Stream Velocity: How it can Affect Riparian Vegetation in the Stoney Creek Area

By: Amanda Schrack and Jessica Wan

Abstract:

Riparian vegetation is not often the first consideration for improvement when installing a weir into a stream or river. It is less likely to be taken into consideration in comparison to the in stream habitat. As the weirs often times change the stream velocity, this study was created to observe how this change in velocity can affect riparian vegetation in the surrounding Stoney Creek area where weirs were put in to assist salmon spawning. The study was not conducted to illustrate the direct impacts of the weir implementation, but rather the stream velocity on its own. The hypothesis for the procedure was that the differences in stream velocity would correlate to plant biodiversity on land. Due to previous similar research being done in different non-alike areas, it could not be argued whether higher or lower stream velocities would show higher or lower diversity throughout the stream. Random plots along the stream were made in order to observe differences in soil pH, stream velocity beside the plot, and the variety of plants within the plot. To test soil pH and stream velocity, pH and velocity metres were used. The plants within the plot were identified using a plant identification book, and counted manually. The results showed that

there were not many patterns that could be related to differences in stream velocity. Some of the patterns that did occur were the abundance of certain plants in certain areas. The diversities within the plots were also seen to be much higher than the diversity of the overall area. At deeper and slower water levels, the diversities and species richness were the highest. This research allows the effect of human remediations to be analysed. With further research, the full effect of velocity on riparian vegetation as a result of the input of weirs in a stream can be observed.

Problem Statement:

Riparian vegetation is not often the cause for the implementation of river or stream weirs. Weirs are most often installed with the purpose of restoring the in stream habitat. It is important to see how differences in stream velocity can affect onshore riparian vegetation because it is a factor that should be considered when installing weirs. If there is a direct correlation and the biodiversity of the riparian vegetation is not considered, then it is possible that there will be long term detrimental effects on the in stream environment, which would defeat the initial purpose of the weirs.

The focus area of this study was between the openings of the culvert to a few meters past the first weir. The richness and abundance of different vegetative species in the area was the main focus, as well as the amount of invasive species. The reason for considering the amount of invasive species is that they contribute to the health of an ecological system. If it can be seen where more invasive species thrive, then it can be known what types of factors contribute to that. From research done by previous studies, our hypothesis was that the stream velocity would play a role in plant diversity. In the article by Mueller et al. (2011), it was seen that the stream velocity can change abiotic factors like substrate types or chemical composition, which then alter the biotic factors of plant growth. Similarly, in the article by Greet et al. (2011) it was seen that where there was a decrease in stream variability due to the input of weirs, and richness increased. More variation of drier land plants were able to thrive due to the little variability in stream flow. Flooding due to the weir does still take place, but it does not significantly alter the richness as the plants in the area that becomes flooded are mostly water tolerant.

The conclusions formed by multiple researchers about stream flow variation and riparian biodiversity are consistent with showing that stream velocity is related to the types of vegetation. However, no assumptions were made about how the variation in velocity would impact the vegetation. The information from the articles were consistent with showing variations, however, since the studies were done in different areas from each other and from this stream site, an assumption about the specific type of change could not be established. Knowing that velocity and vegetation are correlated proves that stream bank vegetation is an important factor to consider when inputting weirs. Richness will increase and decrease in certain areas. However, plants accounting for this richness may also be invasive and possibly detrimental to the area.

Methods:

In order to relate riparian vegetation density to differences in stream flow, we first collected information on which plants were present. To do this, we created 30 2mx2m plots downstream from the weir, where there were 6 plots on either side of the stream. We randomly selected 6 of these plots using an online number randomizer. Within these plots we counted and identified the plants. Using this method allowed for us to know the exact size of the total area we were analyzing. At each plot, we measured 2 meters away from the edge of the bank and 2 meters along the bank in order to have an area of 4m^2. We put nails into each of the 4 corners of the plot, and used string to create borders in order for us to easily see the exact area being observed. We then used plant identification books to see which plants were present in the area and which were native or invasive.

From this collection of data we will be able to observe the abundance and richness through the use of the Simpsons Diversity Index Formula.

$D = \sum (n / N)^2$ is the formula, where n represents the total number of organisms of a specific species, and N represents the total number of all organisms (Offland Woodland and Wildlife Trust).

We will be able to look at the diversity in each plot, as well as the total diversity of the combined plots which will have a total area of 24m^2. As it was inevitable that there would be plants like groundcover or mosses where counting individuals will be problematic, we instead approximated how much of the plot area they covered.

Where the plots started was a few meters downstream from the culvert since there were human disturbances. The disturbance is non-organic materials which does not allow for plants to grow. If we included this area within our plot choices, it would offset the data.

For each plot we will also look at soil acidity levels and stream velocity alongside the plot. To find the soil acidity level, we used a soil acidity meter. Looking at the soil acidity was another factor in seeing the types of plants which could grow in the area. It was also another comparison to make with the stream velocity to see if there were any correlations. In order to see the stream velocity at each plot, we took the velocity at 2m from the middle of the plot on the edge of the stream into the stream. We used a velocity meter to find the magnitude of the stream velocity.

<u>Results</u>:

The first plot started at 0m to 2m on the west side of the stream. It had a richness of 13 different plant species, with an over total of 52 plants. There were a total of 4 known native plants and 3 known invasive plants. Three of the thirteen plants were dune grass, golden moss, and yellow moss which are not included in the total of 52 as we recorded their population by percent coverage of the plot (Chart 18). The most abundant species in this plot was the Yellow Rocket. The entire list of plants and their abundance are located Chart 1. The soil acidity was measured to being approximately 6.3 pH. The velocity was measured to be approximately 2.57 ft/s. By using the abundance and richness, the diversity was calculated to 0.159131.

The second plot started at 4m and went to 6m on the west side of the stream. It had a richness of 12 different plant species, with an overall total of 46 plants. There were a total of 6 known native plants and 2 known invasive plants. Three of the twelve plants were common water moss, clear moss and Menzie's neckera which were not included in the overall 46 plants as we recorded their population by percent coverage (Chart 19). It was noted that the moss coverage took place almost entirely in the first quarter strip of the plot directly beside the stream. The most abundant species in this plot was the salmon berry.

The entire list of plants and their abundance are located in Chart 2. The soil acidity was measured to being approximately 6.3 pH. The velocity was measured to be approximately 5.48 ft/s. By using the abundance and richness, the diversity was calculated to 0.40642. The total grass and moss coverage

The third plot was located from 6m to 8m on the west side of the stream. The plot had a richness of 10 different plant species, with an overall total of 35 plants. There were a total of 6 known native plants and 2 known invasive plants. Two of the ten plants were common water moss and clear moss which were not included in the overall 35 plants as we recorded their population by percent coverage (Chart 20). Similarly to plot 2, the moss coverage took place in the first strip closest to the stream, covering approximately 10% of the total plot. The most abundant species in the plot was also salmon berry. The entire list of plants and their abundance are located in Chart 3. The soil acidity was measured to be approximately 6.1 pH. The stream velocity was measured to be approximately 3.56 ft/s. By using the abundance and richness, the diversity was calculated to being 0.258776.

The fourth plot was located from 14m to 16m on the east side of the stream. The plot had a richness of 13 different plant species, with an overall total of 26 plants. There were a total of 10 known native plants and 0 known invasive plants. Three of the 13 plants were false lily, yellow moss, and cranes-bill… were not included in the overall 26 plants as we recorded their population by percent coverage (Chart 21). The most abundant species in the plot was salmon berry. The entire list of the plants and their abundances are located in Chart 4. The soil acidity of the plot was measured to be approximately 6.1 pH. The stream velocity was measured to be approximately 1.16 ft/s. By using the abundance and richness, the diversity was calculated to being 0.16716.

The fifth plot was located from 24m to 26m on the east side of the stream. The plot had a richness of 11 different plant species, with an overall total of 23 plants. There were a total of 8 known native plants and 2 known invasive plants. Two of the 11 plants were yellow moss and cranes-bill which were not included in the overall 23 plants as we recorded their population by percent coverage (Chart 22). The most abundant species in this plot was lady fern. The entire list of the plants and their abundance can be found in Chart 5. The soil acidity was measured to being approximately 6.1 pH. The stream velocity was measured to be approximately 1.37 ft/s. By using the abundance and richness, the diversity was calculated to being 0.149338.

The sixth plot was located from 26m to 28m. However, from approximately 27m to 28m there were rocks, and no plants. Due to this, we only looked at a plot area of 1mx2m. The plot had a richness of 18 different plant species, with an overall total of 37 plants. There were a total of 10 known native plants and 4 known invasive plants. 4 of these 18 plants were yellow moss, cranes-bill moss, ribbed bog moss, and bottle moss, which were not included in the overall 37 plants as the populations were recorded based on percent coverage (Chart 23). The most abundant species in this plot was Himalayan blackberry. The entire list of the plants and their abundance can be found in Chart 6. The soil acidity for the plot was measured to be approximately 6.2 pH. The stream velocity was measured to be approximately 2.11 ft/s. By using the abundance and richness, the diversity was calculated to being 0.14244.

The overall area that we looked at was 22m^2. It was not 24m^2 as originally planned due to the rocks located in plot 6. From the data collected, it was seen that the most abundant species were salmon berry (native), and yellow rocket (invasive) (Chart 11). For plant populations calculated by percent coverage, it was seen that the coverage of English ivy increased downstream (Chart 9), and the moss coverage mostly consisted of native mosses which did not show a pattern in coverage among the plots. In total, there were 27 plant species observed. It was also noted that there were more invasive species at the plots upstream than there were in the plots downstream (Chart 7). Using the Simpson's Diversity Index Formula, we were able to see that the diversity had generally increased moving down the stream (Chart 8). The numbers calculated for diversity range from 0 to 1, where 0 indicates infinite diversity, and 1 indicates no diversity. For all 6 plots, the diversity was calculated to be 0.874. Using the Plot Estimate Technique (University of Idaho), the overall moss and grass coverage can be found in Chart 10 in the Appendices. It illustrates Dune Grass and Golden Short-Capsuled Moss covered the most ground area over all the plots. The overall species richness and plant abundances over all 6 plots can be found in Charts 12 and 13. To illustrate how velocity affects species richness, plant abundance, diversity, and the likelihood of native and invasive species present, charts were made. Charts 14 to 17 in the appendices show the differences. These different factors help illustrate the environmental conditions that riparian vegetation must face in a stream with a weir.

<u>Discussion</u>:

The results show that there were not any significant patterns between stream velocity and riparian plant species or riparian biodiversity. However, the results did seem to indicate that in general, plots which had a lower stream velocity had a higher diversity of plants. These results differ from our hypothesis which stated that there would be a direct correlation.This theory was based on similar research done for different stream and weir sites. These differences could be due to things like seasonality or locational differences.

Due to the time of year being early spring when our results were taken, many of the plant species were at a seedling stage, or just starting to grow their foliage. This made identification quite difficult, resulting in 11 species being classified as unknowns (Table 1). Since they were unknowns, we also could not indicate whether they were native or invasive species. This information can lead to the hypothesis that if data was taken at a later time during the spring or early summer, the results would be different. If this were true, then the research method done at this point during the year and our conclusions drawn from the data would not be incorrect, but instead it would be incorrect because it was drawn upon information that does not completely represent the stream velocity in relation to riparian biodiversity.

The tolerability of the plants that were present when our data was compiled also needed to be very high. Since the water levels are higher, they need to be much more tolerable, which reduces the amount of variability among the species of plants. The average high temperatures between March and April also have been seen to not reach above 13 degrees celsius (Weather Network (2013)). This means that additionally to the higher water levels, plants must be more tolerable to colder conditions, which also decreases the variability.

In the research done prior, it should be noted that the locations of the different studies were not in similar locations to that of Stoney Creek. One was in Germany (Mueller et al. (2011), 3 were in Austraila (Golab & Indraratna (2009), Greet, J. et al. (2011), Siebentritt, M. A., et al. (2004), and 2 were in the United States (Auble, G. T., et al. (1994), Salant, N.L., et al. (2012). Due to differences in seasonalities in other parts of the world, results would not necessarily be similar to what was found with the Stoney Creek area.

Although the overall results in the Stoney Creek area were not that same as those in the articles, there were some consistencies. In the research done by Greet, J. et al, (2011), it was seen that in areas where there was less variation in stream velocity, there was more richness on land. Likewise, plot 6 had the highest richness among the plots, and the lowest stream velocity. Plot 6 was also only half the plot size of any of the other plots, so if there was a full plot there it would be fair to say that the richness would be even higher.

The information from Siebentritt, M. A., et al (2004) may have had different results, as they looked the information over a different period of time. They first looked at the river before it was flooded, let it flood for two weeks, and then reanalyzed the area. It was noted that after the flooding there was little germination. In relating this to the Stoney Creek area, due to the high waters at this time of year, germination may be lower than during other times in the year. This would explain the lower diversity level of all the plots combined which represent the entire area.

***<u>Conclusions</u>*:**

The purpose in doing this research was to find out if the velocity of the stream affected the diversity and abundance of the plant species in the surrounding area.

Observing 6 different 2m by 2m plots we discovered that the further downstream we went, the diversity increased. There was also higher species richness further downstream, with the maximum at plot 6 at 18 different species. Even though there was not any conclusive evidence, it can be stated that there was a general trend where when there is a slower velocity and higher water level, there will be more species richness and overall diversity. This is also seen in the article by Greet, J. et al, (2011). It was also observed that the acidity levels were the same across the entire studied area so there were no conclusions made on soil acidity, except for that the plants that grow in all the plots can grow in slightly acidic areas. Since there was a limited amount of time that could be spent on this analysis, there were only 6 plots that were observed. For a better illustration of the effects of velocity, further research downstream of the weir should be done to see if the velocity changes the abundance and diversities of the vegetation. The riparian vegetation should also be observed in different weather conditions to see if the different water levels results in different plants and diversities.

References:

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2. Golab, A. N., & Indraratna, B. (2009). Occurrence and consequences of acid sulphate soils and methods of site remediation. Geomechanics and Geoengineering, 4(3), 201-208. doi: 10.1080/17486020902923387
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8. Siebentritt, M. A., George G. G., & Keith, F. W. (2004). Effects of an enhanced flood on riparian plants of the River Murray, South Australia. River and Research Applications, 20, 765-774.

9. Weather Network (2013). Retrieved from

http://www.theweathernetwork.com/statistics/CL1101158/cabc0043

Appendices

Table 1: Unknown Plants

Unknown 1	
Unknown 2	
Unknown 3	

Unknown 4	
Unknown 5	
Unknown 6	

Unknown 7	
Unknown 8	
Unknown 9	
Unknown 10	

Unknown 11	

Appendices

Chart 1: Abundance in Plot 1

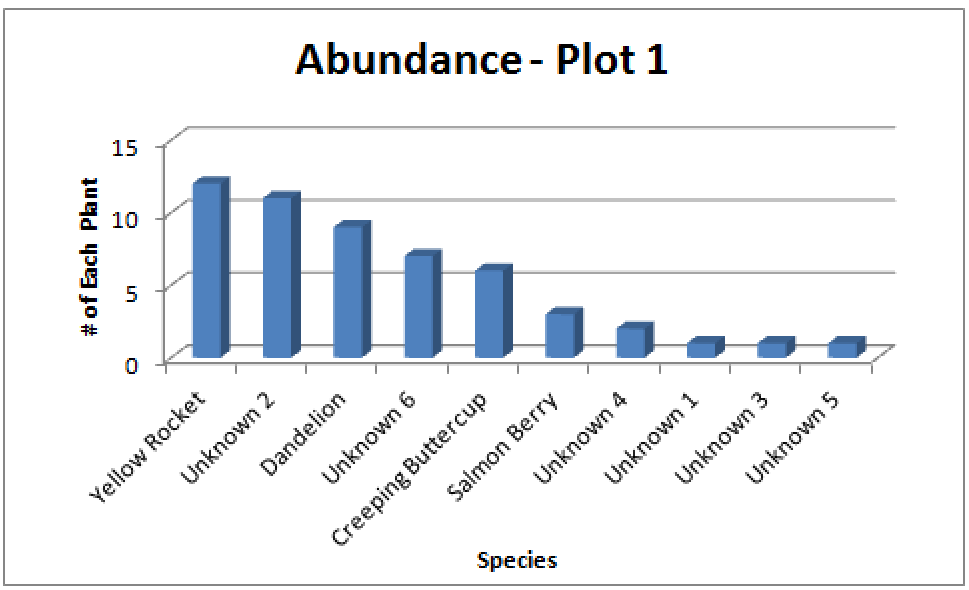


Chart 2: Abundance in Plot 2

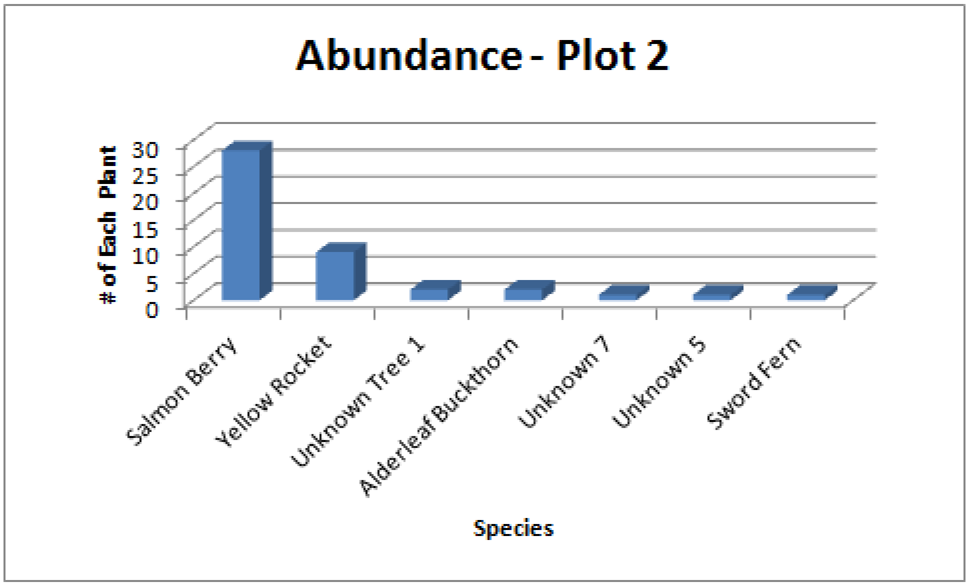


Chart 3: Abundance in Plot 3

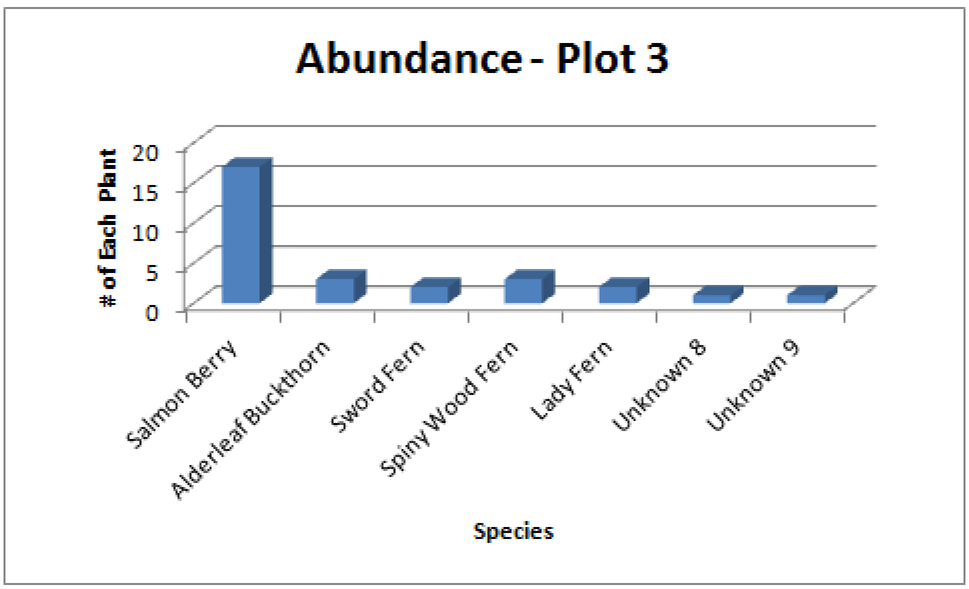


Chart 4: Abundance in Plot 4

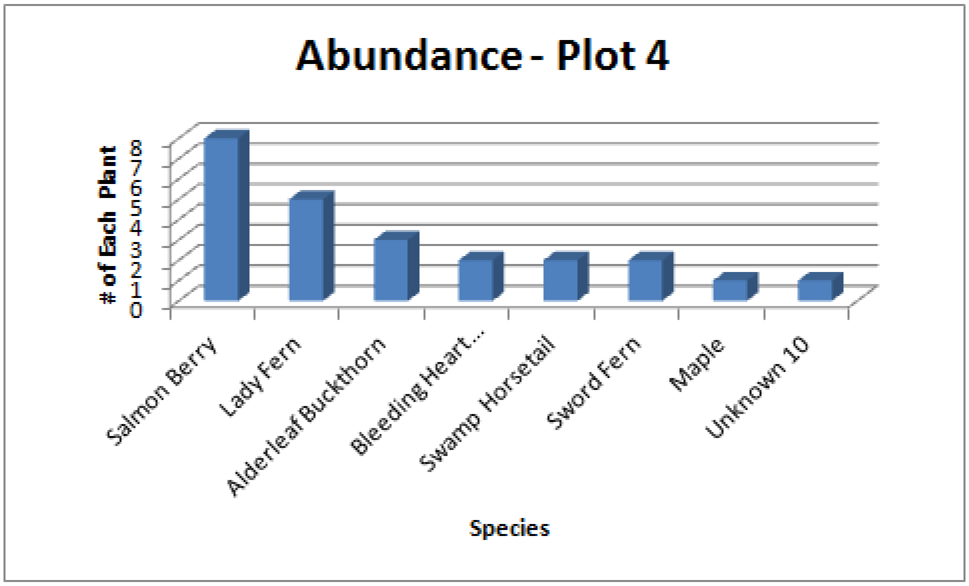


Chart 5: Abundance in Plot 5

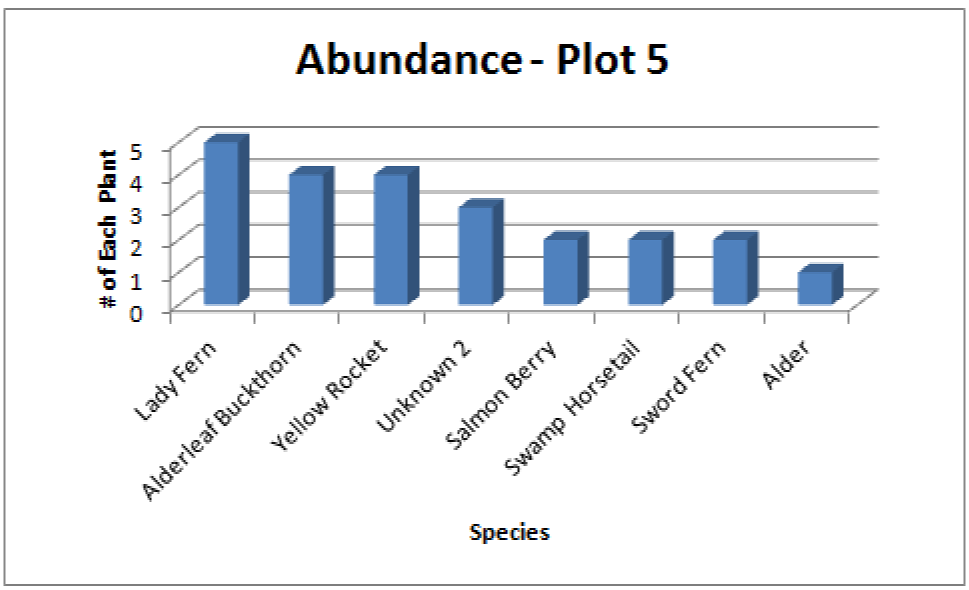


Chart 6: Abundance in Plot 6

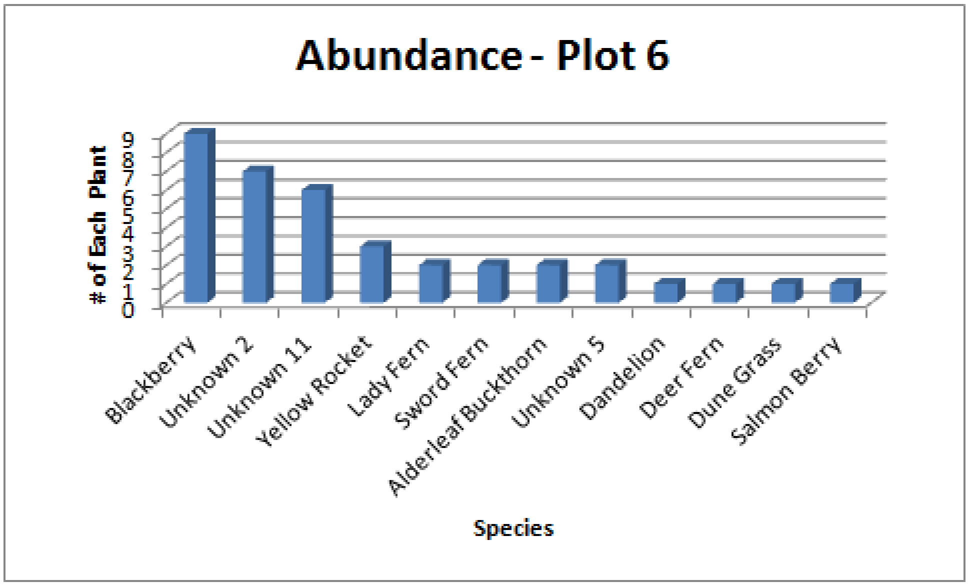


Chart 7: Native Vs Invasive Plants in Each Plot

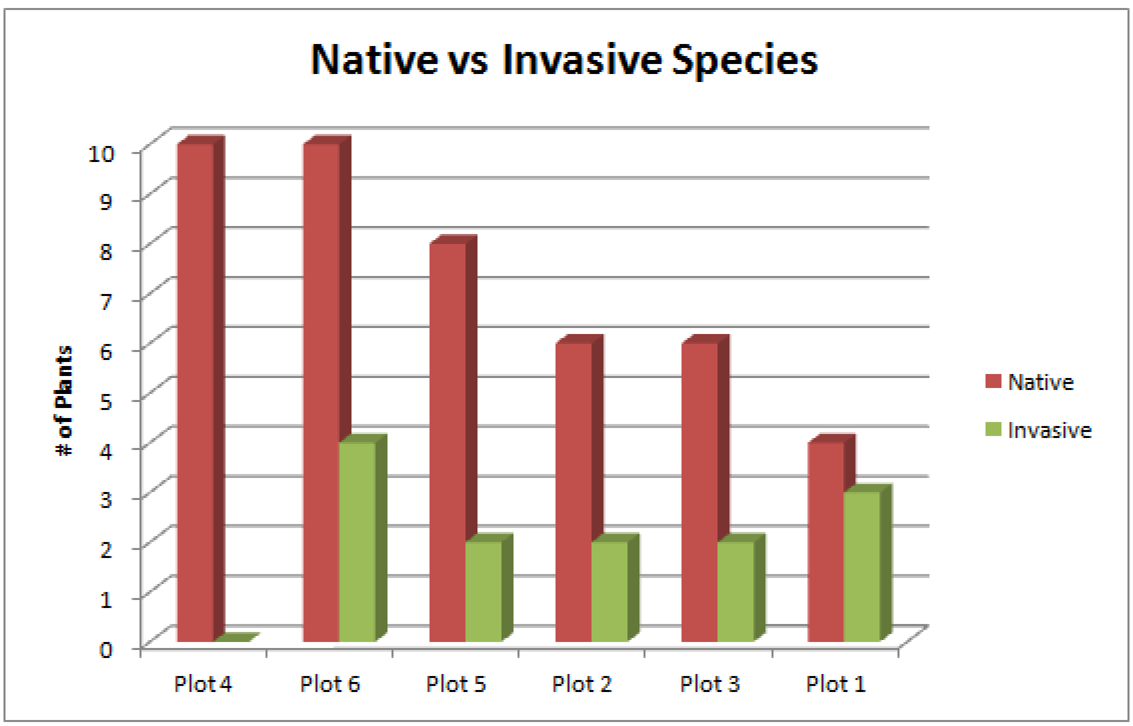


Chart 8: Comparison of the Diversity in Each Plot

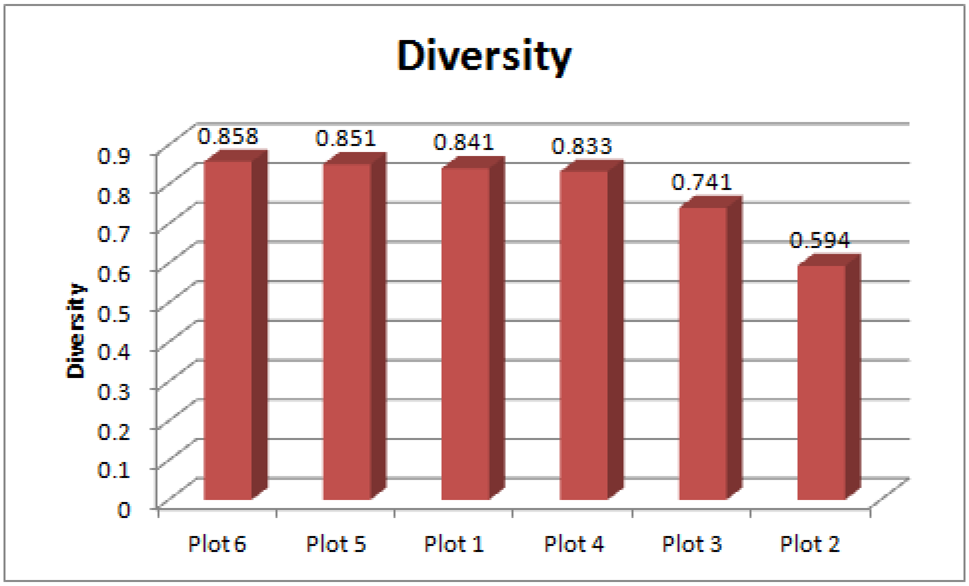


Chart 9: Number of English Ivy Vines in Each Plot

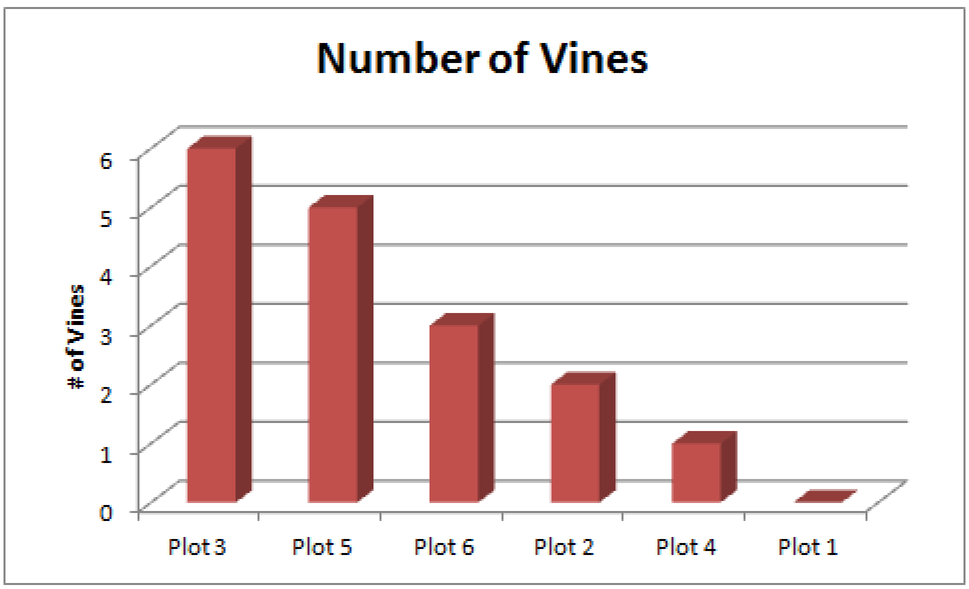


Chart 10: Total Moss and Grass Coverage in All Plots

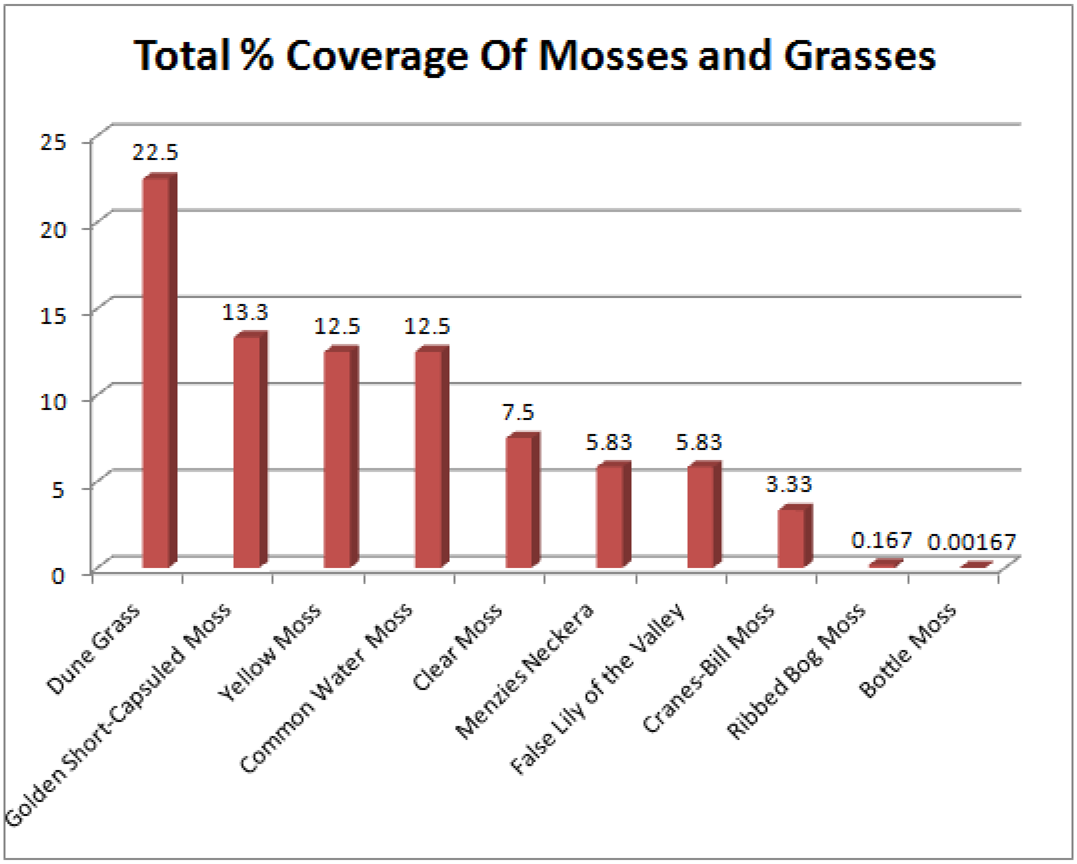


Chart 11: Total Abundance of Each Plant Over All Plots

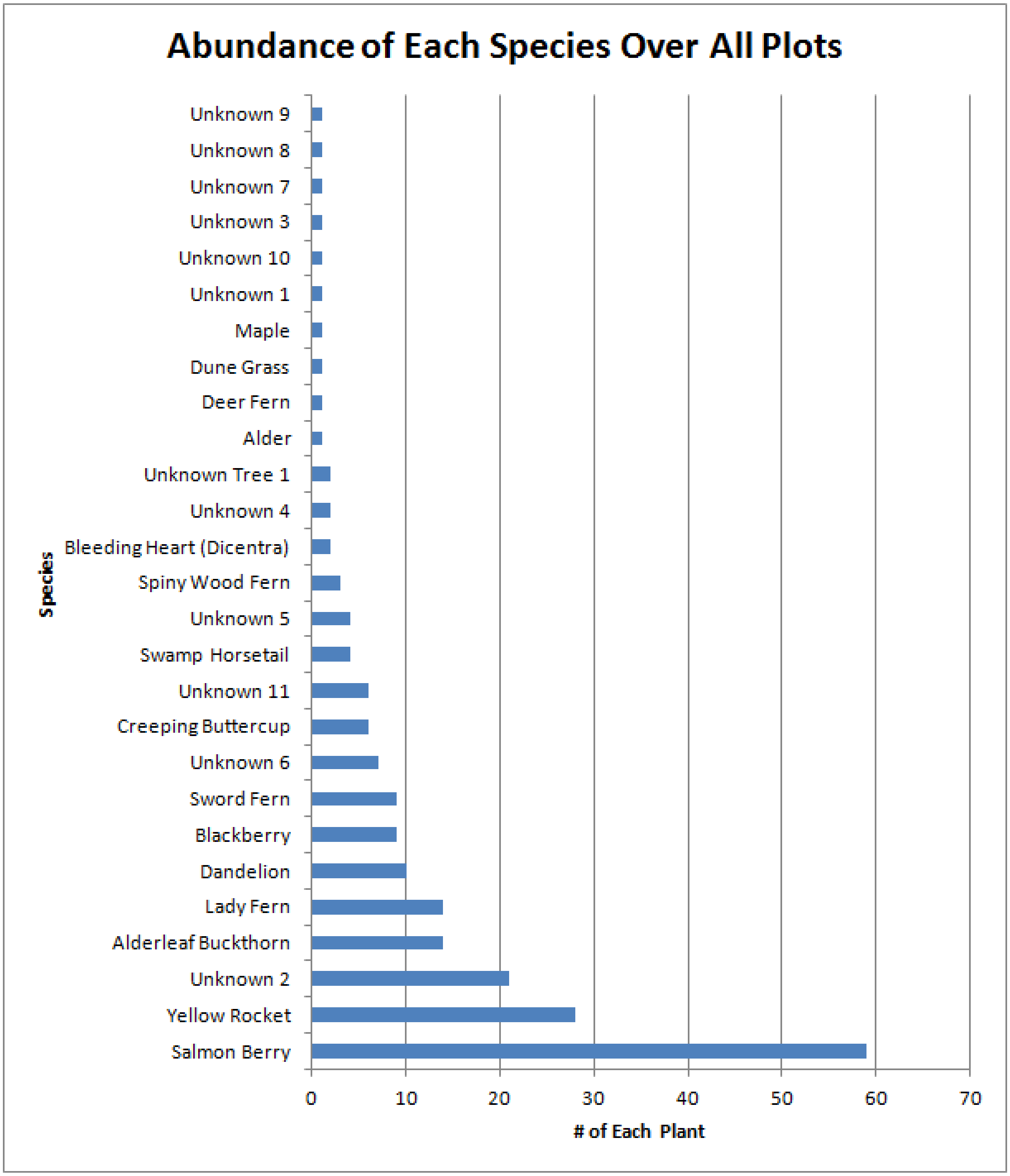


Chart 12: Species Richness Over All Plots

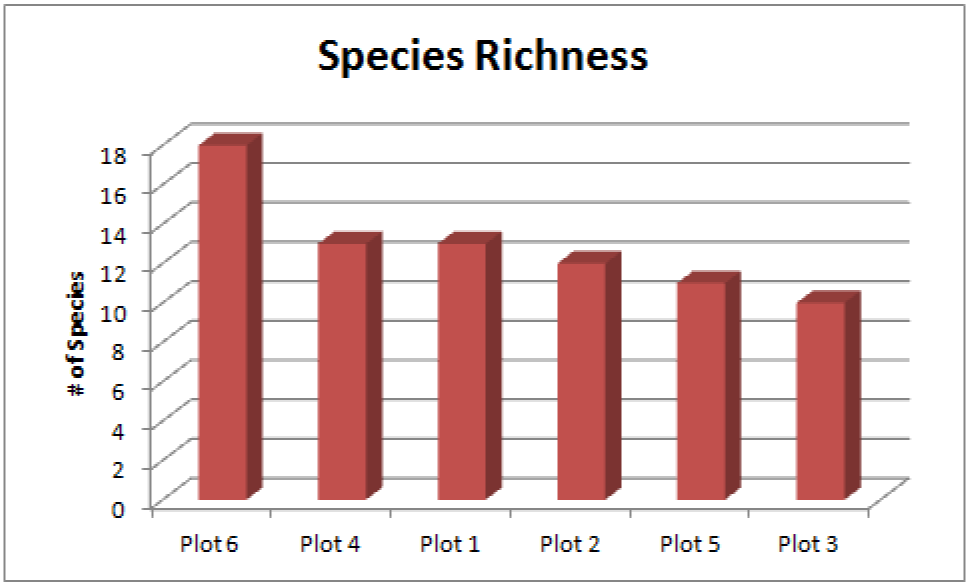


Chart 13: Overall Plant Abundance Over All Plots

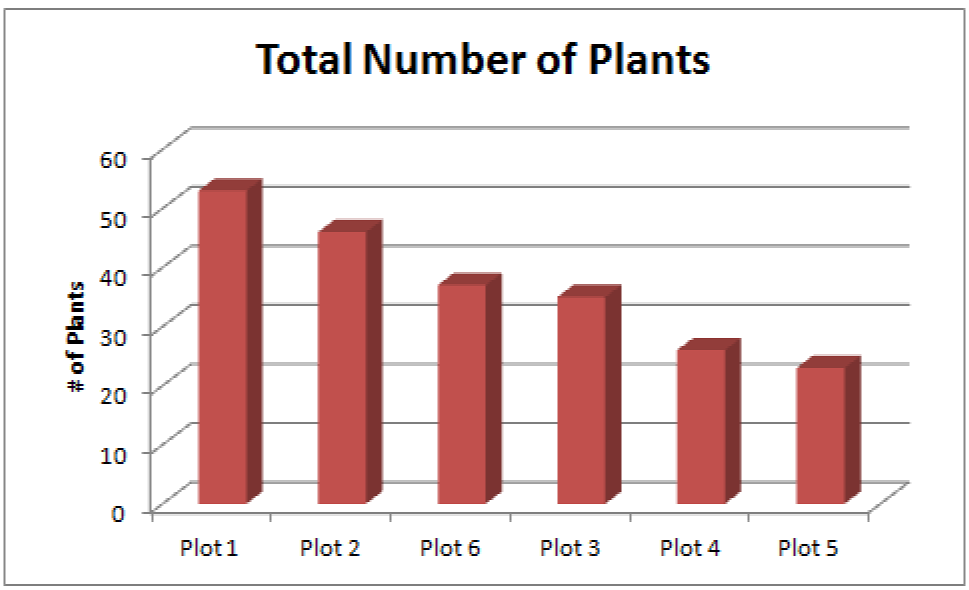


Chart 14: Species Richness at Each Plot Velocity

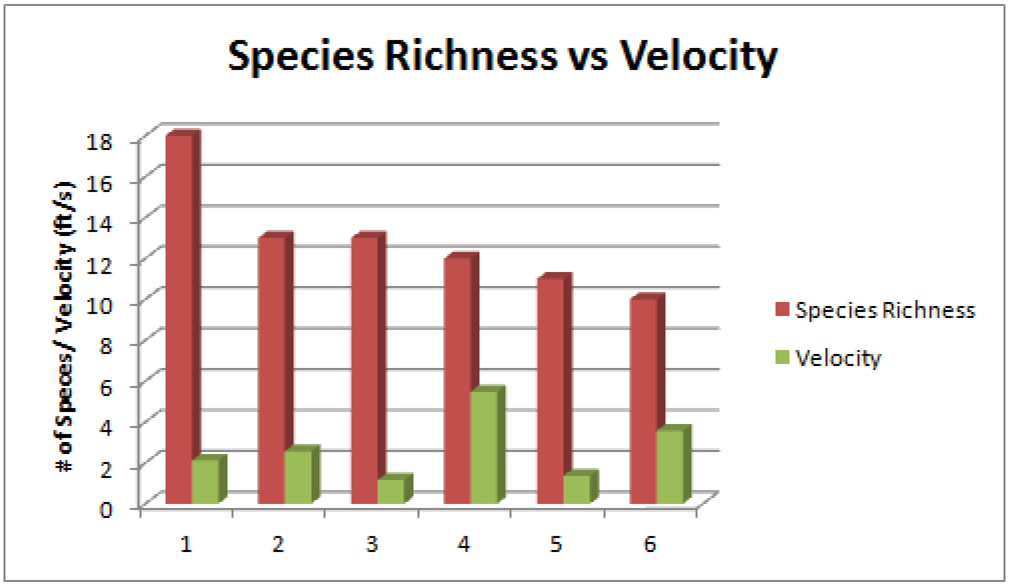


Chart 15: Total Number of Plants at Each Plot Velocity

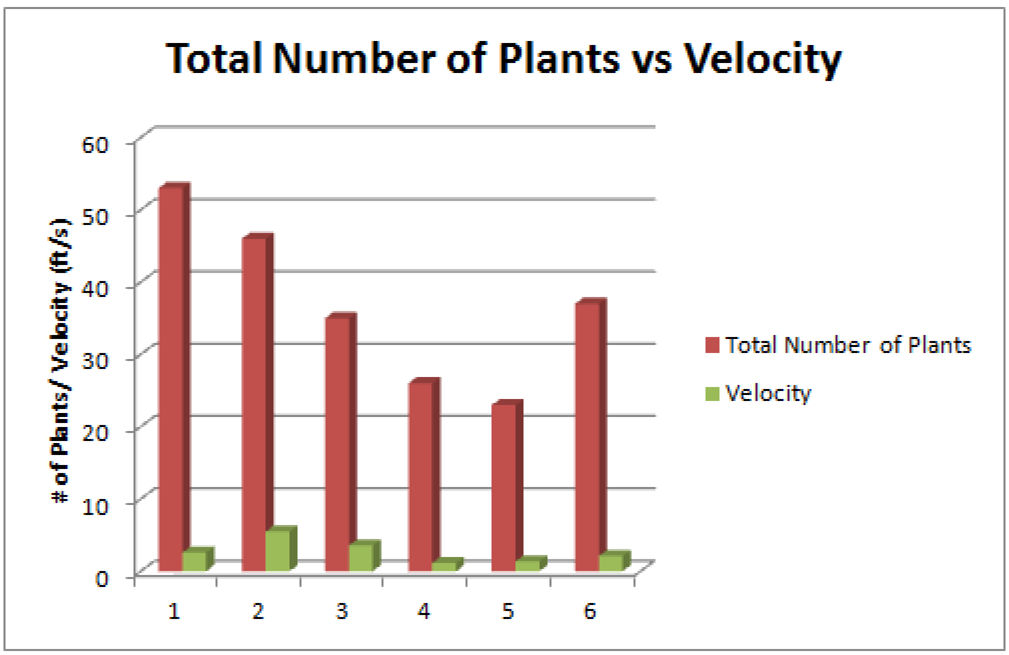


Chart 16: Diversity of Plots at Each Plot Velocity

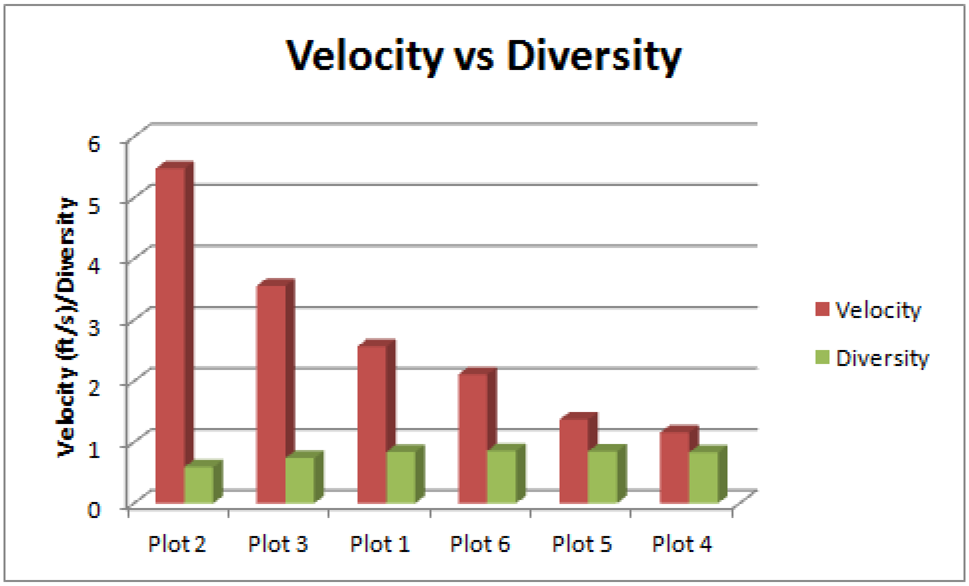


Chart 17: Native and Invasive Species at Each Plot Velocity

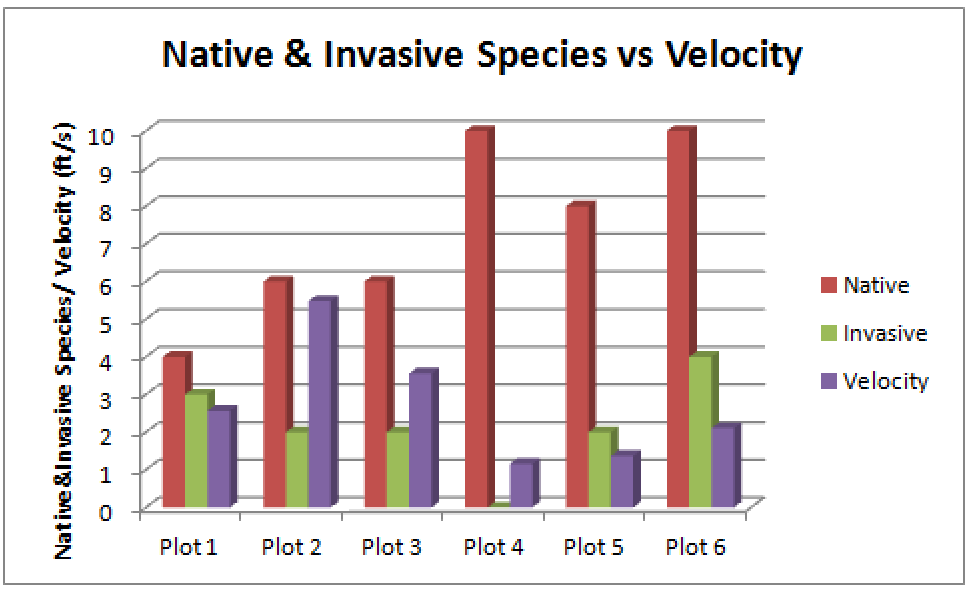


Chart 18: Grass and Moss Coverage in Plot 1

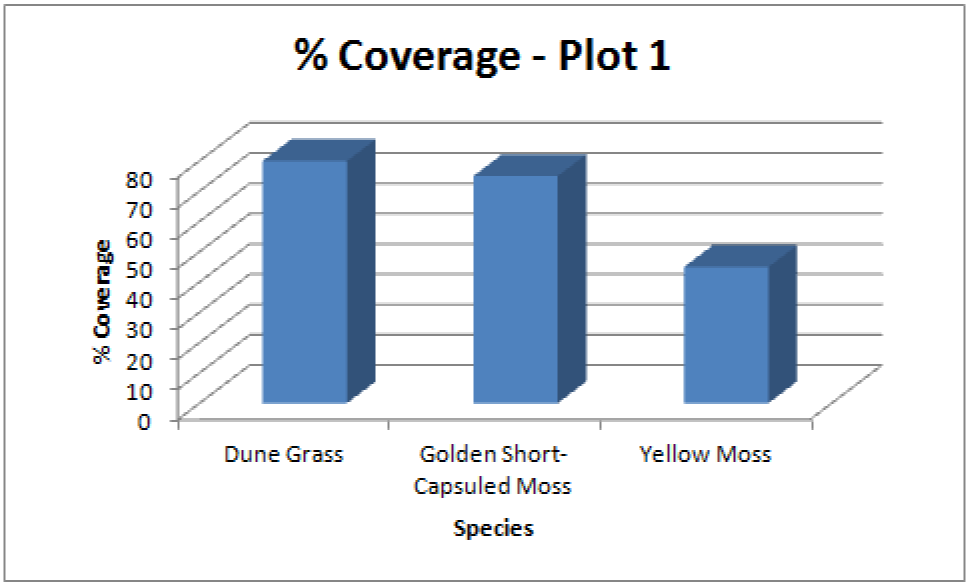


Chart 19: Grass and Moss Coverage in Plot 2

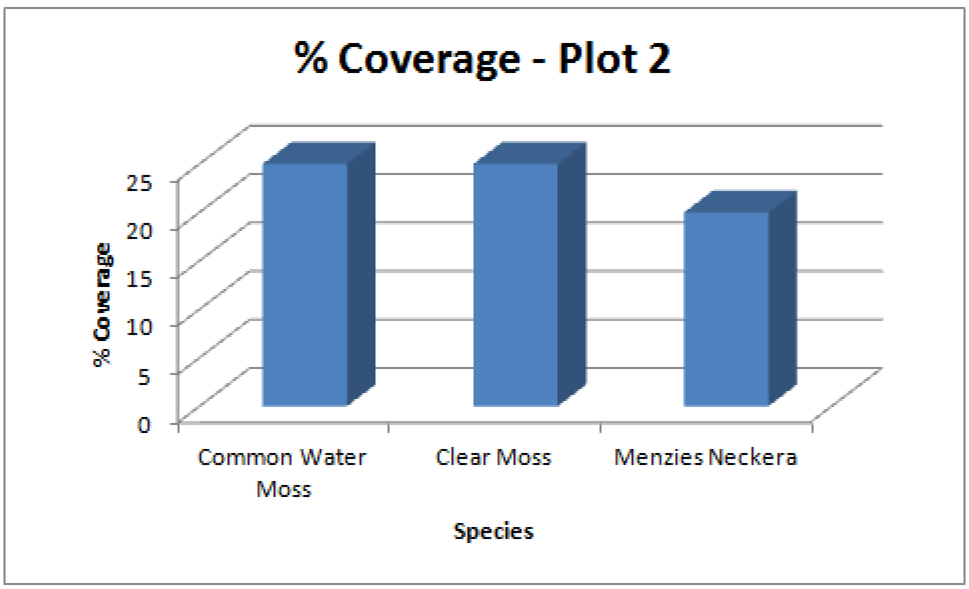


Chart 20: Grass and Moss Coverage in Plot 3

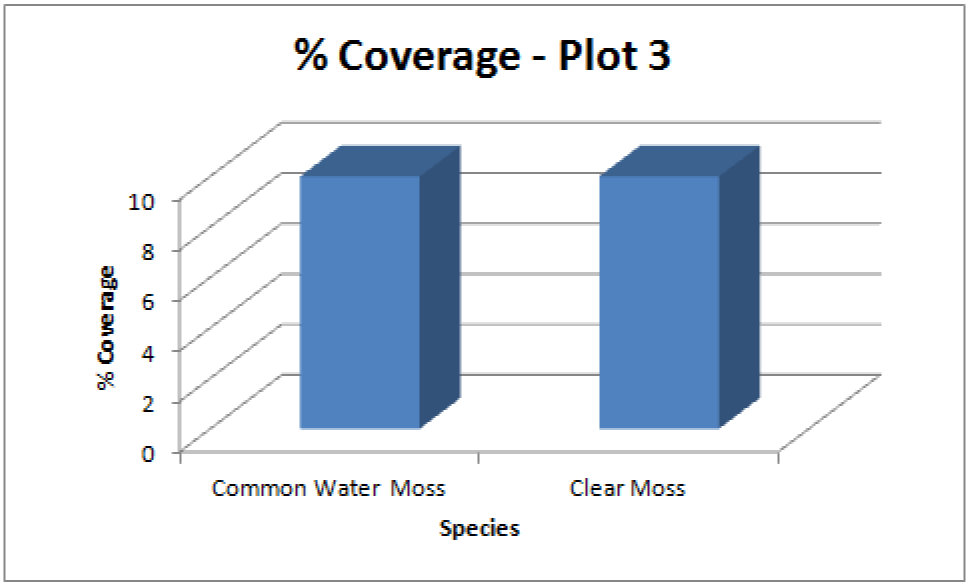


Chart 21: Grass and Moss Coverage in Plot 4

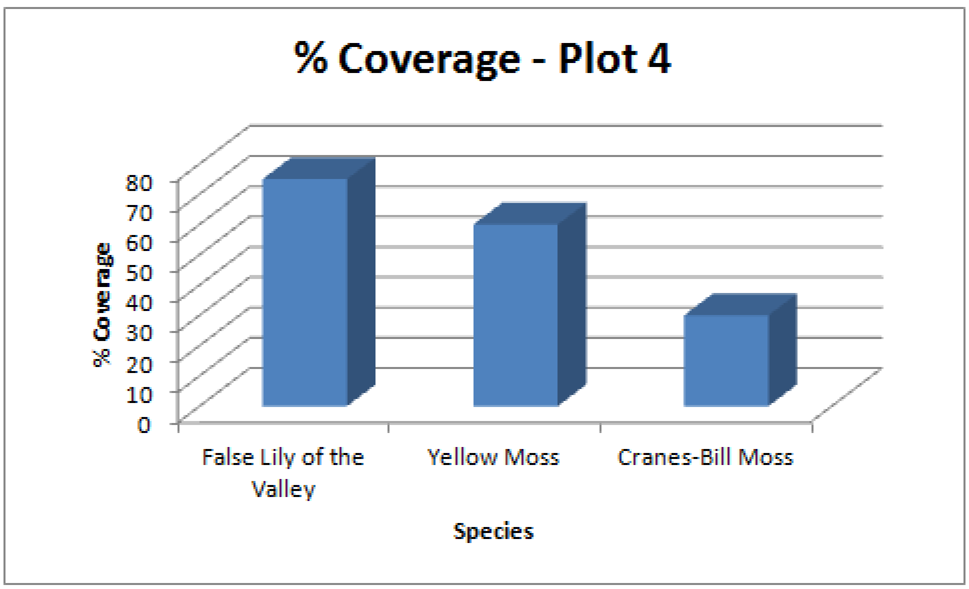


Chart 22: Grass and Moss Coverage in Plot 5

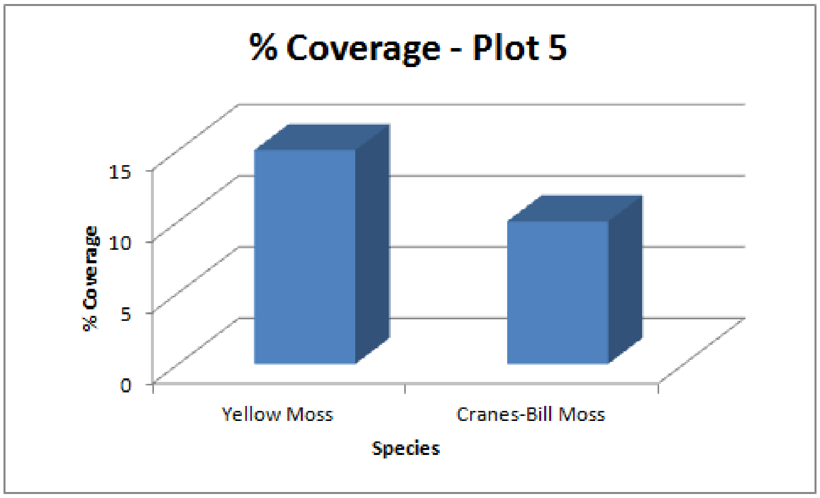
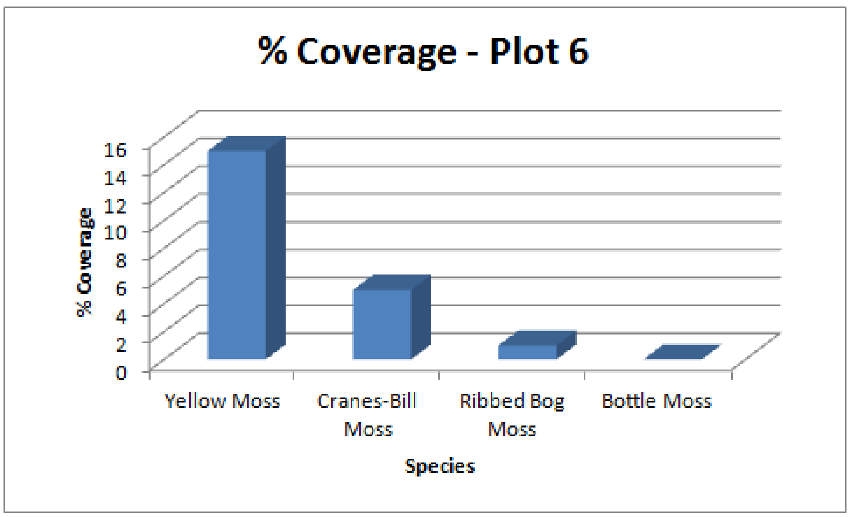


Chart 23: Grass and Moss Coverage in Plot 6



Graph 1: Average Rainfall in Burnaby, British Columbia

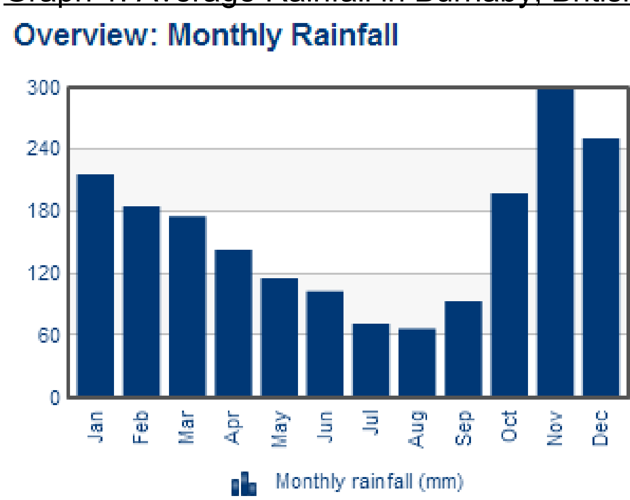
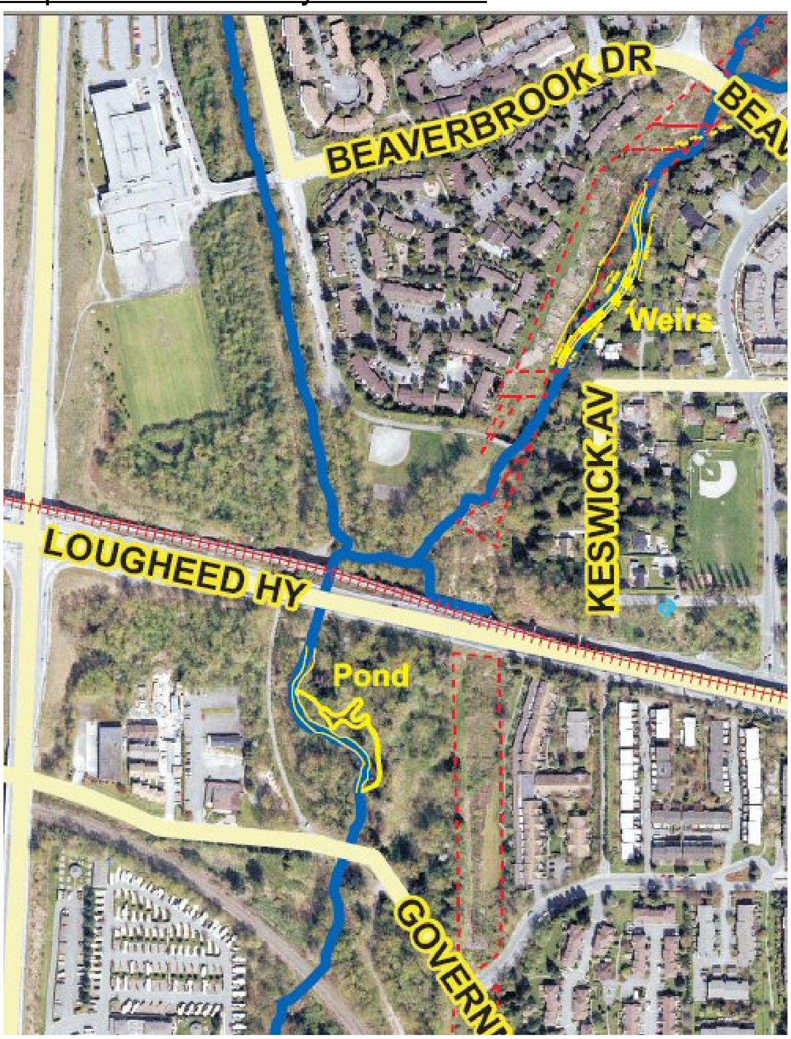


Table 2: Average Temperature in Burnaby, British Columbia

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Average	2.8	4.2	5.9	8.5	11.6	14	16.8	17	14.6	9.6	5.2	2.8
Average high	4.9	6.6	8.8	12.1	15.4	17.7	20.9	21	18	12.1	7.3	4.8
Average low	0.6	1.7	2.9	4.9	7.7	10.3	12.7	13	11.2	7.1	3.1	0.7
Record daily high	16.5	18.5	22	28	33	31.1	33.3	33.9	34.5	26.5	19.4	16.1
Date	Jan 20 1981	Feb 27 1986	Mar 28 1994	Apr 30 1998	May 29 1983	Jun 02 1970	Jul 30 1965	Aug 01 1965	Sep 03 1988	Oct 01 1987	Nov 01 1974	Dec 02 1969
Record daily low	-13.9	-14	-7.8	-3.3	0	3.9	5	3.3	2	-7	-14	-19.4
Date	Jan 29 1969	Feb 01 1989	Mar 03 1976	Apr 13 1966	May 05 1965	Jun 01 1976	Jul 01 1979	Aug 23 1973	Sep 30 2000	Oct 31 1984	Nov 27 1985	Dec 29 1968

Map 1: Overall Stoney Creek Area



Map 2: Map of Overall Plots in Studied Area