environmental condition. The various species of biota cumulatively respond to the effects of episodic pollutant events (Frydenborg, 2010). Biological indicators integrate chemical and physical stressors throughout much larger spatial and temporal scales than can be assessed through direct water quality measurements (USEPA, 2006).

Moreover, a critical characteristic of biological monitoring method(s) is that it quantifies the cumulative effects of pollution, habitat, and hydrologic alterations using relatively long time scales (Barbour et al., 1996). Principally for this reason (and as discussed below), the SCI is considered the primary indicator of stream ecosystem health, identifying impairment with respect to the reference or natural condition (www.dep.state.fl.us/water/bioassess/) in Florida's waters. Moreover, other assessment tools have been successfully developed to complement SCI. The metrics of the Human Disturbance Gradient (HDG) have been used in parallel with SCI, to both complement that strictly biological assessment, and to provide additional information that may provide some level of understanding of the environmental drivers that may have led to any impairment of the stream condition.

METHODS: HDG AND SCI

Human Disturbance Gradient (HDG)

An SCI considers only the biological responses to environmental conditions within a water body. The HDG is a dimensionless index involving attributes of 1) land use development, 2) hydrologic modification, 3) stream habitat assessment, and 4) water quality. Typically values of HDG may vary along stream disturbance gradients, with each of the four attributes contributing to the overall HDG value for each site along the gradient.

The HDG is independent of SCI, and was used to assess the relative utility of SCI (Fore et al., 2007). In theory, the SCI and HDG may both be used to better assess the relative degree of human impacts on a water body. In practice, the FDEP uses the Habitat Assessment component of HDG to complement the assessment of a stream by SCI methods. Because a low SCI score could be the result of impairment by either physical habitat destruction or by contaminants, the application of a habitat assessment in conjunction with SCI provides a more comprehensive understanding of the relative health of a water body. Thus, to complement the overview of SCI, I first provide a brief summary of the components of HDG.

<u>Landscape Development Intensity Index</u>

The Landscape Development Intensity (LDI) index is itself a dimensionless index of the relative degree of human development within a watershed of interest, with the total LDI for a watershed ranging from 1 to 10, with 1 being a natural system, and 10 being a highly developed urban business district. Brown and Vivas (2005) developed tables of LDI coefficients for land uses in Florida. Those coefficients were based upon each land use's calculated emergy use (per area units per time units), where emergy used in the case of LDI involves non-renewable human energy inputs (such as fuels or fertilizers). Using GIS-based map data of watershed land use (typically the Florida Land Use and Cover Classification System, FLUCCS), the LDI for the watershed of interest is calculated from the summation of the land uses and their specific LDI coefficients (i.e., non-renewable energy inputs).

<u>Hydrologic Modification Scores</u>

Hydrologic modification scores are derived from how a system's hydrographs respond to rain events. If there is a natural flow regime with slow and somewhat continual release of water after rain events, few impervious surfaces in the watershed, and high connectivity with ground water and surface features delivering water (Frydenborg, 2010), the system scores well. On the other hand, a system's flow regime may be largely human controlled with a "flashy" hydrograph (i.e., scouring after rain events with subsequent reductions in flow leading to stagnant or dry conditions, related to impervious surfaces and/or ditching throughout the watershed), with water withdrawals and/or impoundments that fundamentally alter the hydro-ecology of the system (Frydenborg, 2010). Such a human-modified system scores low in this index.

Habitat Assessment

A Habitat Assessment (HA) accounts for the habitat type, factors that might affect the habitat, and water quality. The HA procedure allows for mapping of a system stretch and noting any and all pertinent information regarding the system's characteristics. The scored portion of the HA include quantity and quality of habitat types, water velocity characteristics, width and vegetation quality in riparian buffers, stream bank stability, artificial channelization, and habitat smothering. The non-scored portion of the HA includes information about land use, water quality, NPS pollution sources, canopy cover, abundance of periphyton, fish, aquatic macrophytes, and iron/sulfur bacteria. The FDEP's bioassessment protocols require that a field HA be performed at each stream sampling site when completing an SCI.

Chemical Water Quality Assessment

Chemical water quality is assessed by water column ammonia concentration, obtained from FDEP field sampling that also includes total phosphorus, Kjeldahl nitrogen, and nitrate/nitrite-N. Total phosphorus was initially considered the best candidate to simply characterize overall water quality, but subsequently was thought to be more related to fertilizer runoff and farming practices. Ammonia seemed to be a more general indicator of both urbanization and agriculture (Fore, 2004).

SCI

The SCI is a multipart macroinvertebrate index for use in freshwater, flowing, streams and rivers with a definable channel and banks. The multimetric approach selects metrics that best discriminate between reference and study sites for a specific region, (USEPA, 2006). The system must function like a stream or river to meet this definition (FDEP, 2010). By this definition, water bodies such as lakes, estuaries, wetlands, marshes, prairies, canals, and/or ditches do not function like streams or rivers, and therefore are not candidates for application of SCI as defined by the State of Florida (FDEP, 2010).

Biota in streams and rivers respond to both natural and anthropogenic stressors. With time, biotas establish a distinctive community based on their habitat and the associated natural or man-made inputs. When the man-made influences affect a "natural" system, the biological community will respond, resulting in a weakened biological population (Frydenborg, 2010). Natural stressors include flood, drought, low diversity of substrates (i.e. snags, rocks, etc.), periodically low dissolved oxygen, and other constraints on the biological productivity (FDEP, 2007). Five adverse manmade factors have been identified by Karr (1991) and colleagues, including those that affect flow regime, physical habitat structure, water quality, energy inputs, and biological interactions (Fore, 2004). See Figure 1 for an overall conceptualization of all of the factors that interact to affect the animal biota.

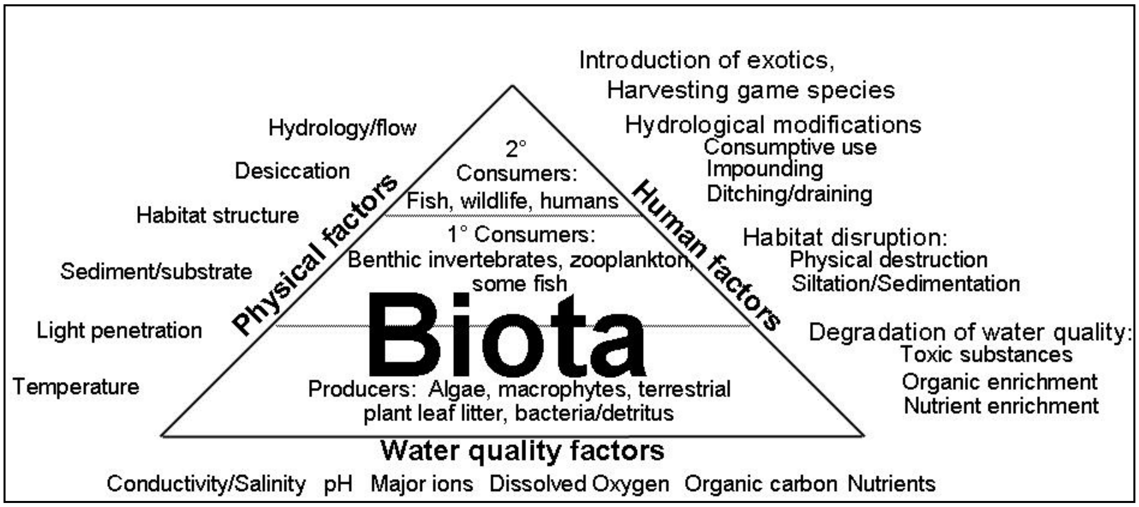

Figure 1: Factors affecting biological communities (from FDEP 2007).

With increasing human disturbance, a (biologically-based) SCI score should decrease. The analysis of multiple Florida data sets by Fore et al. (2007) provided a rigorous testing of the utility of SCI. Overall SCI scores were well correlated to HDG scores (Figure 2), supporting the use of SCI biomonitoring (that is comprised of multiple individual metrics). While there is significant variability in any stream assessment procedures, the detailed analyses by Fore et al. (2007) have led the FDEP to conclude that SCI provides strong, field-based evidence of stream water quality, which is supported by the simpler HDG metrics that capture other aspects of human disturbances. Both HDG and SCI provide useful information, and as noted above, the HA component of HDG is always used as part of an SCI assessment for streams in Florida.

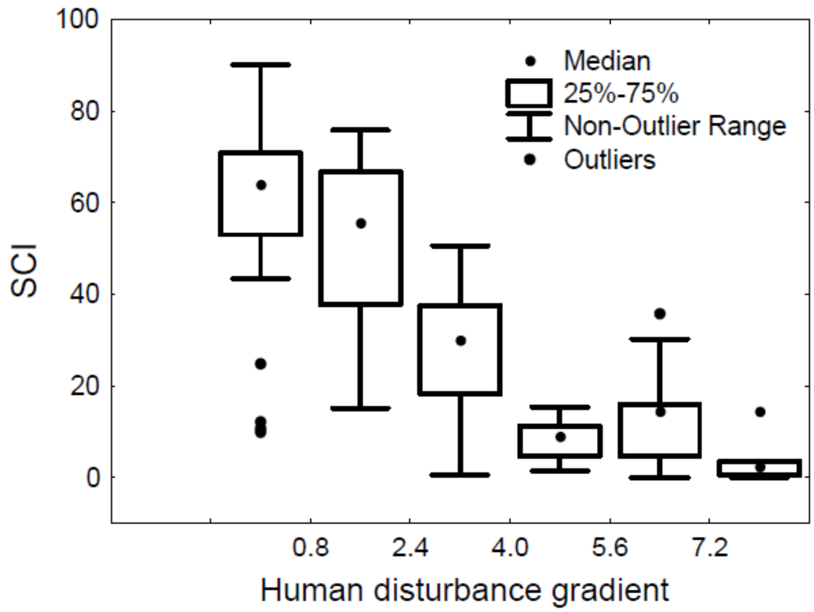

Figure 2: SCI Score Category vs. Human Disturbance (from Fore et al., 2007).

Figure 3 shows the multiple biomonitoring metrics that have been measured in a Florida system, including the specific metrics that were chosen to be incorporated into an overall SCI (starting in 2004). These individual biomonitoring metrics span ecological characteristics ranging from pollution tolerance, to species richness, to habitat structure and reproductive frequency/lifetime.

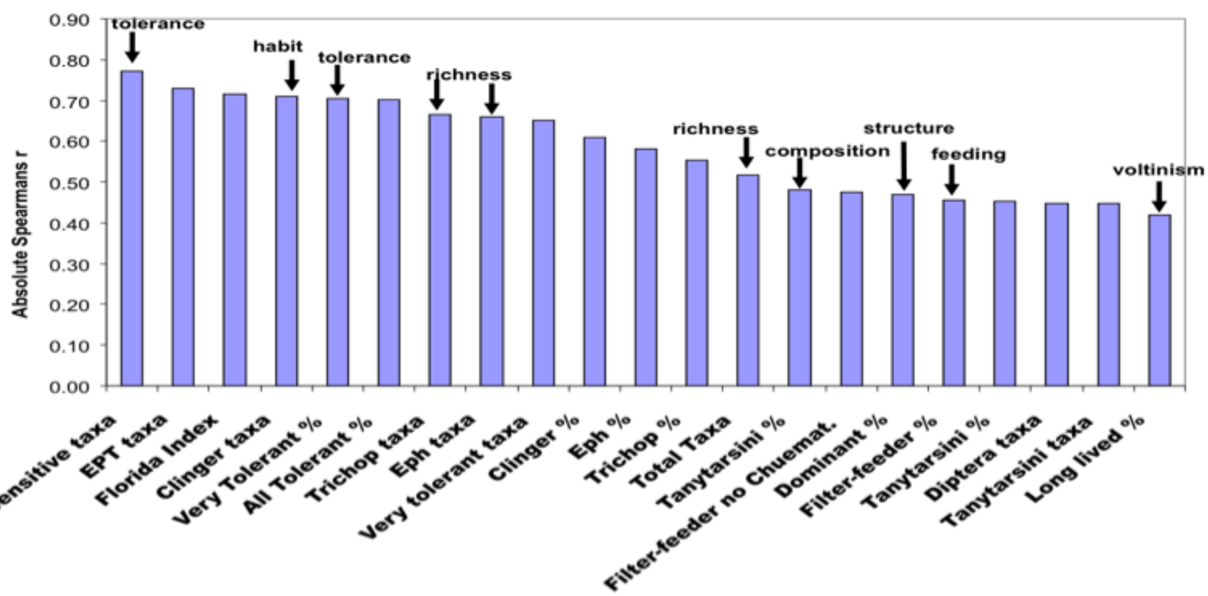

Figure 3: Correlation between various biomonitoring metrics and the HDG (from Fore et al., 2007). Arrows indicate the ten metrics selected for the SCI, and the associated attribute group for FDEP's implementation of SCI (FDEP, 2007).

The "sensitive taxa" and the "percent dominant taxa" (see Figure 3) are two examples of metrics that were selected when calculating SCI for the state of Florida (Fore et al., 2007), with Figure 4 showing examples of the sensitive, bottom dwelling macroivertebrates used in the SCI. These insects are sensitive to pollutants and will be absent or in low abundance in a polluted/degraded system. High relative abundance of these insects is one of the biological indicators that strongly imply a healthy water body.

Mayfly (Ephemeroptera) Stonefly (Plecoptera) Caddisfly (Tricoptera)

Figure 4: Photographs of several bottom dwelling macroinvertebrates that are commonly considered in SCI, due to their consistent relationship with HDG. The Plecoptera is typically found in Florida's panhandle region.

SCI field sampling

Before sampling, a trained SCI field scientist must consider a number of factors that may determine whether the current time and place appropriately characterize "normal" conditions that are representative of the targeted site (for consistent cross-site comparisons). The most critical conditions are existing and/or antecedent flow conditions, and habitat conditions (FDEP Primer, 2007). Invertebrates need a certain amount of time to recolonize the water column at an available spot if flood conditions have been occurring. If the system is flashy (i.e., high hydrologic variability), then invertebrates may have been washed out if a large rain event has occurred within the last month. An analogous situation may apply to extremely dry conditions. According to the FDEP Standard Operating Protocols (SOPs), water must be in the system for at least three to six months before insects will again be able to inhabit that area. Another factor that the field scientist must consider is the recent and current habitat availability. If the system was recently inundated with sand, the habitats that would otherwise be available for invertebrates may be covered, and insects will not inhabit such an area lacking food, shelter, and reproductive sites. If it is determined that the current site is not representative of "normal" conditions, the field sampling may be cancelled.

To collect resident stream biota used in SCI, D-Frame dip-nets with a 595um mesh size are used to sweep an area to collect organisms in the different habitats located in the system. There are five different major habitats: leaf pack or mats, snags or logs, roots or undercut banks, rocks, and submerged aquatic vegetation. There is also a minor habitat that is relatively "featureless" sediments of sand, muck, peat, etc. A total of twenty sweeps are made, with the numbers of sweeps per habitat determined by how many habitats are found within a particular area in a 100 meter distance. If there are 3 major habitats, five sweeps are made in each major habitat, and five sweeps in the minor habitat, totaling twenty sweeps. If there are two major habitats, seven sweeps are made in each major habitat, and six sweeps in the minor habitat, totaling twenty sweeps. All twenty sweeps are then combined into one container for storage, and thus all material (i.e. leaf debris, small twigs, insects, etc.) are mixed together as one sample for the site. Once field sampling and site assessment/interpretation is complete, samples are sent to a certified FDEP lab for sorting, taxonomic identification, and enumeration. FDEP staff conducts the data entry and summary statistical analyses, used to calculate the overall SCI score for the site.

As summarized in this paper (regarding standard procedures), all of these steps are performed by FDEP - with the exception of the field sampling and site assessment/interpretation. Training in field sampling is the only part of the process that could be conducted in a workshop type setting, i.e., with comparatively little cost and/or time. Everything else must be performed by FDEP certified labs.

SCI calculations

Leading up to the current SCI version, there have been a variety of index calculations used in Florida. Initially, Beck (1954) developed a list of sensitive taxa for Florida that was used to calculate a biotic index, which was later modified to be the "Florida Index" (Fore, 2004), and ultimately refined into the SCI that is used today. As indicated above, the SCI integrates ten "best" individual metrics into the single, multi-metric evaluation of a stream.

A single- metric index example is provided for a hypothetical stream reach location, for which the overall SCI score is compared to an associated reference site. The reference site provides an expected score for an unimpaired location in the stream, based on the knowledge of the taxa presence, their ecological requirements and biological uniqueness. The reference site expectations have been previously established for each of the metrics, and individual metric scores are assigned to the hypothetical location according to whether they are within the range of reference expectations (Barbour, 1996).

To calculate the single SCI score for the location, scores are allocated to each of the individual metrics in an additive manner, ultimately leading to the overall SCI score for that particular location. If an individual metric falls in the expected (reference) range, it is scored with a high value, with lower scores depending on the distance outside of the expected range. For this procedure, an FDEP database (Statewide Biological Database or SBIO) is used, containing results from all of the reference sites and other sampled locations. Comparisons of the new sample information to values in this database are made to assign the SCI score for each site. From the field sample, two replicate subsamples are made, with a goal of 150 individuals each (encompassing all ten invertebrate metrics). During sub-sampling, the first replicate's taxa list is entered into SBIO for a score calculation, followed by entry of the second replicate's taxa list. Scores are allocated to each of the individual metrics, which are summed to provide the overall SCI score for that subsample replicate. Those replicates are then averaged to get the overall site SCI score (dimensionless index, ranging from 1 to 100).

DISCUSSION

The process of developing the SCI, assessing its utility, and implementing this monitoring method has evolved with time. Currently, field and laboratory biologists collaborate on multiple steps along the process of assessing a particular stream reach, as summarized in the flow chart of Figure 5. The FDEP has determined that SCI provides useful information for assessing stream health, with those strengths and limitations summarized below.

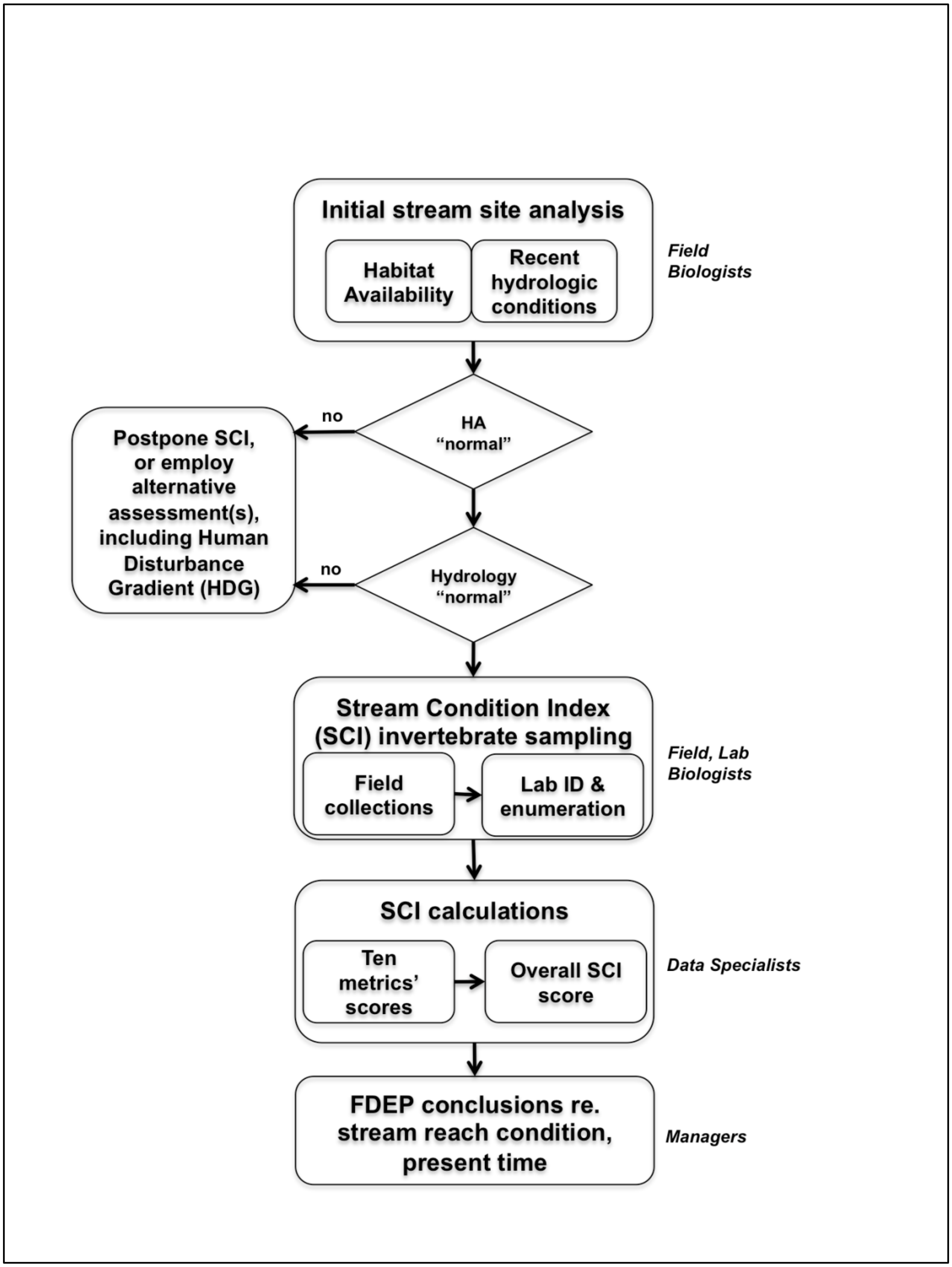

Figure 5. Fundamental steps in the use of SCI for stream assessment.

SCI strengths and limitations

As discussed by Barbour et al. (1996), the expected benefits from the implementation of the SCI apply to a broad spectrum of management programs, including:

- Characterizing the existence and severity of point and nonpoint source impairment.
- Targeting and prioritizing watersheds and ecosystem management areas for remedial or preventive programs.
- Evaluating the effectiveness of nonpoint source Best Management Programs.
- Screening ecosystems for attainability of different water use criteria.
- Developing new biocriteria that relate to regional water quality goals.

Overall, SCI applications can be used in evaluating stream/river restoration effectiveness: i.e. sampling in multiple years, have new management/restoration practices been effective with respect to invertebrates and stream morphology?

However, limitations associated with SCI include:

- Intensive training that takes significant time. If training is not made available, the number of qualified individuals to conduct SEI measurements will limit the number of surveys throughout the state.
- Total error associated with a biological assessment is a combined result of each component of the process. There are seven different components to attaining a SCI score, including: Field Sampling, Sorting, Taxonomy, Enumeration, Data Entry, Metric Calculation, and Site Assessment and Interpretation. All of these steps are performed by different people, all of whom must be adequately trained.
- Land uses are continually changing with time, often leading to increased numbers of impaired waterbodies. This continued development not only may remove more stream systems out of the pool of 'good' systems to be used as reference sites, but also decreases the number of systems that meet all of the requirements that are requisite to perform the SCI. For example, if development is the dominant land use within a watershed and stream flows have become slow or stagnant, then water velocities do not meet the sampling criteria of 0.05 meters per second, and thus SCI cannot be conducted.
- Data collected across different water basins, and/or using different Standard Operating Procedures among years, makes inter-site and inter-year data comparisons difficult, if not impossible.

SCI in Florida

Because the net benefits of the SCI approach have been recognized, this tool has been accepted in evaluating Florida waters. To increase its utility, the SCI has gone through changes since its creation by FDEP in 1992. The original Standard Operating Procedures (SOPs) and metrics were generated from data collected in 1992 through 1994. In 2004, more individual metrics were added to the SCI index, and HDG became a large part of metric selection. In 2007, the changes to the field and laboratory SOP were more subtle. The only change made in this year was for the methods of sub-sampling the field collections, which take place in FDEP's lab. See Table 1 below for a quick reference to the SCI SOPs evolution, indicating the initial changes in metric selection, to the more recent refinement in sub-sampling targets and shifts in the use of "reference" sites.

Version	Target	Calculation	# Metrics	Calibration *	Name	Score range
SCI_1992	100-120 individuals	by Bioregion by season	7	Reference vs. Test Sites	Excellent Good Poor Very Poor	varied by Bioregion (never greater than 33)
SCI_2004	100-110 individuals	by Bioregion no season	10	HDG	Good Fair Poor Very Poor	68-100 48-67 35-47 0-34
SCI_2007	average 2 reps x 150 individuals	by Bioregion no season	10 (same as 2004)	HDG, BCG, + Reference Approach	Category 1 Category 2 Category 3	68-100 35-67 0-34

* HDG = Human Disturbance Gradient
BCG = Biological Condition Gradient

Cannot compare SCI_1992 scores to SCI_2004 or SCI_2007 scores!

Table 1: Evolution of the SCI SOPs. The major Version changes, including: Target number of individual organisms per sample, changes in spatial/temporal considerations in index Calculation , the number of individual Metrics per overall SCI score, comparisons used in (re)Calibrations of the method, the Name of SCI-derived water condition classes, and their corresponding SCI Score ranges (Jackson - personal communication, 2012).

The SCI is currently being used in Florida for freshwater spring studies, ambient monitoring, Impaired Waters Rule (TMDLs), point source permitting, watershed (NPS) studies, Best Management Practices (BMP) effectiveness studies, the Fifth Year Inspection (FYI) Program, and the 305 (b) Program. Reports summarizing FYI, TMDL, BMP, Mitigation, and Basin studies can be accessed through the FDEP'S Bureau of Laboratories Library (www.dep.state.fl.us/water/monitoring/). At least through 2011, the Environmental Assessment Section at the St. John's River Water Management District (SJRWMD) worked on two contracts for FDEP: the Status and Surface Water Temporal Variability (SWTV) Programs both include SCI. The SWTV program's sampling began in 2000 and the SWTV program began in 1992. The SWTV Network consists of 75 fixed location sites in streams and rivers that are sampled on a monthly basis within the St. Johns River basin. The SWTV randomly selects ten stream and river sites every year throughout the St. Johns River basin for assessments using SCI.

The recent history of SCI use at the SJRWMD is an example of current status of the use of SCI in the state. SCI has been a standard procedure for that agency's SWTV since about 2003, but at the end of 2010, budget reductions appeared to largely be responsible for SCI being dropped from that project. As a result of budget cuts, the SJRWMD lost all contract workers who had been the primary trained experts in field sampling for SCI. Because the proper in-depth training is so time intensive, it was unlikely that existing staff (with other duties) would conduct the requisite sampling. In cases where water management districts did not participate, the FDEP staff conducted the SCI sampling. In addition to loss of staff, 7 of 10 SWTV monitoring sites possibly were no longer meeting all of the criteria required for a SCI to be completed, resulting in few data being provided for analysis to FDEP. There were originally thirty samples per resource type, which was then reduced to twenty. With the decreased sample numbers, along with increased numbers of sites not meeting exclusion criteria, there apparently was not enough data being collected to justify the SCI applications, which may have led FDEP to drop the SCI from being completed across the state for this project. Thus, with increasing numbers of unsuitable sites, combined with the new SCI/HA training and retraining that would have to occur to continue, SCI no longer appeared to be cost effective given future state budget constraints. However, the HA is still being done at all sites for this project, requiring continued training and retraining of field scientists, but not as extensively as would be required with both SCI and HA.

Biomonitoring in other regions

In Canada, benthic invertebrates are also used for a national biomonitoring program called the Canadian Aquatic Biomonitoring Network (CABIN). The Reference Condition Approach (RCA) is their primary method for site assessments. The RCA uses indices of the benthic macroinvertebrate population as a measure of a system's condition (Reece and Richardson, 1999), in a similar fashion to the SCI. With the RCA, the benthic community of a potentially stressed ecosystem is compared with that of unstressed reference sites that have similar environmental conditions (Reece and Richardson, 1999).

Similar SCI methods are used in other states of the U.S. In New Mexico, a version of the SCI is being refined for use in their wadeable streams and rivers (www.nmenv.state.nm.us/swqb/biology/). Vermont's Department of Environmental Conservation conducts annual biological monitoring and assessments of fish and macroinvertebrate communities in streams and rivers throughout Vermont (Douglas et al., 2008). Working with the U.S. Environmental Protection Agency, they determined the five-year rotational watershed-monitoring plan worked best for them. The process is somewhat like Florida's SCI and HA, with some adjustments and different sampling methods, including the collection of fish, aquatic plants, and periphyton. California also conducts biomonitoring, with similar sampling methodologies to Florida, but

California assessments separate streams into those that are wadeable or non-wadeable. Those methods also change the sampled length of the stream stretch depending on its width, and sample insects with multiple methods (http://swamp.mpsl.mlml.calstate.edu/wp-content/uploads/2009/04/swamp_sop). In general, while there are a range of differences among programs, biomonitoring is used in a number of important state monitoring programs.

SCI field training in Florida

Anyone interested in stream or river assessment can benefit from learning about SCI, and the use/application of SCI field methods can be learned through available training sessions. These training sessions are geared dominantly towards the field sampling portion of SCI. There is a FDEP training process that must be completed before being able to perform formally accepted SCI and HA in Florida.

For the SCI, the field sampler must pass a field performance test to demonstrate competence (FDEP Sampling Manual, 2010). Moreover, to qualify for this test, the sampler must first pass the HA portion and complete both the HA and SCI on twelve systems with someone already certified in both HA and SCI. Individuals conducting HA must train with FDEP (or equivalent) staff (via workshops and/or participating in field sampling) and remain in "pass status" for field performance tests (FDEP Sampling Manual, 2010). HA testing is conducted at select streams/rivers located throughout the state, and sites will change every two years, as needed (FDEP Sampling Manual, 2010). The scores from trainees are then compared with are then compared to the experts scores. If the sampler's scores are +/- 10 points of the experts' scores on at least three out of the five sites, that sampler is in pass status. The sampler must repeat this testing procedure every two years to remain in pass status. Once the HA portion is complete, the sampler can then begin the process to set up a SCI test with FDEP. Once both the HA and SCI training is completed, FDEP staff updates the trainee's testing status (FDEP Sampling Manual, 2010).

Unless the sampler is working on a FDEP project, typically a sampler cannot get the needed training directly from FDEP. For non-FDEP projects, SCI and HA training is available through independent contractors that are affiliated with projects with state agencies. More information on these training opportunities may be obtained from the relevant agencies, or the senior author (Mixon).

Conclusions

SCI is an important biological assessment tool that adds value to water resource management and has been well accepted for making decisions regarding water body impairment and ecological health. SCI is a tool that has been used in Florida for more than a decade and has evolved in a positive way. Every effort should be made for individuals to have access to the type of training and knowledge needed to accurately apply SCI.

Recent reductions in the use of SCI in evaluating Florida water bodies may be related to the availability of trained SCI field scientists, which apparently has been reduced due to budgetary constraints. However, relatively inexpensive training from contractors is available for field sampling and site assessment/interpretation methods of SCI and HA. While those training opportunities are somewhat limited currently, increased training availability would allow broader opportunities for continued use of SCI and HA in Florida. The "hard work" of SCI/HA development and SOP documentation is done, and availability of field practitioners is one current constraint on its continued, long-term use in Florida. The FDEP (or other) certified labs still must be used for laboratory enumeration and analysis, but removing the constraint of available field practitioners would be desirable to maintain this method for long term comparisons of the status of Florida waters.

Resident stream biota function as natural and continual monitors of environmental conditions and if we pay attention to what inhabits our streams and rivers at this level, we will have a wealth of information pertaining to stream environmental health. SCI based knowledge that invertebrates are abundant, healthy, and flourishing provides sufficient confidence on stream health conditions in the season or year before sampling; repeated sampling using standardized protocols allows long-term, multi-year, assessments of water quality in Florida streams. Such information enables managers to make decisions that (hopefully) maintain the health of the environment. The SCI provides a great source of data and when combined with water quality and habitat data, a complete stream condition can be properly established.

List of Terms with Definitions

- **Biomonitoring** - The use of a biological entity as a detector of environmental stress
- **Stream Condition Index (SCI)** - A composite macroinvertebrate index for use in flowing streams
- **Human Disturbance Gradient (HDG)** - Establishes criteria, independent from the biology, to determine which sites are impaired by humans vs. those that are not. The HDG consists of land use information, hydrologic modification scores, habitat assessment scores, and water quality data.
- **Number of intolerant taxa** – Richness of those organisms considered to be sensitive to disruption
- **Percent dominant taxa** – Measures the dominance of the single most abundant taxon
- **Habitat Assessment (HA)** – Determining overall habitat quality by measuring attributes known to have potential effects on the stream biota
- **Biological Condition Gradient** – An EPA model that predicts that biological health will decline in response to increasing levels of stress.
- **Impaired Waters Rule (TMDLs)** - A TMDL is the maximum amount of a given pollutant that a water body can absorb and still maintain its designated uses (e.g., drinking, fishing, swimming, shellfish harvesting). One water body may have several TMDLs, one for each pollutant that exceeds the water body's capacity to absorb it safely.
- **Best Management Practices (BMP)** - Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources.
- **Fifth Year Inspection (FYI) Program** - Domestic wastewater facilities permitting program
- **305 (b) Program** - A report to EPA on the status of Florida's water resources
- **Landscape Development Intensity Index (LDI)** – A land use based index of potential human disturbance. It is calculated spatially based on coefficients applied to land uses within watersheds.

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