An Assessment of the Restoration of Shade in the Stoney Creek Habitat Improvement Project

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Abstract

The Stoney Creek restoration project was expected to have a large impact on the surrounding riparian vegetation. Canopy shade is an important factor affecting salmonids through regulation of water temperature. In seven restored and three unrestored sites, fish-eye photography was used to measure canopy openness as an indirect measurement of shade, and to determine if this was similar between restored and unrestored areas. There were several limitations of this analysis, however, including the fact that deciduous trees did not have all their foliage at the time of year this project was conducted. A clinometer was used to measure the heights of the tallest trees surrounding the sites to see which sites would have more cover from the sun. There were several limitations with the clinometer use, as well, including the weather. Several of the restored sites had similar levels of canopy openness as unrestored sites, but several had lower levels. Tree heights were found to be fairly similar across all sites. We conclude that it appears as though several sites were not sufficiently restored to their pre-restoration project levels, which may be due to an insufficient amount of growing time since replanting occurred, and this may have important impacts on salmonids.

Introduction

The Stoney Creek Habitat Improvement Project was completed in August 2012. Stoney Creek is an urban area creek extending from Burnaby Mountain down to the Brunette River. Chum and Coho salmon are the main salmonid species that spawn in the fall, and cutthroat and steelhead in the winter and spring (Stoney Creek Environment Committee, 2012). As part of the restoration project, weirs and rock riffles were constructed in order to help salmon navigate up the creek and provide additional spawning areas. Heavy machinery was used to accomplish this task, heavily disturbing the vegetation that was there. Replanting was also done in some of the disturbed areas in an attempt to replicate what vegetation was naturally there previously (TommyNatureBoy, 2013). Riparian vegetation is thought to be an important component of salmon habitat since it can aid in temperature regulation, provide shelter from aerial predators, and provide an input of nutrients (McCormick & Harrison, 2011).

Our objective was to determine if the restoration project replanting was successful in restoring stream shade to pre-restoration levels and providing adequate shade for salmonids. In the absence of previous data on shade levels in restored areas, we decided to compare shade in restored sites to unrestored sites, to see if there are similar levels of shade. We selected several areas along Stoney Creek where the restoration project was performed and compared the shade at these sites to ones that are relatively undisturbed and have not undergone restoration projects.

Fish-eye photography analysis is a method that can be used to analyze shade. It specifically measures the amount of canopy openness at a particular site. Fish-eye photography analysis has commonly been used in forestry to analyse the light reaching a forest floor (e.g. Ackerly & Bazzaz, 1995; Madgwick & Brumfield, 1969; Whitmore et al., 1993). This method has also been used to measure percent canopy openness in streams (Davies-Colley & Payne, 1998; Dignan & Bren, 2003; Foley, Torres, & Mueller, 2002; Kelley & Krueger, 2005). Davies-Colley and Rutherford (2005) and Kelley and Krueger (2005) found that fish-eye photography yields the highest accuracy for measuring canopy openness out of several different methods, and that this is a good metric for shade, which is why this method was chosen.

We also analyzed the heights of some trees at each site. We originally wanted to measure the vegetative shading angle because of its ultraviolet (UV) light component, which has harmful impacts on salmon behaviour (Lee, et al., 2011; Holtby & Bothwell, 2008; Johnson, 2004). However, determination of the UV component was not in the scope of this project due to time constraints. It would have required a great deal of work, including using a model provided by the study conducted by Lee et al. (2011), which includes an equation using a direct measurement of topographic shading angle. This formula also depends on the season of the year and a large scale of the area, with eight directions based on the azimuth angle and sun's elevation (Lee et al. 2011). Since topographical cover was not included in our research topic, we decided to measure the height of the trees instead; we wanted to see how the height of the trees blocked sunlight. We chose the tallest trees because they block more sunlight than shorter vegetation. To determine the heights of the trees, we used a clinometer, which is commonly used in forestry to find the angle of a certain object. The advantage of using the clinometer is that it is easy to use and not very expensive. It is very small and can be carried by hanging around the neck.

Methods

Canopy openness

On our first field day on April 2nd we performed fish-eye photography analysis on ten sites along the stream, as shown in Figures 3 through 7. Three were unrestored sites and seven were restored sites. In the unrestored area upstream of the restored area we used two sites, one that was naturally more open and one that was naturally more closed (Figure 4). The only downstream site we used was also naturally more closed (Figure 7). We included both more open and closed sites because we do not know if the restored sites used to be naturally more open or closed, so we must be able to compare them to either type.

Fish-eye photographs were taken at each site. The camera used was a Canon 18.0 Megapixel EOS Rebel T2i digital SLR camera. Each photograph was taken through a 0.42x HD super wide angle panoramic fisheye lens attachment on an 18-55mm lens attached to the camera. At each site, one photograph was taken with the camera positioned in the middle of the stream on a tripod, leveled and pointed vertically upward, elevated about 10-30cm above the water. However, the pond at site 8 increased in depth quite quickly away from the edge, so the camera and tripod was placed about a foot inside of the pond's edge instead of in the very center.

Studies that have used fish-eye photography for the analysis of stream shade used image analysis software to automatically calculate canopy openness. These programs were not within the scope of this project due to time constraints. Photographs were analysed using Adobe Photoshop CS4 Essentials, version 11.0, as explained below.

To keep user error consistent, only one operator analysed the pictures. The overall approach of the analysis was to calculate the percent open area of the canopy at each site. First the total area of canopy captured in each photograph had to be calculated. Diameter was measured in each photograph from one edge of the lens to the other in pixel in Photoshop, and then total area was calculated using the equation for the area of a circle using diameter:

$$\text{total area} = \pi(\text{diameter}/2)^2$$

An issue with using fish-eye photography analysis in this project is that at the time of year the photographs were taken (April), the deciduous trees had not grown their leaves yet. This is problematic because shade is usually most important for salmon in the summer when temperatures are warm, when deciduous trees have open foliage. In an attempt to overcome this obstacle, when analyzing the photographs, we made a general assumption that all of the deciduous branches would have leaves on them in summer, and thus there should be a general buffer around all branches for cover. Using Photoshop's magic wand tool with a tolerance level of four, gaps in the canopy were selected; then the number of pixels in all of these gaps was determined from Photoshop (see Figure 1 for an example of a photograph that has undergone analysis). Percent open area was then calculated using the equation:

$$\text{open area} / \text{total area} * 100\%$$

These percent open area values should not be considered absolutely values, since the methods used to obtain them were not as rigorous as previous scientific studies, and there will be a large amount of user error present. However, for the purpose of this project (to compare percent open area between sites), this error will be consistent in all photographs, and the absolute percent open area will just be used for comparison. The resulting percent open area values were then assessed qualitatively by comparing the unrestored sites to the restored sites and observing trends.

Tree heights

In this case, because we were studying the shade cover of vegetation over the stream, we measured the height of the tree by determining the angle. Measurements using the clinometer were conducted on our second field day, one week after the first day. The day was cloudy and rainy with no sun. According to the manual for the clinometer (SUUNTO PM-5/360PC) we used, the location where the measurements have to be taken is supposed to be 15 meters away from the tree. However, this was a problem because we were in the stream where we measured the vegetation shade cover the previous field day, there was much vegetation along the bank of the stream which were too close to be measured. Therefore, we decided to measure the height of the tallest trees.

A clinometer is a small device that is used to measure angle. In this case, the height of tree is measured by adding base of the tree and the top of the tree when viewed from the level of the eye as shown in Figure 2 with more details. The degrees were recorded so the height of the tree could be calculated manually using trigonometry. The equation for calculating the height of the tree was:

$$height = \tan(degree) * distance$$

Results

Canopy openness

The unrestored sites that are more naturally closed over have around 1% open area, while the more naturally open unrestored site has around a 13% open area (Table 1). This indicates that there are unrestored areas of the stream that will naturally have a greater percent area, which must be remembered when comparing restored sites to unrestored sites.

The restored areas segregate into two classes of percent open area: below 5% and above 24%. All of the sites below 5% are sufficiently low to be able to claim that these sites are similar to the unrestored sites in terms of the level of shade. The sites above 24%, however, are too high above even the open unrestored area of 13% to be able to say that they have similar levels of shade. Thus, restored sites 3, 4, 5, and 7 all had enough vegetation to restore the level of shade to sufficient values. However, restored sites 6, 8, and 9 did not have their levels of shade restored to sufficient levels.

Tree heights

Tree heights across all sites range from 12.59m and 91.4m (Table 2). These are typical heights of the trees found in the area, with an average of 32.93m, including coastal Douglas fir and western hemlock. However, 91.4m seems to be a possible outlier as there was little variance between all the other measurements. One explanation for this is that the angle and distance could have been inaccurately measured (the angle is out of place).

To obtain better results, it would be ideal if the sites would be revisited; however, this was beyond the scope of this project. In the future, measurements would have to be measured more than once in order to obtain data with little error.

Discussion

Canopy openness

After assessing ten locations using our revised fish-eye photography method it was discovered that not all locations have actually had their levels of shade restored, when comparing them to unrestored sites. The areas at weir 1, between weir 1 and weir 2, at weir 3, and the section of stream at the pond intake point (sites 3, 4, 5 and 7; see Figures 5 and 6) have been restored to a sufficient level of shade, while the disturbed area just downstream of weir 3, the pond, and the stream from the pond to the creek (sites 6, 8, and 9; again, see Figures 5 and 6) have not had their levels of shade sufficiently restored.

There are several limitations of the fish-eye photography analysis process used to measure shade through measuring percent canopy openness. The first one is that the photograph of the pond was taken near the edge of the pond and not in the middle of it. This means that the canopy openness will not be completely accurate. A major assumption is that all deciduous branches in all of the photographs will have leaves in the summer. While this will generally be a fair assumption, there is still some uncertainty introduced here due to the fact that we are not directly measuring openness from the deciduous trees in bloom. Therefore, the percent canopy openness values should be interpreted with caution.

Another limitation of this analysis is that in comparing the restored sites to the unrestored sites, we are assuming that the amount of shade in the restored sites was similar to the amount of shade in the unrestored sites. We do not have data on the previous amount of shade in each site, so this is an assumption that we must make in order to assess how well shade was restored in this project. We must consider, however, that there may have been other unidentified environmental factors that may have altered the shade level in either or both of the restored and unrestored sites. In this case, shade differences would not be attributable to the restoration project alone, but it is impossible to be able to know if environmental factors have caused such alterations.

Another factor that must be considered when comparing restored areas to unrestored areas is that the restoration project was completed only within the last year. Therefore, the vegetation that was re-planted with the restoration project may not have had enough time to grow to pre-restoration levels.

Tree heights

Due to the obstacles in finding UV components of light in the creek, we decided to measure the height of the trees instead, in order to assess how trees are blocking sunlight around Stoney Creek. Shade cover is partially or completely influenced by the sunlight that comes through the highest trees or other nearby trees. The main issue with conducting the research with the clinometer for this project was the weather. Because the weather was cloudy and rainy with no sun, we had to estimate where the sun was, and it may not have been at its highest point. Another problem was that the areas where the clinometer was used to determine the heights of the trees did not have many trees clustered together; there was often a large gap between one another. As the position of the sun varies every day, it is difficult to say which direction the suns' light is coming from and as to whether the sunlight is actually blocked or not. The best solution for this would be to restore the Stoney Creek area by replacing the trees so the sunlight that warms the creek, which in turn may affect salmon behaviour, can be efficiently blocked. It is recommended that in future studies, this should be done on a sunny day in summer and perhaps during spawning months to assess if the vegetation is acting as a barrier by protecting salmonids from the harmful rays. This is important since there has been evidence that UV radiation impacts aquatic productivity and can also have direct physiological effects on fish from a simple sunburn to suppression of immune responses and egg mortality (Walters & Ward, 1998).

Conclusion

According to Moore et al. (2005), stream temperature is an important and critical factor in relation to habitat conditions. Lee, et al. (2011) has stated that main factors controlling stream temperature are air temperature and direct solar radiation. With scientists predicting a global increase in average air temperatures, attempting to reduce the amount of direct solar radiation hitting the creek is a decent option to attempt to regulate creek temperature.

From our results we have determined that several areas where the restoration project took place have not had their vegetation cover restored, when comparing to the areas outside the restoration project. However, using the original fish-eye method when all vegetation has open foliage the accuracy of our results could be improved. In future studies, if the clinometer method was altered the amount of UV light penetrating the stream could also be determined with more accuracy. Another aspect to keep in mind is the fact that the restoration project was only completed about a year ago, and this is most likely not enough time for higher-canopy vegetation to re-grow. Therefore, it is recommended the frequent monitoring be done to assess whether the vegetation cover is growing enough and if it will be sufficient enough to act as a temperature buffer for salmonids. As part of restoring the levels of shade in areas that were disturbed we recommend that more planting be done in these areas.

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Tables and Figures

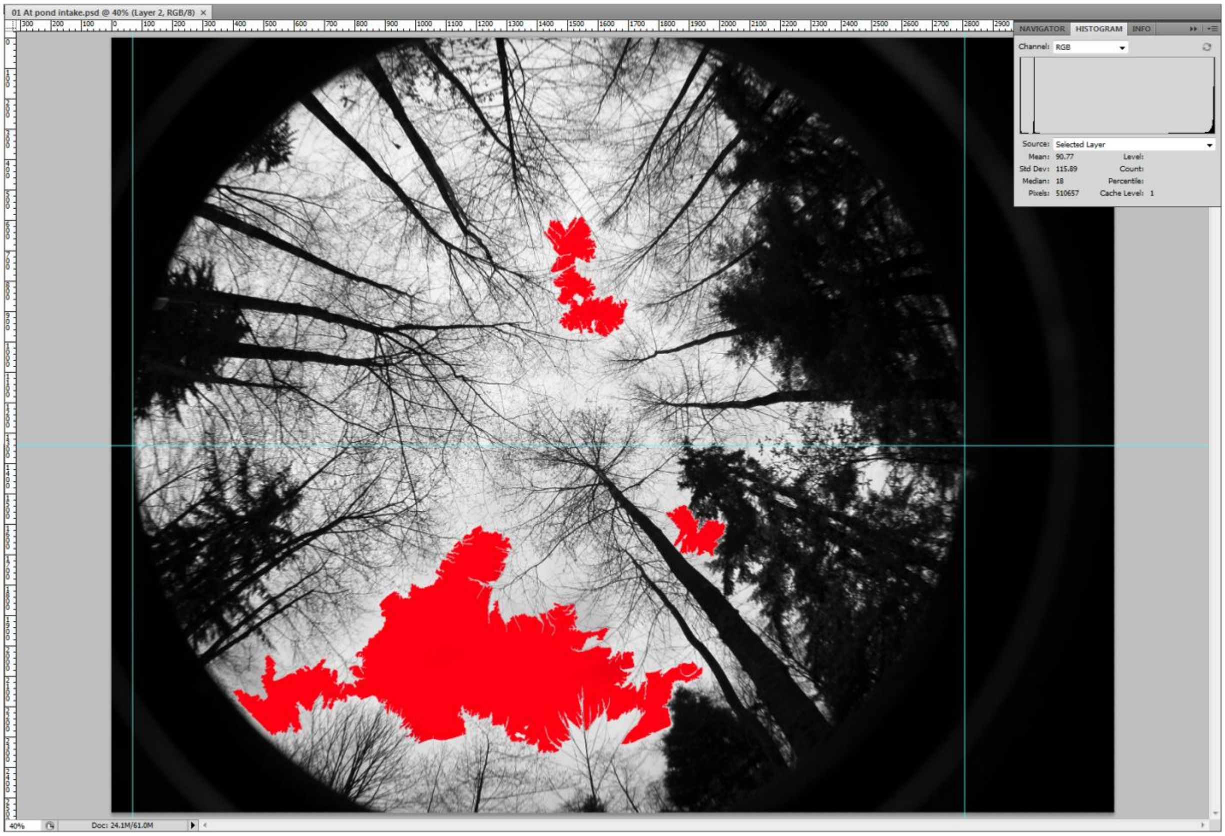

Figure 1. A snapshot of one of the fish-eye photographs after undergoing analysis in Adobe Photoshop CS4 Essentials. The red area is the area of canopy openness, which was selected by the operator using the Magic Wand tool with a tolerance level of four. Diameter of the total area captured inside the lens edge was calculated as the distance between the two blue vertical lines, which were placed manually at the widest part of the circle.

Table 1. The results of the analysis of fisheye photographs taken at each site at Stoney Creek. Site 8 was a naturally more open section of the unrestored stream upstream, while Sites 9 and 10 were naturally more closed sections. Colours highlight the percent open area values: green = <5%, red = >24%, blue = between 5% and 24%. Total area is calculated from the diameter using the equation "total area = $\pi(\text{diameter}/2)^2$". Diameter, area, and open area are in pixels.

Site	**Total Area**		**Open Area**	**% Open Area**
	Diameter	Area		
1: Unrestored upstream (open)	3716	10845293	1397923	12.9%
2: Unrestored upstream (closed)	3708	10798647	128598	1.2%
3: Weir 3	3756	11080033	408586	3.7%
4: Between Weir 1 and Weir 2	3746	11021112	41906	0.4%
5: Weir 1	3724	10892040	389582	3.6%
6: Disturbed area just downstream of Weir 3	3724	10892040	2682553	24.6%
7: At pond intake	3708	10798647	510657	4.7%
8: Pond	3723	10886191	3266348	30.0%
9: Stream from pond to creek	3810	11400918	2987805	26.2%
10: Unrestored downstream (closed)	3709	10804472	141900	1.3%

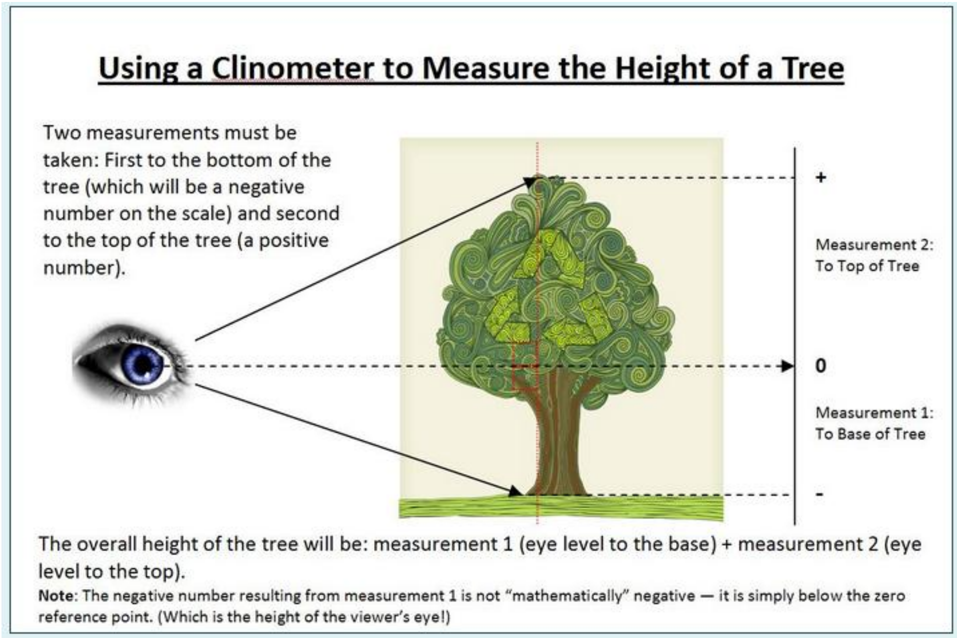

Figure 2: Visual description of the measurement of the angle. Source: Elms Environmental Education Center (n.d.)

Table 2: Results taken from the measurement of tree height by using clinometer. The black boxes have no values, as Site #1 had no measurements taken.

Site #	**Angle (Degree)**		**Calculated Angle (degree)**	**Distance (m)**	**Calculated Height (m)**
	Tree top	Tree base			
1	40	5	45	20.00	20.00
2	50	3	53	20.00	26.54
3	55	5	60	20.00	34.64
4	55	1	56	17.00	25.20
5	70	6	76	12.00	48.13
6	55	1	56	10.00	14.83
7	75	10	85	8.00	91.40
8	75	4	79	7.50	38.60
9	55	5	60	10.00	17.32
10	37	3	40	15.00	12.59
Average	56.7	4.3	61	13.95	32.93

Figure 3. A full view of all of the sites (1-10) in Stoney Creek that were sampled.

Figure 4. A closer view of the unrestored assessment area upstream from the weirs: (1) unrestored upstream (open); (2) unrestored upstream (closed).

Figure 5. A closer view of the areas assessed at the weirs: (3) weir 1; (4) between weir 1 & 2 under a tree; (5) weir 3; (6) disturbed site downstream from weir 3.

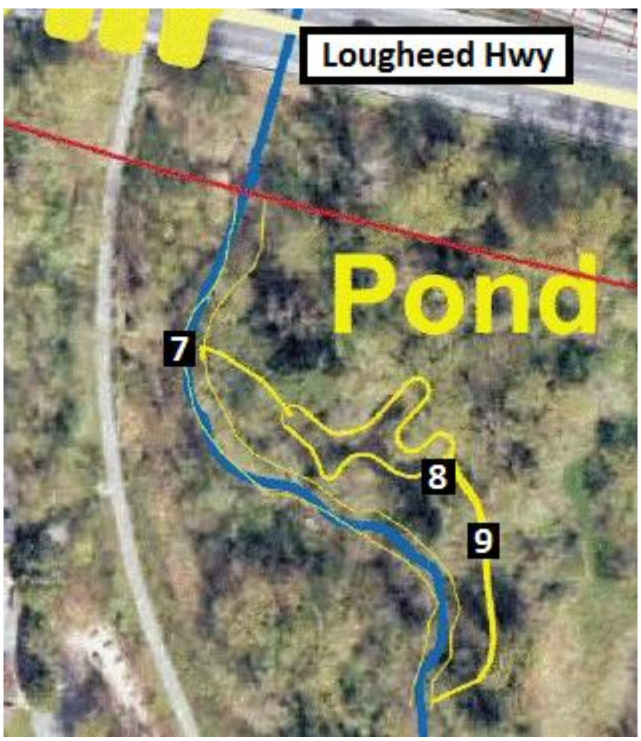

Figure 6. A closer view of the areas assessed near and at the pond South of Lougheed Highway: (7) pond intake; (8) pond; (9) stream from pond to creek. Source: Stoney Creek Environment Committee (2012).

Figure 7. A closer view of the area assessed downstream from the pond, across Government Street, next to the train tracks: (10) unrestored downstream.