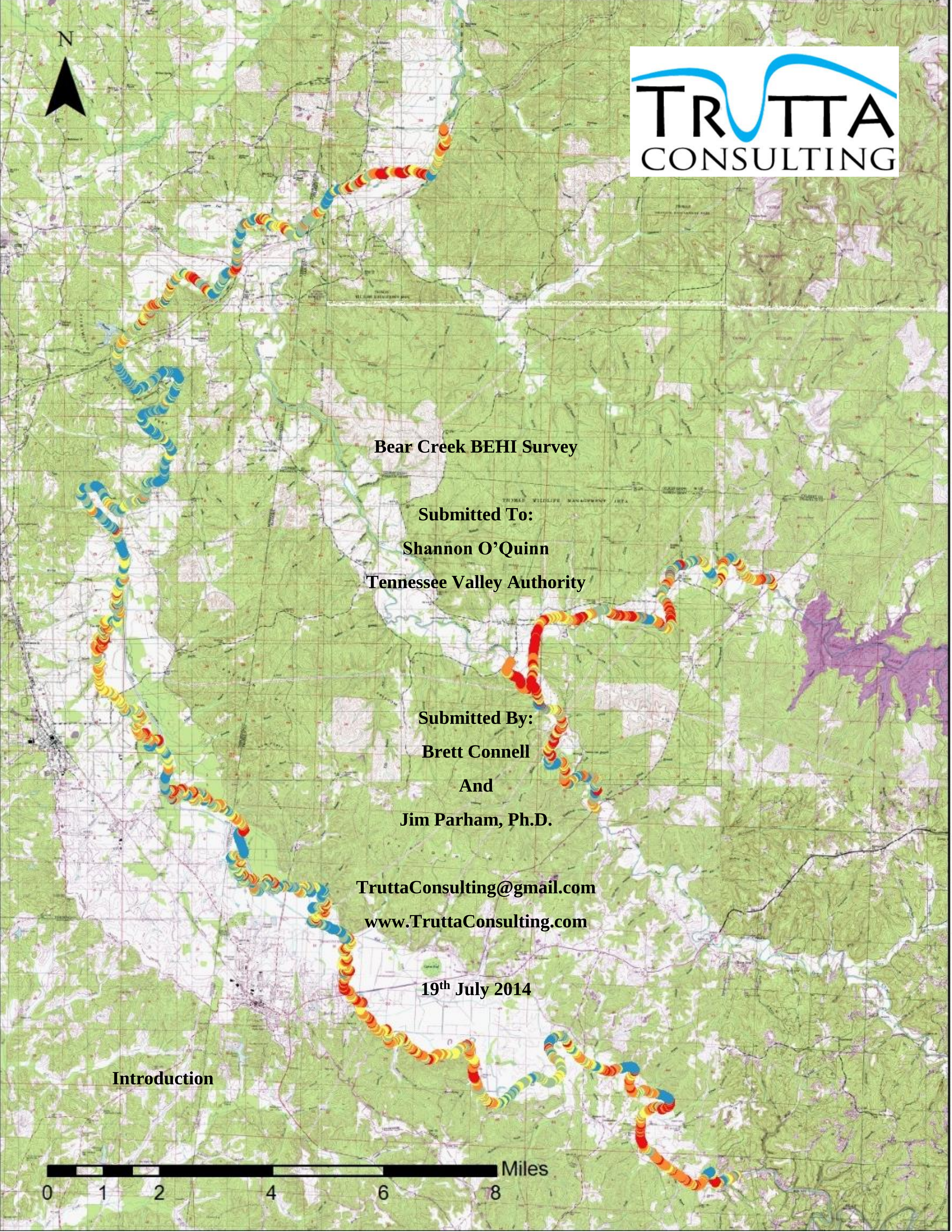

TRUTTA CONSULTING

Bear Creek BEHI Survey

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Introduction

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The Bear Creek watershed has a drainage area of about 946 square miles in north western Alabama and a small part of Mississippi. Major tributaries are Cedar Creek with a drainage area of 330 square miles, and Little Bear Creek with a drainage area of 91 square miles. Due to the high biodiversity of this watershed, it was selected to be one of the 51 SHU's (Strategic Habitat Unit) in the much larger Mobile River basin.

To better understand the current conditions within the stream channels of the Bear Creek system, Trutta Consulting was contracted by TVA to provide up-to-date geo-referenced video and develop spatially continuous maps of BEHI (Bank Erosion Hazard Index) throughout the river system. The Cedar Creek section is approximately 8 miles long starting at the highway 247 bridge and ending at the highway 15 bridge. The Little Bear Creek section is approximately 4 miles long and will be starting at the highway 247 bridge and ending at the confluence of Cedar Creek. The Bear Creek section is approximately 50 miles long starting from just below the dam and ending at the Rock Creek confluence.

The survey results were intended to be used in three ways.

1) To help prioritize future restoration efforts and action areas.
2) To provide a baseline characterization of river bank conditions in 2014.
3) To support the collaborative efforts of federal and state agencies, private landowners, and non-governmental organizations in this watershed to achieve long-term water quality, habitat and species benefits.

Methods

Equipment

The Streambank Video Mapping System (SVMS) of the High Definition Stream Survey (HDSS) approach was used that consisted of a sit-on-top kayak, two GPS-enabled video cameras mounted facing left and right (90°), a flush-mounted depth sensor, a National Marine Electronics Association multiplexer; and a GPS receiver. The GPS receiver had provided sub three meter GPS accuracy and outputted time and location data approximately one each second (1Hz). The GPS data was combined with the depth data within the multiplexer and then was recorded onto a flash drive. The geo-referenced video was combined with the GPS and depth data such that each data point is associated with Coordinated Universal Time (UTC) and coordinate information.

Development of Bank Erosion Susceptibility Index

The Bank Erosion Susceptibility Index (BESI) method was created to provide a rapid way to classify geo-referenced video to estimate the ease that a particular bank location would erode (Connell, 2012). The BESI looks at the bank's height, angle, protective surface vegetation, riparian diversity to develop an objective classification to predict bank erosion. This approach is based on modifications to the Bank Erosion Hazard Index (BEHI) (Rosgen, 2001).

The five variables classified from the video were bank angle, bank height, bankfull height, surface protection, and riparian diversity. In addition to the visually classified variables, depth was measured at each second and was recorded from the georeferenced depth sensor. The parameters of bank angle, bank height to bankfull height ratio, surface protection, and riparian diversity were combined to create four parameters for the BESI metric.

Bank Angle: Holding all other variables the same, streambanks with steeper bank angles are more susceptible to erosion (Rosgen, 2001). Within this BESI analysis, bank angle was visually classified into one of four categories.

- 0-60 degrees received a BESI score of 2.45
- 61-80 degrees received a BESI score of 4.95
- 81-90 degrees received a BESI score of 6.95
- >91 degrees received a BESI score of 9

Bank Height to Bankfull Height Ratio: Bank height and bankfull height were separately determined by visual assessment and where the observer focused on the distance from the water surface to bank height elevation. Seven height categories for bank height used in this study were 0-1 ft., 1-3 ft., 3-6 ft., 6-9 ft., 9-12 ft., 12-18 ft., and > 18 ft. Bankfull height was visually estimated where obvious bankfull erosion scars were observed. Depth was recorded at each GPS from direct measurement in the field. To create the Bank Height to Bankfull Height Ratio, each GPS point was assigned a bank height (of the lower bank), bankfull height, and depth, and then the ratio, $\frac{(\text{Bank Height} + \text{Depth})}{(\text{Bankfull Height} + \text{Depth})}$, was calculated at each location. This ratio is the same for both banks as the Bank Height to Bankfull Height Ratio is controlled by the lower of the two streambanks.

Surface Protection: Surface protection (%) was visually categorized into one of four groups which relate to how much soil is exposed to moving water and rainfall directly on the stream bank. In general, the higher percent of the streambank covered by vegetation results in lower erosion potential. The categories used were:

- 56-100 percent surface protection received a BESI score of 2.45
- 30-55 percent surface protection received a BESI score of 4.95
- 15-29 percent surface protection received a BESI score of 6.95
- <14 percent surface protection received a BESI score of 9

Riparian Diversity: The variable of riparian diversity reflected the potential soil holding strength of riparian vegetation. In general, the larger the trees and more complex the understory in the riparian zone would result in deeper and thicker root development that would slow lateral erosion into the bank. Riparian Diversity scores were defined as:

- Optimal- Surrounding area consists of several sizes of trees, shrubs, and grasses of all sizes. High diversity is presumed to be indicative of very high root depth and density. BESI score = 2.45.
- Sub-Optimal- Surrounding area consists of low diversity trees with some understory and grasses. Sub-Optimal is presumed to be indicative of good root depth and density. BESI score = 4.95.
- Marginal- Surrounding area consists of a few trees with a few shrubs and grass. Marginal is presumed to be indicative of moderate root depth and density. BESI score = 6.95.
  Poor- Surrounding area consists of short grass or bare soil. Poor is presumed to be indicative of poor root depth and density. BESI score = 9.

These four variables were additively combined to create a single BESI score for each streambank for each second of video collected. The four BESI categories corresponding to low, moderate, high, and very high, changed at values of 18.5, 24.4, and 30.2, and had an overall range of 9.8 to 36.

Data Analysis

All data were collected, the GPS time and location information was linked to each second of the left and right bank video files. This resulted in video for both banks referenced to a common location and time. The individual files were assembled to form a continuous tracklog of the survey areas with associated left and right bank identifiers. The video for each bank was then classified using HDSS video coder software which allowed each of the BEHI parameters score to be applied to any second of the video and associated GPS location. Once the data was classified for all video files, the results were mapped in ArcGIS 10.1 to view the data.

Results

Field Survey

The survey covered a total of 64 miles and took five days including the single unsuccessful data collection day at Bear Creek. Cedar Creek was surveyed on March 10 with no issues covering the 8 mile section. The first section of Bear Creek (15 miles) and Little Bear Creek (4 miles) were both surveyed March 11. Issues with the power connection prevented depth measurements for the first four miles of Bear Creek but was then corrected for the remaining river miles. For the first two video files on Bear Creek, the bank height to bankful height ratio was calculated without depth measurements and resulted in a score that reflected the corresponding video. While this decreased the accuracy of the BESI scores at these sites, the results appeared good enough to use when compared to the video. These first four miles should be used with caution with respect to the rest of the analysis.

The third day (March 12) was cold and windy making data collection difficult and ultimately causing the cancellation of the data collection efforts. The survey resumed March 19 at the baseball fields outside of Red Bay and finished on March 20 just passed the confluence of Rock Creek.

Maps of the entire project area BESI scores are produced for both left (Map 1) and right (Map 2). At this scale, the obvious trend is the long stretch of low BESI scores around Tishomingo State Park likely reflecting the abundant Cypress trees that line the streambank preventing erosion. It is easy to locate the high BESI scores surrounding the confluence of Little Bear and Cedar Creek but is hard to make any judgments on the cause at this scale.

Tennessee Valley Authority and US Fish and Wildlife wanted Trutta Consulting to highlight a few areas of higher than usual BESI scores. To accomplish this goal, maps and accompanying screenshots from the geo-video surveys are shown. For reference purposes, video files are labeled with Name of stream, first digit is day, and second digit is for #of video that day. For example, Figure 7: Video File; Bear Creek Right 21, 16:24 means Bear Creek, day 2 of field survey, first video of the day, at 16 minutes and 24 seconds.

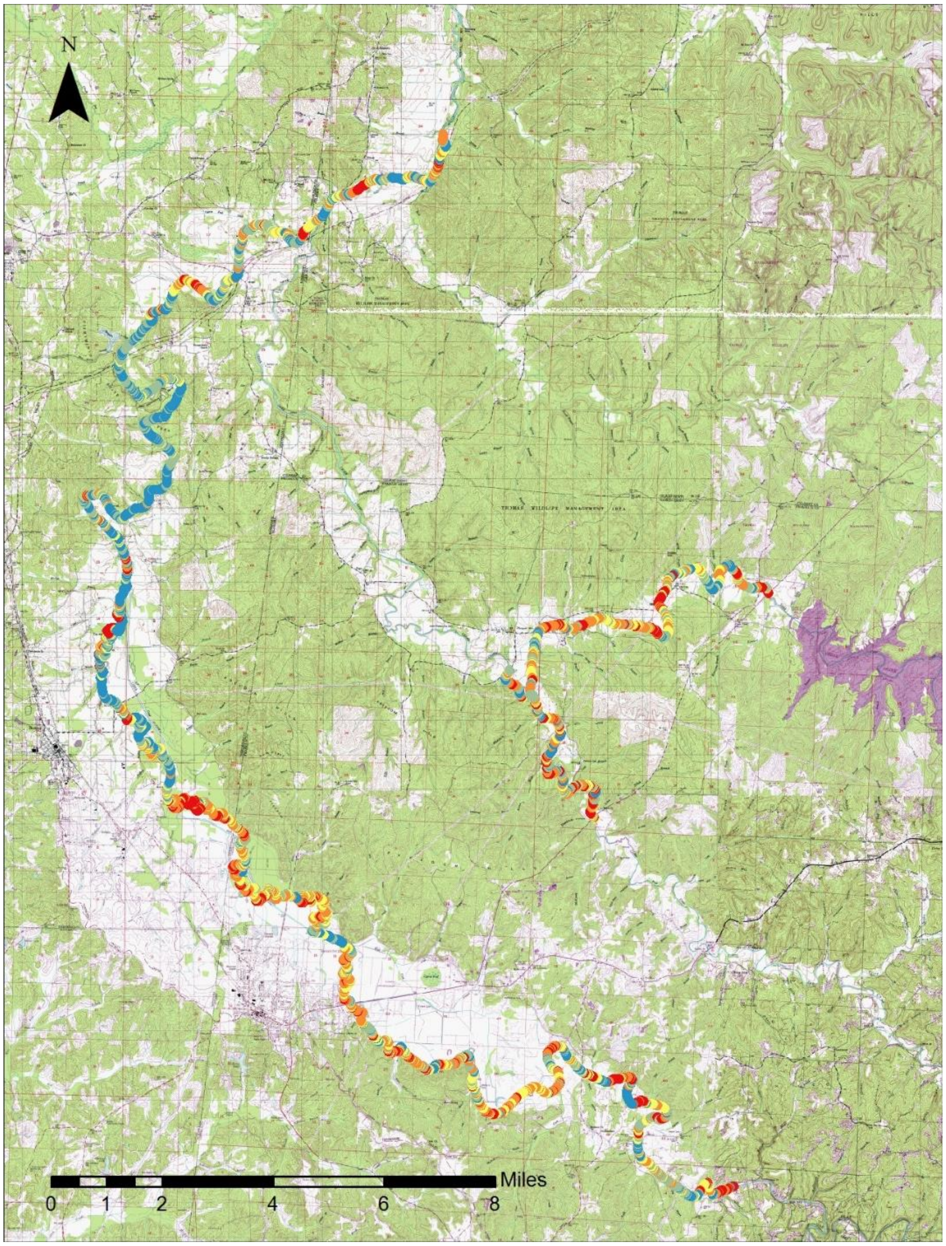
Looking closer with Map 3 and Map 4 at the confluence area of Little Bear and Cedar Creek, the lack of riparian cover and agriculturally dominated land use become the obvious reasons for high BESI scores. Figure 1 and Figure 2 are geo-referenced on the map and show the actual conditions during the survey.

Map 5 not only highlights some very high BESI scores, but also very low scores which shows how dynamic a river can be. Map 6 shows the right side of Bear Creek which has the same pattern and is displayed in Figure 5 and Figure 6. These results highlight some of the powerful differences between the HDSS approach to traditional surveys. Traditional point or couple hundred meter samples typically are assumed to be representative of miles of stream. If a traditional survey was performed at the locations of Figure 3 or Figure 4, extrapolating the data would be very inaccurate. Using the HDSS approach, we continuously samples every second and eliminates the need for extrapolation.

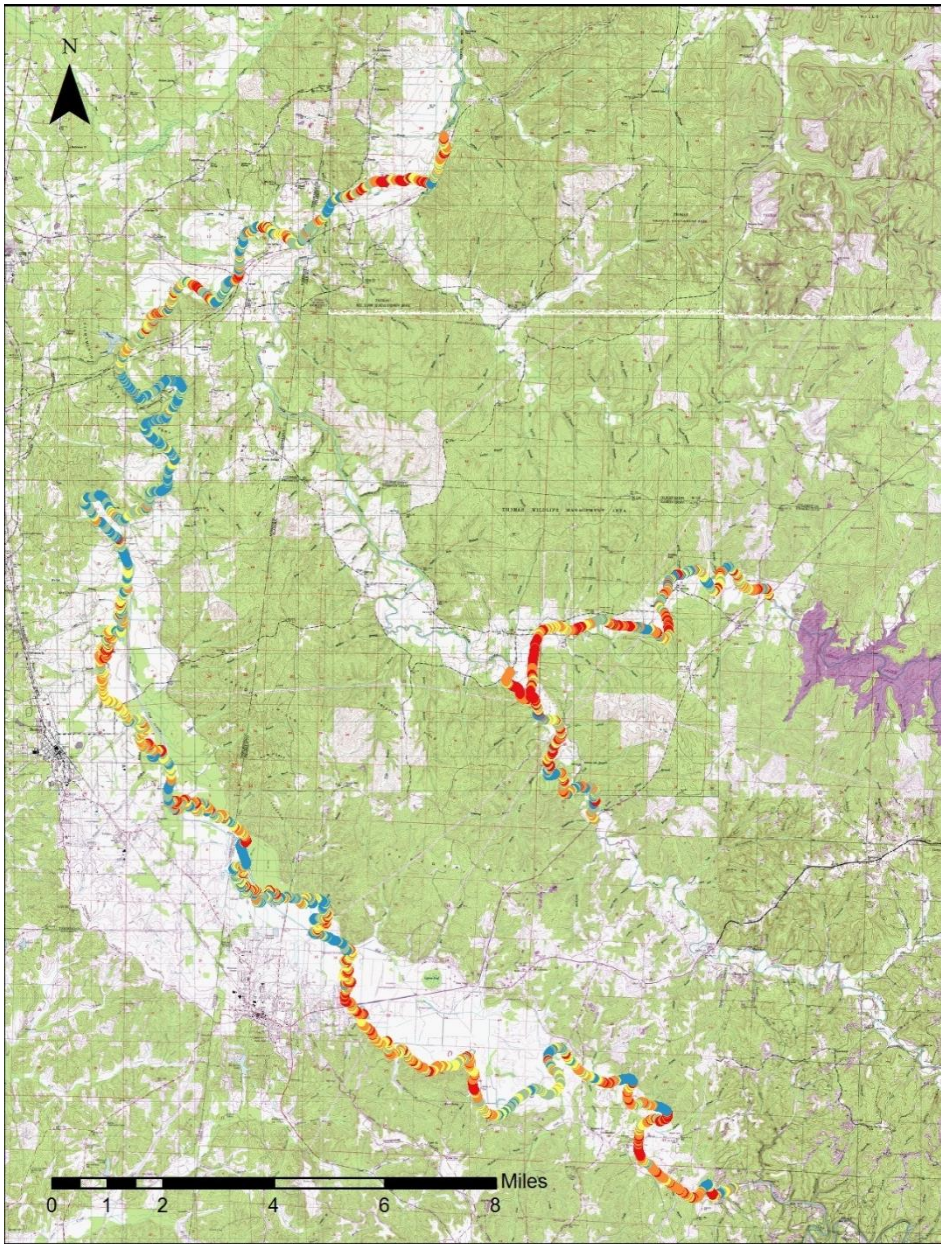
Map 7 is an area with high BESI scores for multiple possible reasons. Land use practices causing lack of riparian diversity would be a likely issue and possibly complicated by higher peak flows from the impervious surfaces just upstream in Red Bay. Figure 7 shows an actively slumping streambank with Figure 8 showing a farmers attempt to prevent more erosion. The benefit of a large riparian buffer is obvious once Bear Creek flows back into a forested section.

Map 8 highlights how outside bends often show higher BESI scores likely reflecting higher levels of sediment input from actively eroding streambanks. The red circle encompasses the next 3 pictures which are the worst areas surveyed in this whole project. Figure 9 shows the bottom of large tree roots and actively slumping streambanks. In addition to high BESI scores from the golf course, a pipe that is discharging bubbling green effluent was also located here (Figure 10). Another issue for this area is the highly incised tributary flowing through the golf course has a high probability of contributing excess nutrients to the stream (Figure 11).

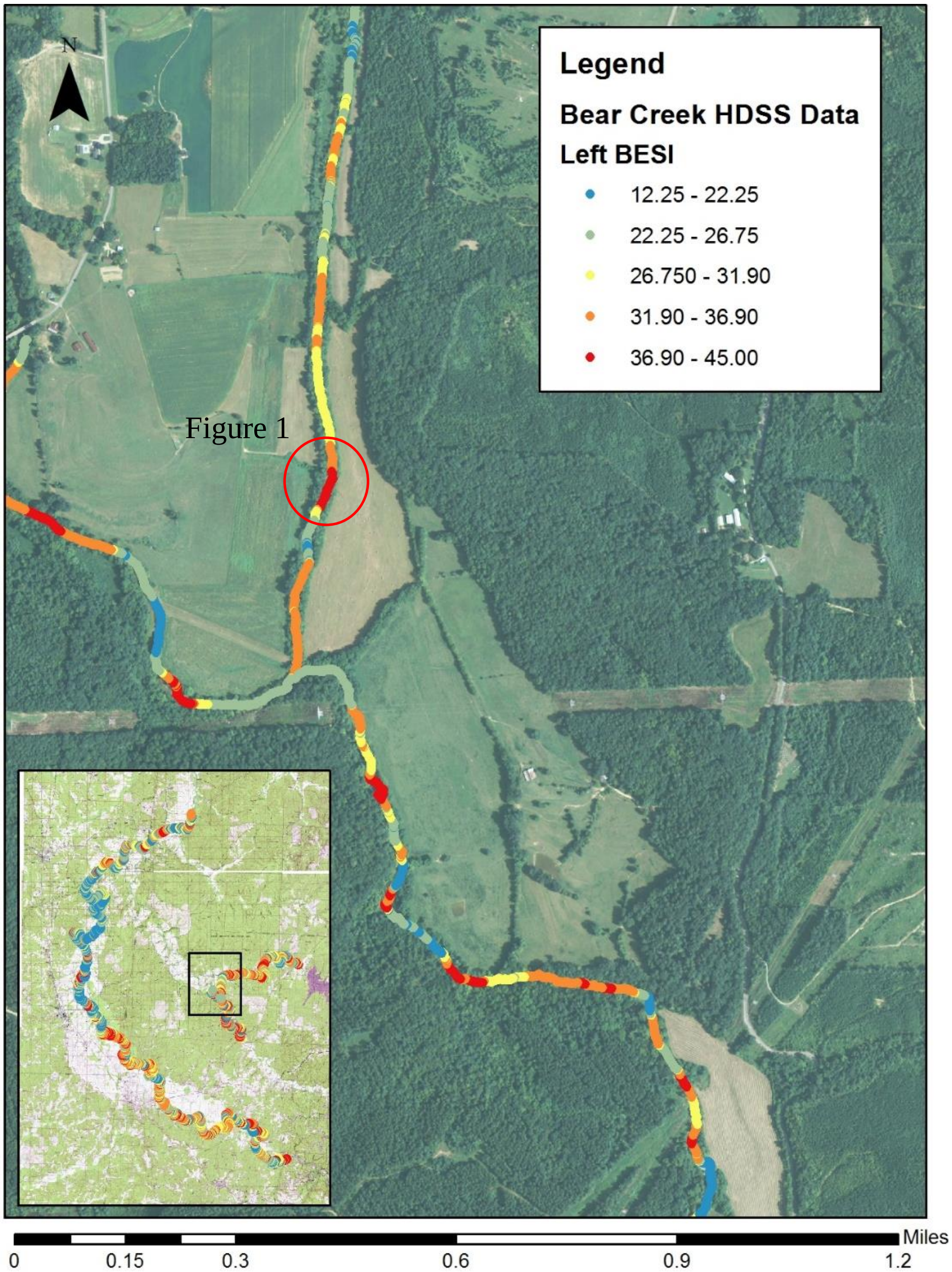
Map 9 and Map 10 highlight the lower BESI scores that can be seen for long stretches in Tishomingo State Park. Lack of agriculture and a presence of large Cypress trees in the riparian zones contributed highly to the low erosion potential scores. The presence or absence of Cypress trees highly influenced each parameter of the Bank Erosion Susceptibility Index (Figure 12 and Figure 13).



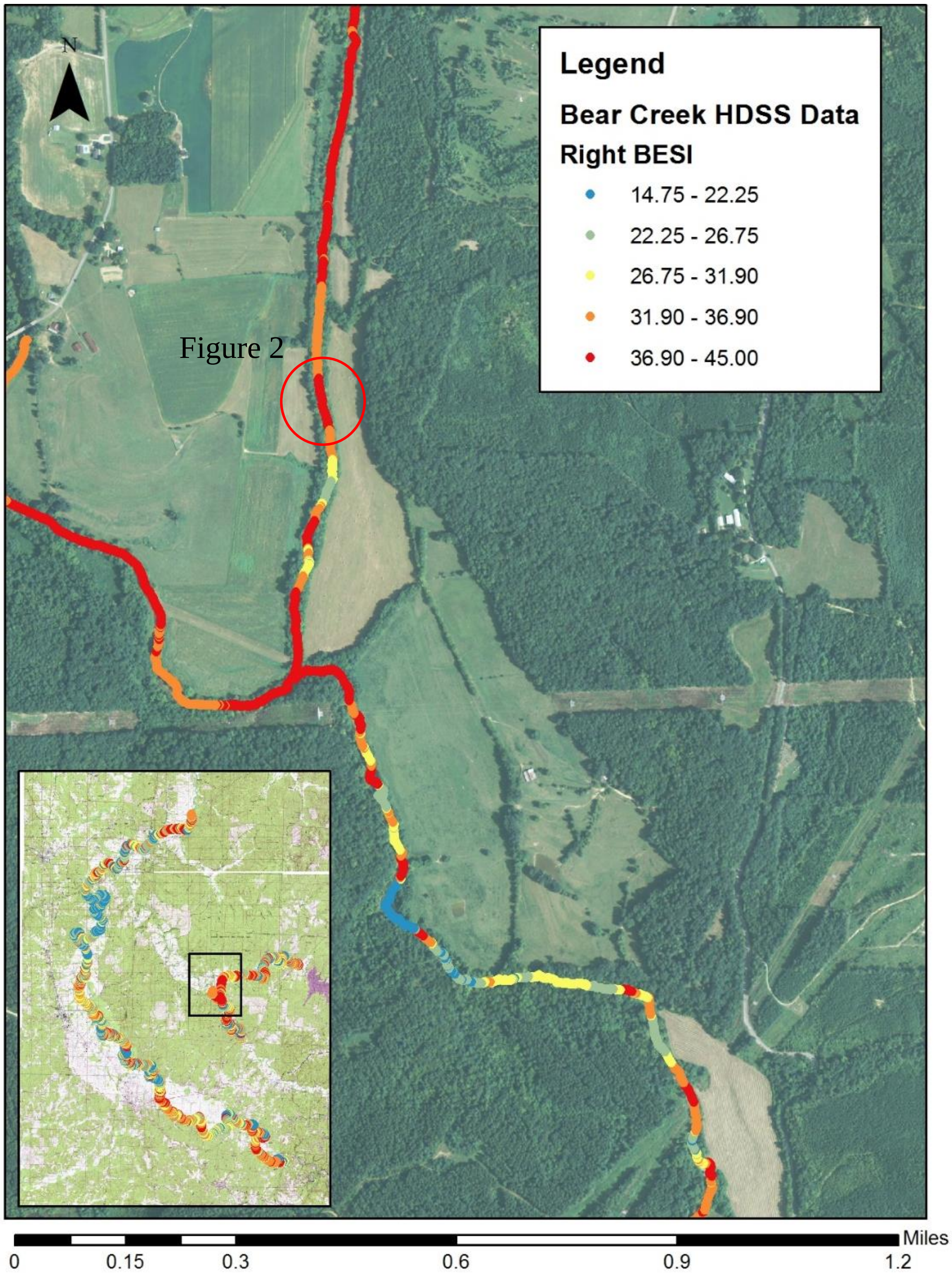
Map 1: The 56,000 data points for Left BESI scores over the entire project area.



Map 2: The 56,000 data points for Right BESI scores over the entire project area.



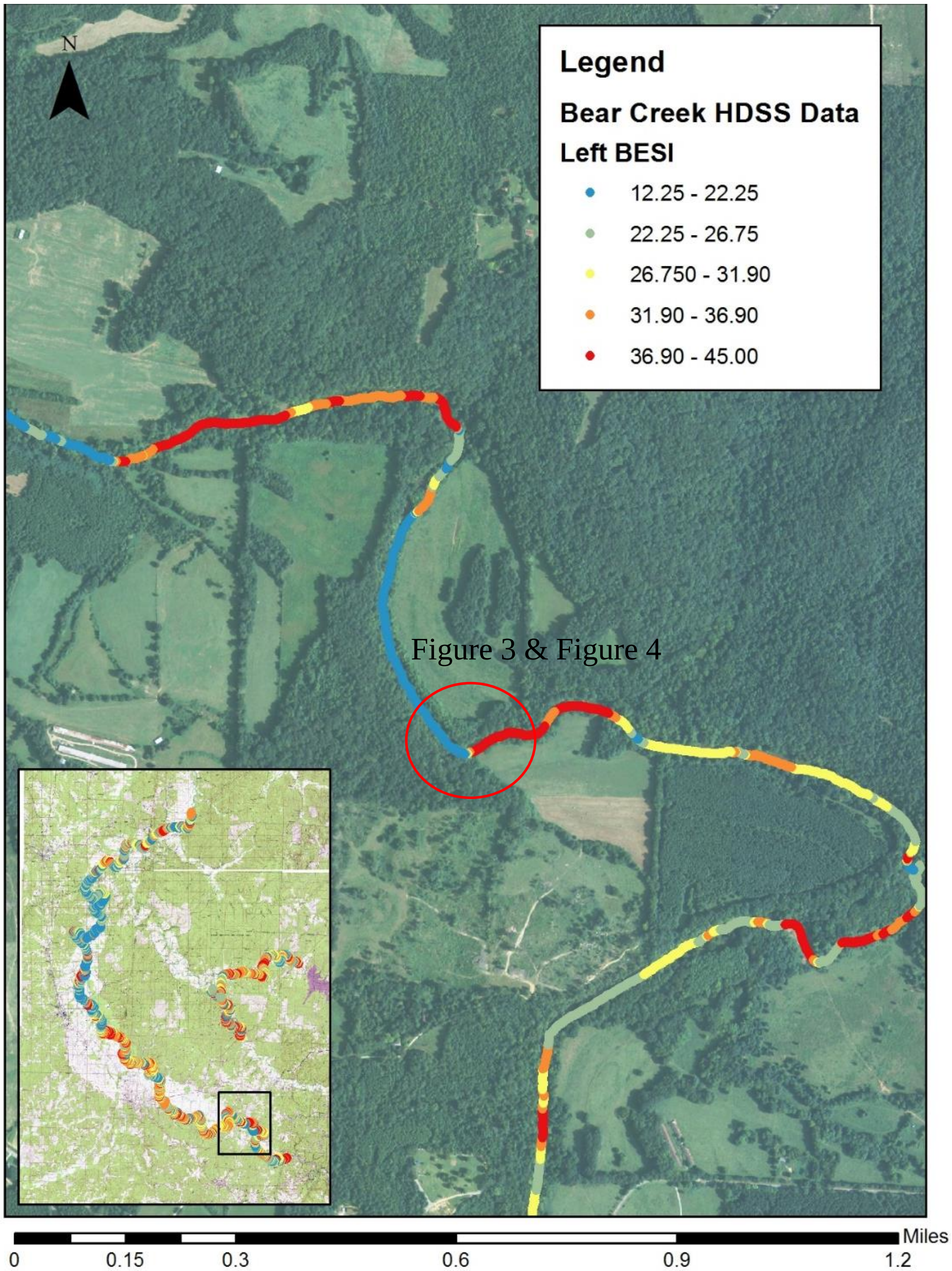
Map 3: Close up of Left BESI at confluence of Little Bear and Cedar Creek.



Map 4: Close up of Right BESI at confluence of Little Bear and Cedar Creek.

Figure 1: Video File; Cedar Left 13, 40:39

Figure 2: Video File; Cedar Right 13, 44:32



Map 5: Close up of Left BESI scores on Bear Creek

Figure 3: Video File; Bear Creek Left 11, 1:10:44

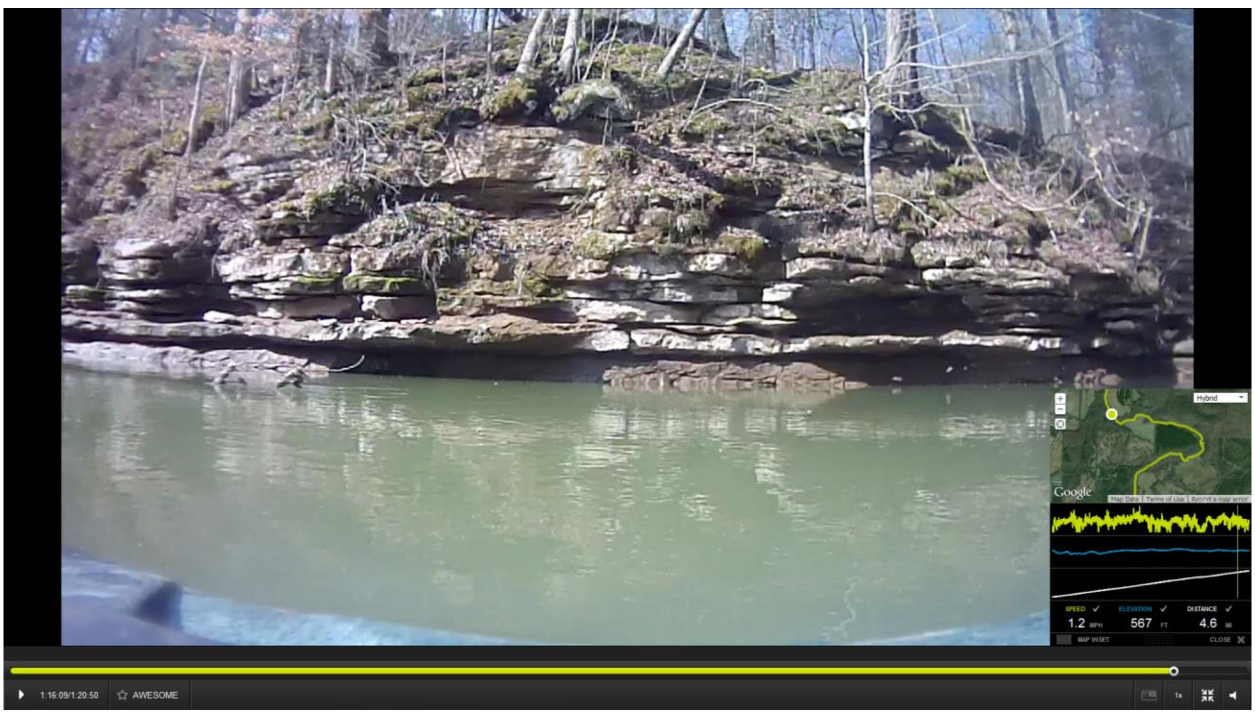
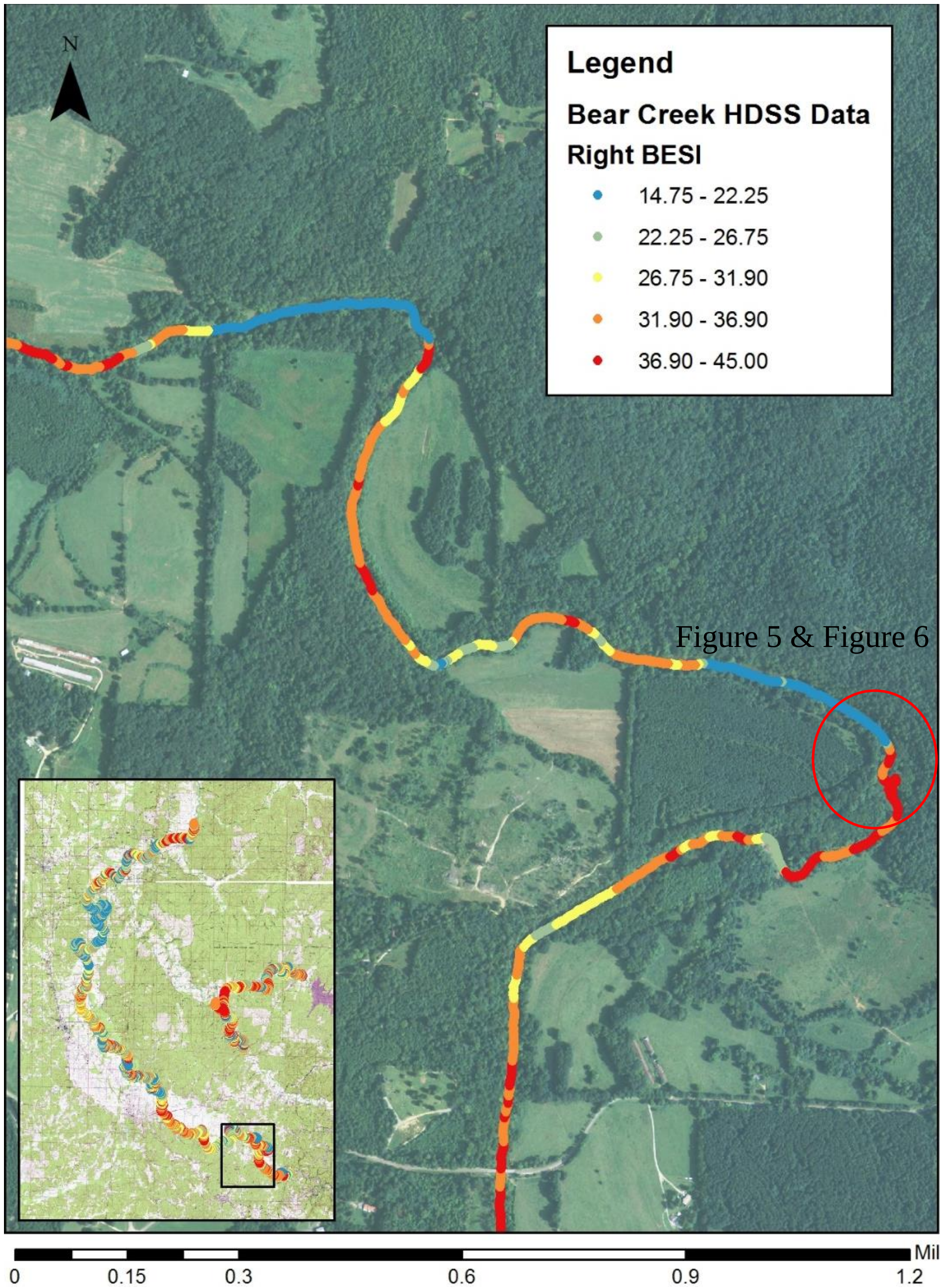


Figure 4: Video File; Bear Creek Left 11, 1:16:09



Map 6: Close up of Right BESI scores on Bear Creek

Figure 5: Video File; Bear Creek Right 11, 59:13

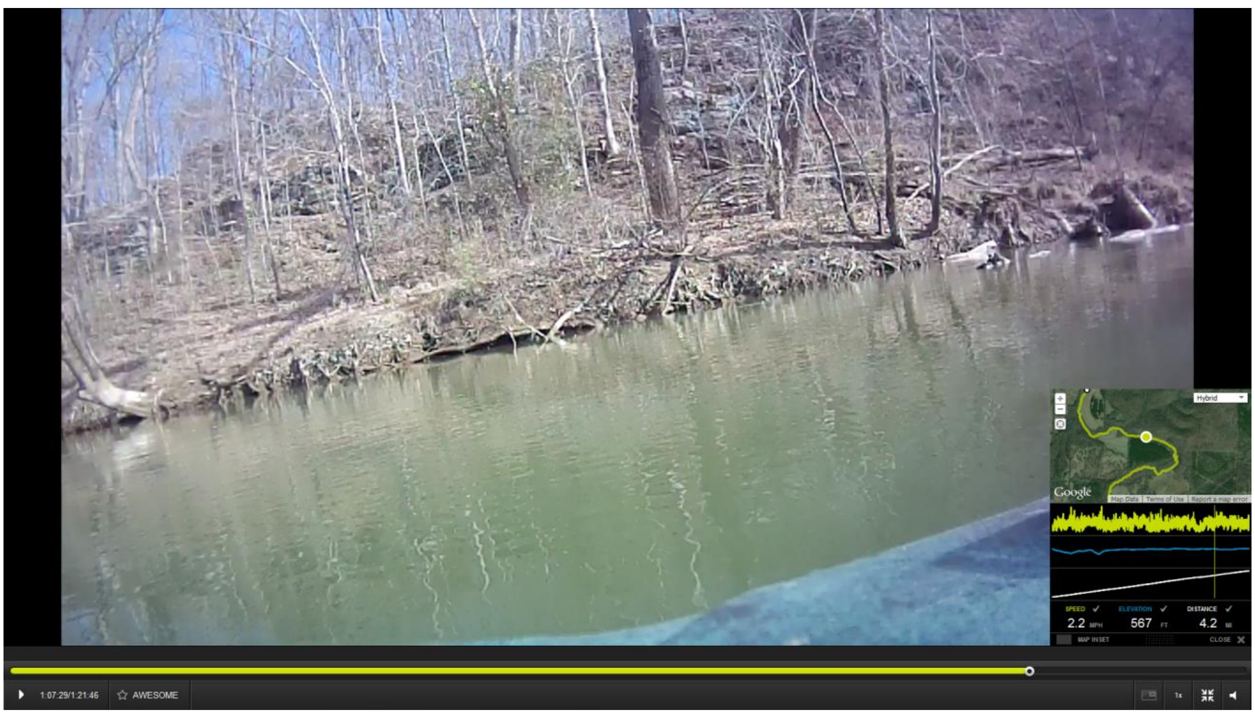
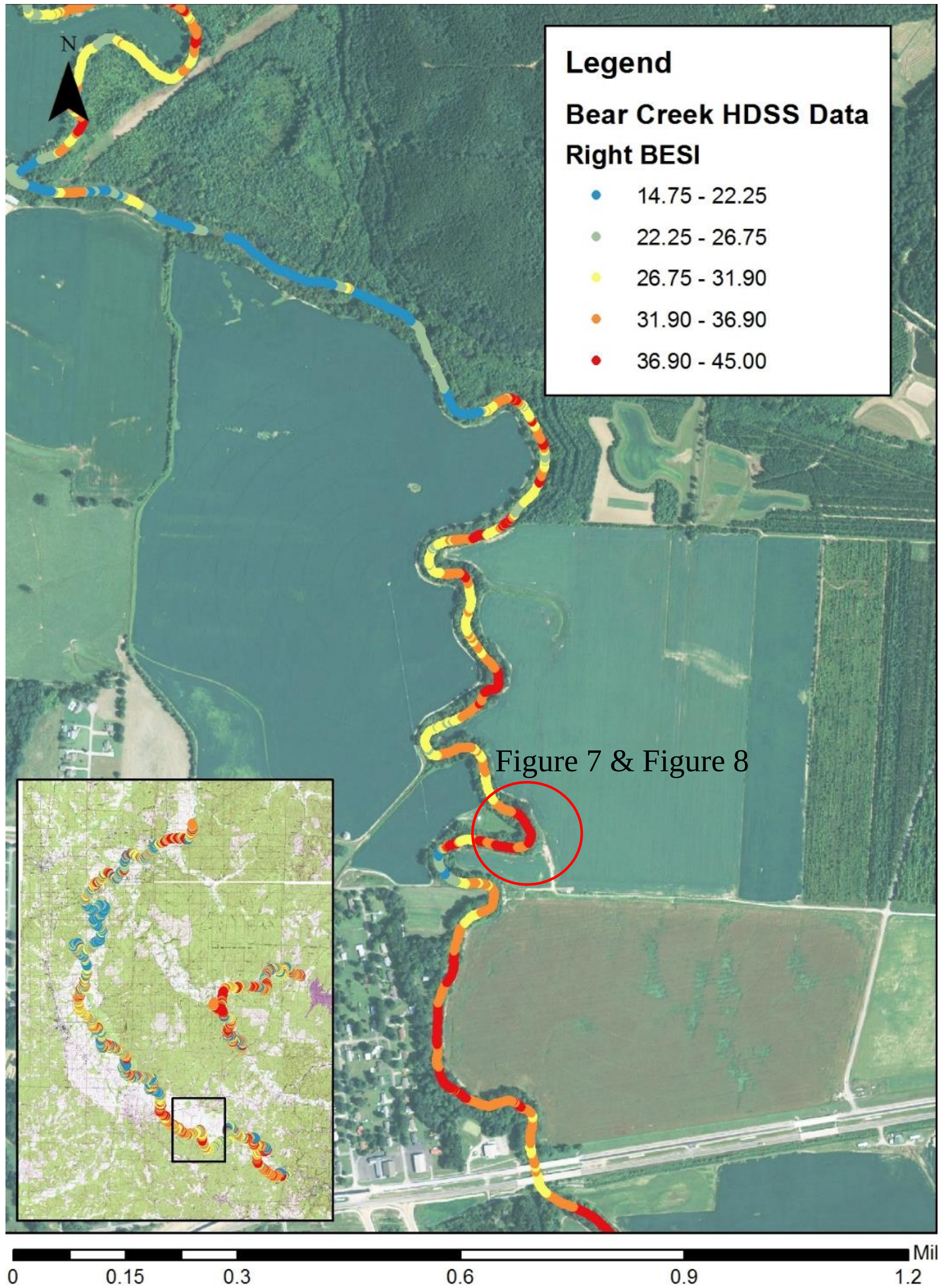


Figure 6: Video File; Bear Creek Right 11, 1:07:29



Map 7: Close up of Right BESI scores on Bear Creek

Figure 7: Video File; Bear Creek Right 21, 16:24

Figure 8: Video File; Bear Creek 21, 16:32

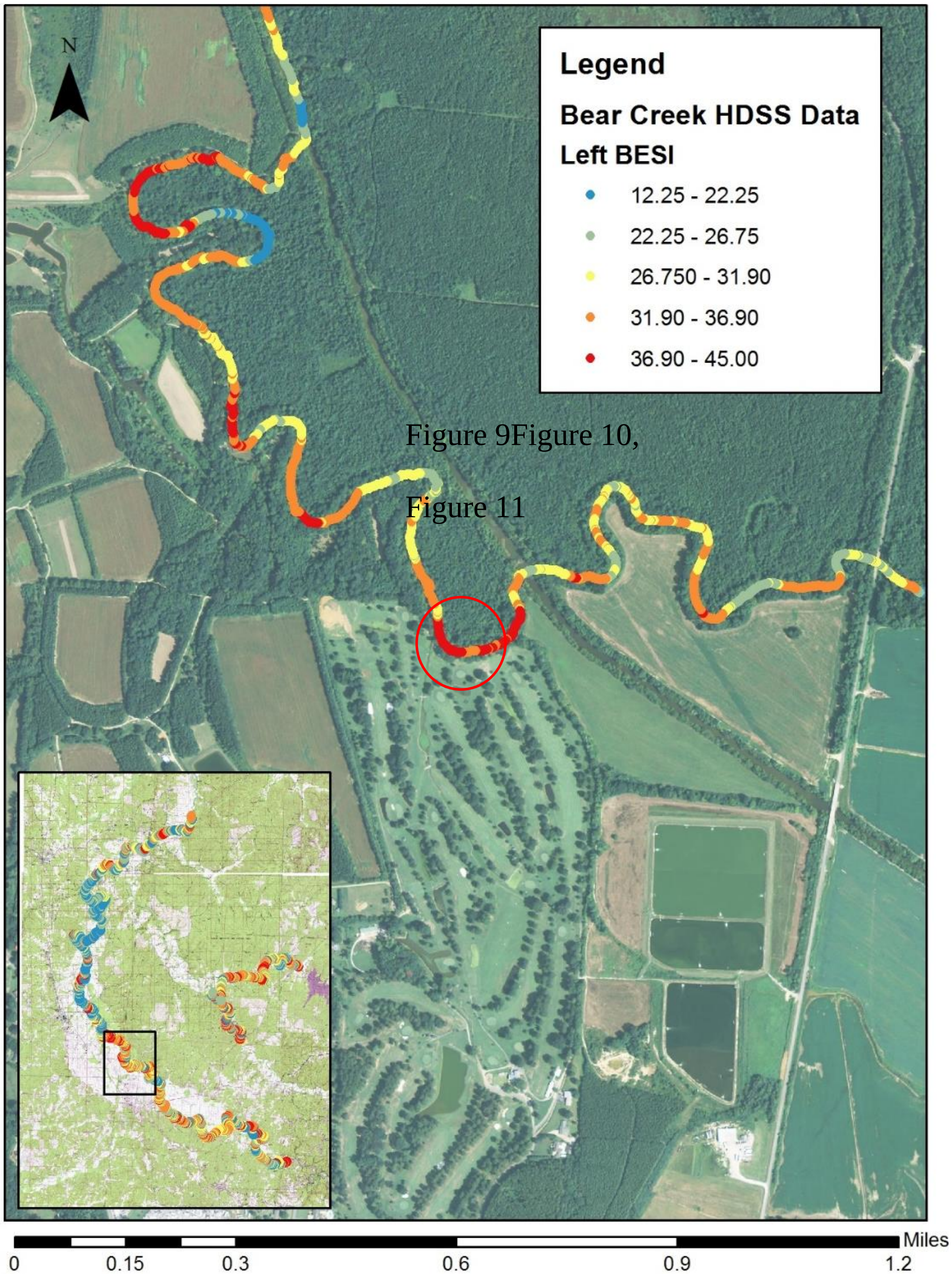


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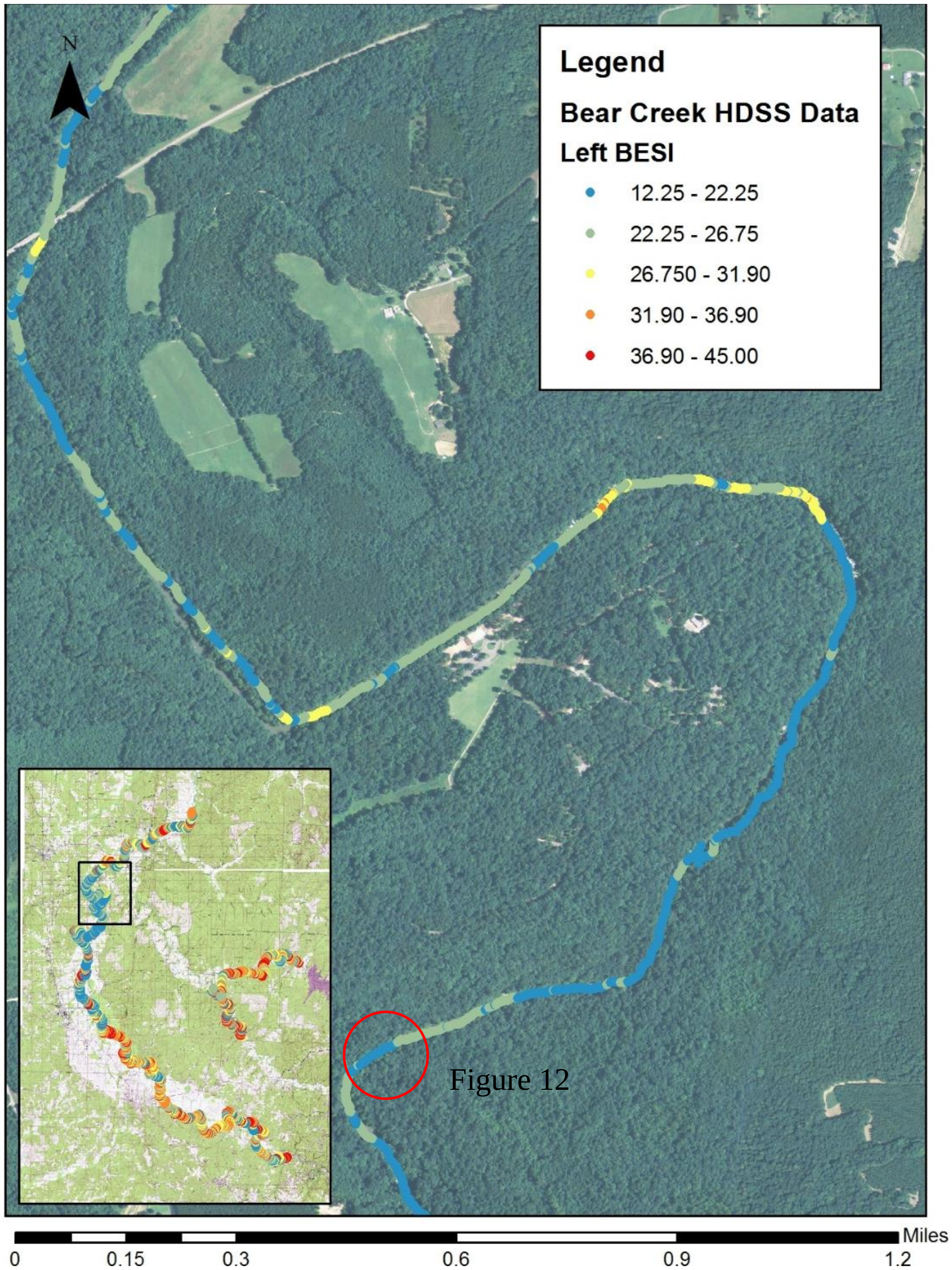
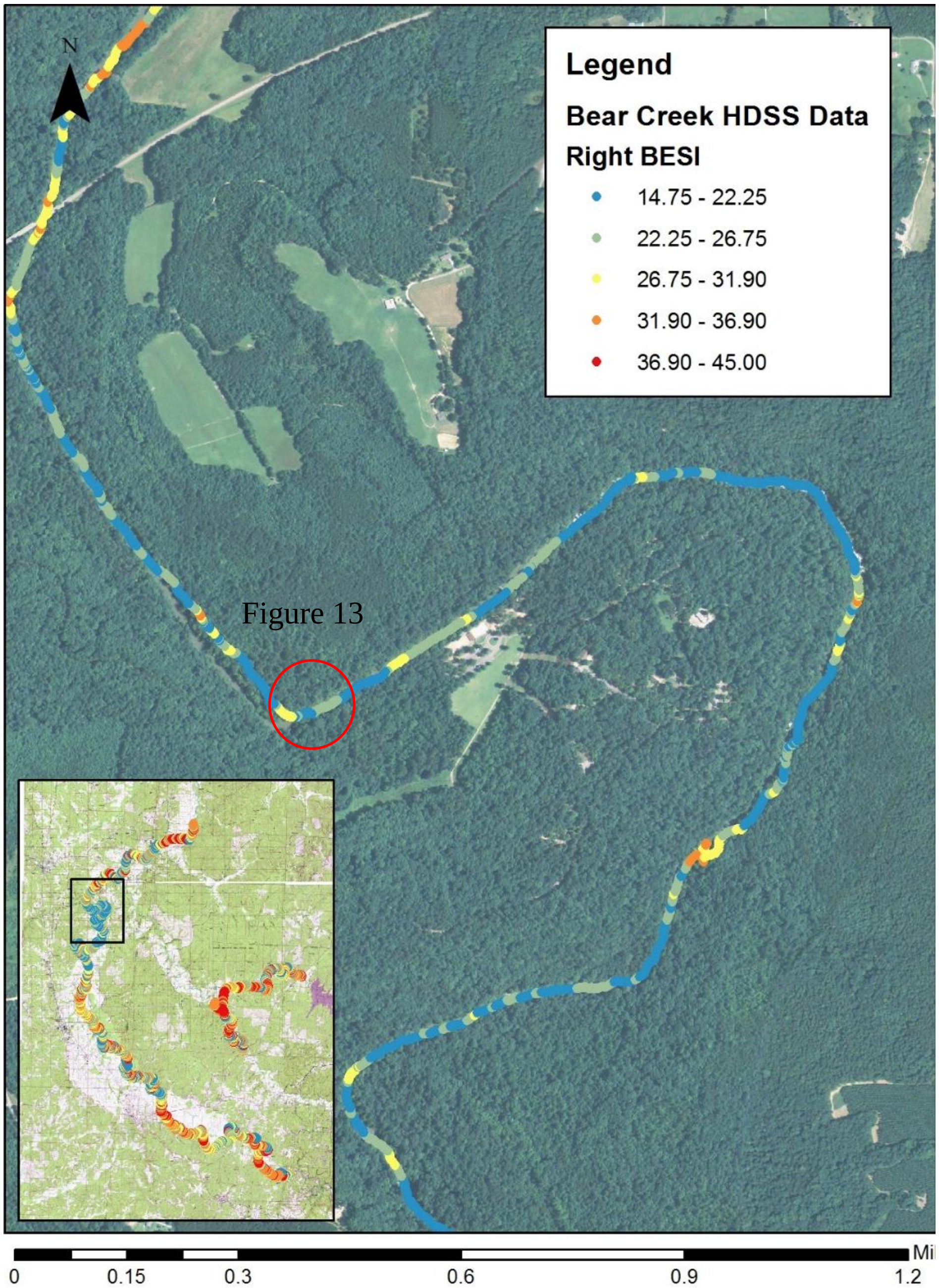
Figure 10: Video File; Bear Creek Left 23, 01:52

Figure 11: Video File; Bear Creek Left 23, 012:21



Map 9: Close up of Left BESI scores on Bear Creek



Map 10: Close up of Right BESI scores on Bear Creek

Figure 12: Video File; Bear Creek Left 33, 38:38

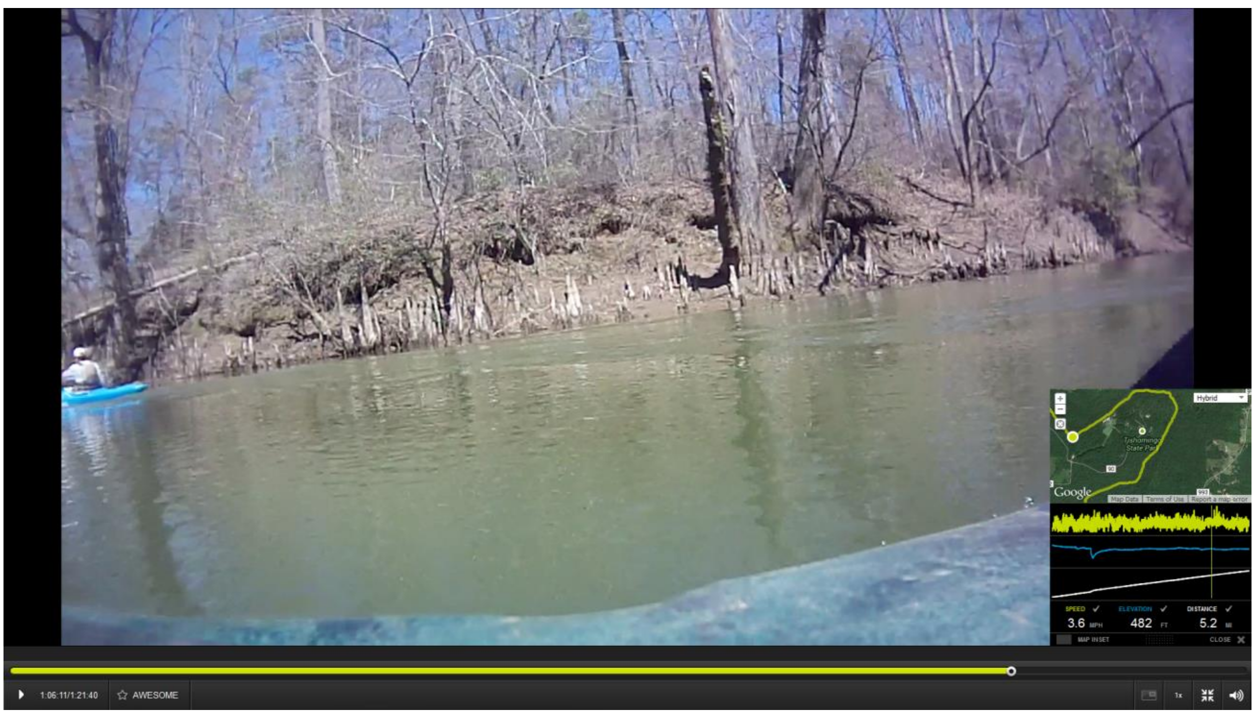


Figure 13: Video File; Bear Creek Right 33, 1:06:11

Conclusions

Stream reconnaissance provides the basis for scientific studies of channel form and process that integrate the collection and analysis of both qualitative information and quantitative data on the fluvial system (Downs and Thorne 1996). The Streambank Video Mapping System (SVMS) methods of the High Definition Stream Surveys (HDSS) used by Trutta Consulting on the Bear Creek watershed for the Tennessee Valley Authority proved fast and effective and the output had numerous applications. We surveyed over 64 miles in a four day field survey with data collected for both streambanks each second. Compared to traditional erosion assessments which tend be costly, isolated, restricted by access, and at times inaccurate due to extrapolation, the HDSS-SVMS approach was applied to survey more streambank, in less time, with fewer people and resources.

The survey results were intended to be used in three ways.

1) To help prioritize future restoration efforts and action areas.
2) To provide a baseline characterization of river bank conditions in 2014.
3) To support the collaborative efforts of federal and state agencies, private landowners, and non-governmental organizations in this watershed to achieve long-term water quality, habitat and species benefits.

(1) Being able to prioritize stream sections as well as tributaries and entire watersheds, will reduce the subjectivity when trying to justify future restoration areas. Each second of video has a BESI score of 9.8 to 36 giving the ability to prioritize future restoration sites. Combining the results of these surveys with data on other important factors such as land ownership, land use, geology, and jurisdictional boundaries within a GIS approach will allow further prioritization of

restoration sites. There is great value in these maps when combined with property lines while deciding with which landowners to work. All areas with a bank condition score of 30 or higher and a willing land owner is a potential spot for restoration and the results of this survey provide an effective way to locate and prioritize restoration sites.

(2) One of the strengths of collecting geo-referenced video of streambank conditions is the ability to review conditions at any site within the watershed at a later date. These archived videos will be available in the future if any additional questions arise about the condition of the Bear Creek watershed in 2014. Over time, the value of these video archives is likely to grow as it will be easy to document change-over-time for sites throughout the watershed.

(3) The video and associated classified data is very helpful to collaborative research and management within the Bear Creek watershed. The data can be shared as a data table (in spreadsheet or database format), as a shapefile for use in mapping software, or video files to directly review of the survey information. As a result, the bank condition survey data can be combined with various other data sets to create new and novel analyses of conditions and management actions and this will support the long-term goal of improving water quality, habitat and species within the Paint Rock River system.

Overall, this project further documented the efficiency of the HDSS-SVMS as a reliable monitoring tool for acquiring geo-referenced video in order to assess streambank condition. We collected and classified over 64 miles of high-resolution, geo-referenced video of both streambanks to provide a highly useful and important documentation of current bank conditions within the Bear Creek watershed.

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