The Effects of Creek Restoration on Creek Health

Stephanie Melton

Abstract Creeks become degraded when they are used or when development occurs close by. As degradation to creeks has become widely acknowledged creek restoration projects have increased. Creek restoration is used to restore degraded creeks to a more natural state. The effects of restoration on creek health are unknown. In order to study the effects of restoration, creek health monitoring is used. One such monitoring method is the evaluation of macroinvertebrate populations. Macroinvertebrates are good indicators of creek health because the response rate to disturbance varies amongst the species. Macroinvertebrates are also a cheap and easy way to measure stream health and it is the method that is mandated by the Environmental Protection Agency. In this study, the number of individuals, the species richness, and the diversity of macroinvertebrate species was studied in Cordonices Creek in Albany, California and in Cerrito Creek in El Cerrito, California. A comparison was made between these three parameters in restored and unrestored stretches of both creeks. These comparisons were made for all macroinvertebrates and for the families of Ephemeroptera, Plecoptera, and Tricoptera (EPT). The results of this study indicated that there was no significant difference found in the number of individuals, species richness, and species diversity for all macroinvertebrates and EPT in both Cordonices Creek and Cerrito Creek. There was an interesting pattern in the data that illustrates that the unrestored stretch of Cordonices Creek had higher values for number of individuals and species richness, but the restored stretch had a higher diversity. This pattern held true for all macroinvertebrates and EPT. On the other hand, the restored stretch in Cerrito Creek had higher values for total number of individuals and species richness; the diversity was higher in the unrestored stretch for all macroinvertebrates and higher in the restored stretch for EPT. The lack of significance and the pattern established could be due to the difference in time since restoration, the type of restoration, and the length of the stretches.

Introduction

Creek restoration projects have become increasingly popular as people have become more aware of the degradation to creek health (Ebersole, *et al*. 1997). The main source of degradation comes from human use and the urbanization of the area near creeks. These sources of degradation have altered and destroyed the habitats of organisms inhabiting creeks, thus decreasing the animal and plant biodiversity of these ecosystems (Sweeny 1993). The purpose of restoration is to reestablish habitats and the associated biodiversity back to the natural, pristine state, or as close as possible (Ebersole, *et al*. 1997).

There are different methods of creek restoration. The first method is revegetation; which includes the removal of all non-native plant species and replanting the area with native species (Brooks, *et al*. 2002). Channel modification is another type of restoration. In this method, the creek banks are stabilized to minimize erosion and a flood plain is created (Brooks, *et al*. 2002). Channel modification is also used to reestablish habitat heterogeneity within the streambed by placing different sediment types in the channel to construct riffles, pools, and flows. (Ebersole, *et al*. 1997). The third type of restoration is daylighting. Daylighting involves taking a creek out of an underground culvert, or pipe, and exposing it to the open air. Daylighting practices involve the creation of a creek channel and revegetation (Brooks, *et al*. 2002).

In order to understand the effects of creek restoration on creek health, monitoring is used. There are many aspects of creeks that can be used to monitor and measure creek health. One of the most commonly used methods is the evaluation of macroinvertebrate populations because they are good indicators of creek health (Brooks, *et al.* 2002). They are good indicators because the response time after degradation varies between species as the levels of sensitivity to disturbance vary between species (Brooks, *et al.* 2002). Thus, the species present in the creek will be different depending on the health of the creek. Macroinvertebrates are also a source of food for many fish species (Wallace, *et al.* 1996) and they influence ecological processes in the stream (Brooks, *et al.* 2002). Because of these characteristics of macroinvertebrates one can infer that if densities are small and not diverse a creek is unhealthy, likewise, if a creek is healthy the populations are large and very diverse.

Macroinvertebrates live in the interstitial area of the sediment (Maridet, *et al* 1996). Most restoration disrupts the sediment beyond the minor disturbances macroinvertebrates can normally withstand. The impact to macroinvertebrates is proportional to intensity of disturbance

(Laasonen, *et al*. 1998). It is the difference in macroinvertebrate populations between restored and unrestored stretches or pre and post restoration that are used to measure creek health.

The effects of creek restoration on creek health are unknown. Studies measuring the effect of restoration on creek health, using macroinvertebrates as indicators, have resulted in a variety of conclusions. On the River Esrom in Denmark, it was found that restoration had a positive impact on the number of macroinvertebrates, but no impact on the species richness and diversity of macroinvertebrates (Gortz 1998). Contrary to this result, a study conducted on multiple creeks in Finland concluded that the number of macroinvertebrates in restored streams would never reach the pre-restoration number (Lassonen, *et al*. 1997). A third study conducted on the River Brede in Denmark and the River Cole in England concluded that species richness and number of macroinvertebrates returned to pre-restoration levels (Biggs, *et al* 1998). These three studies, producing differing data regarding the effect of restoration on creek health illustrates the need for more multi-stream, post-restoration evaluations.

In an attempt to establish more continuity in the results of creek health studies, this study will evaluate the populations of macroinvertebrates in restored and unrestored stretches of two urban creeks in Alameda County, California. Based on the studies presented above, I had no predictions for the outcome of this study. However, the study was completed to help answer the question, does creek restoration effect creek health?

This study was conducted on Cordonices Creek in Albany, California and Cerrito Creek, in El Cerrito, California. Cordonices Creek and Cerrito Creek are urban creeks located in mixed neighborhoods consisting of residences and businesses. Both creeks have unrestored and restored stretches. The restoration of Cordonices Creek, which began in 1995, consisted of daylighting a portion of the creek (Friends of Five Creeks 2000). Cerrito Creek was restored in 2000 through revegetation and channel modification (Friends of Five Creeks 2000).

By conducting another macroinvertebrate sampling, I hoped to add more data to the existing, conflicting data in order to establish a pattern illustrating the effects of creek restoration on creek health. The more data that is collected the more solid a conclusion can be made determining if creek restoration is beneficial to creek health. Furthermore, in determining the effects of restoration on creek health, information can be gathered as to what changes should be made to restoration practices, in order to reduce the impact to creek health or to make restoration even more successful.

Methods

Site Description The samples for this study were taken on Cordonices Creek in Albany, California and Cerrito Creek in El Cerrito, California. These creeks were used because both creeks have restored and unrestored stretches. A stretch of Cordonices Creek was daylit in 1995. The restored stretch of Cerrito Creek was revegetated, the banks stabilized, and a flood plain constructed in 2000. The samples in this study were collected on both restored ad unrestored stretches (see Figure 1). The lengths of the sampled stretches are different for each creek. Cordonices Creek has a restored stretch of about fifty meters whereas Cerrito Creek has a restored stretch fifteen meters in length. Because of this difference the number of samples taken from each creek was different, Cordonices Creek had five sample sites in each stretch and Cerrito Creek had three sample sites per stretch. The samples for Cordonices Creek were taken between Eighth and Tenth Avenues, west of San Pablo Avenue, north of Harrison Street and in Cerrito Creek the samples were taken between Kains and Evelyn Streets, east of San Pablo (see Figure 1).

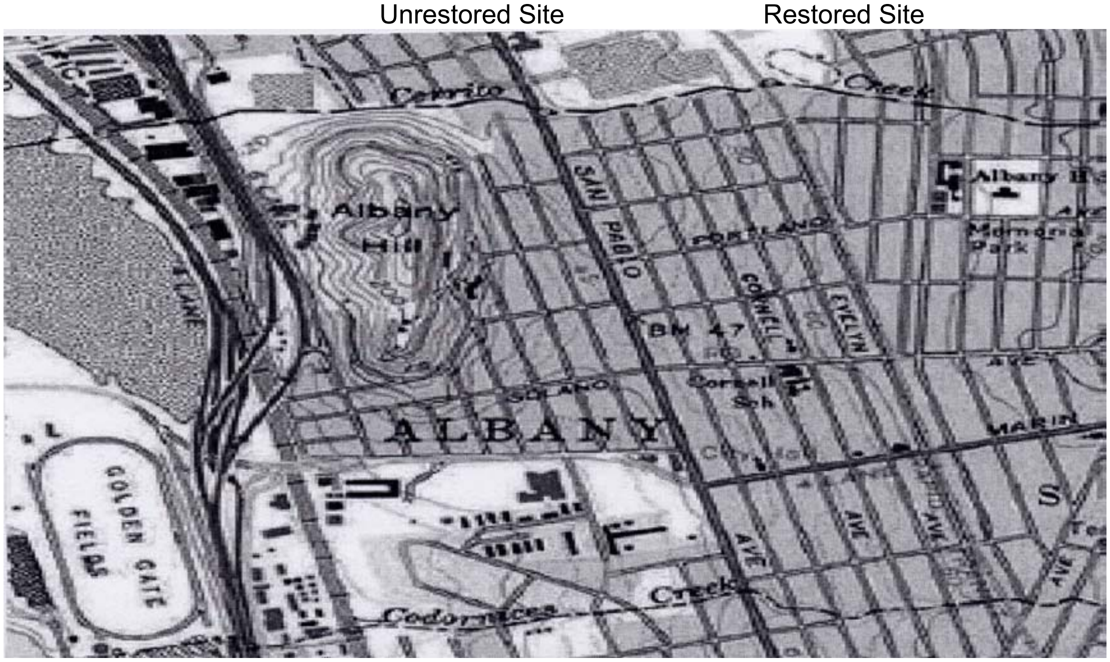

Figure 1: Map of Cordonices Creek and Cerrito Creek. The sampling sites are indicated as well as some of the creek surroundings. (Map taken from www. Fivecreeks.org, 2000)

The surroundings in which the creeks are located are different as well. Cordonices Creek has few businesses on one side of the back with little traffic and on the other bank are baseball diamonds and University Village, although the Village is set back from the creek banks. Cerrito Creek has a shopping center on one side and lots of housing on the other side; there are also BART tracks that run over the creek.

Data Collection There were four days of sampling between February 2003 and April 2003. On each sampling day five samples were collected from the restored and unrestored stretches of Cordonices Creek and three samples were taken from each stretch in Cerrito Creek. The samples were spaced five meters apart and were collected starting at the most downstream position, working upstream. For each day of sampling, the sample site was 1.0 meters upstream from the previous sample site to prevent resampling the same location. Each sample was collected from a 0.5 meter^2 quadrant of the creek bed.

The samples were taken using the Environmental Protection Agency recommended kick-sampling method (www. epa.gov 2002). This method consists of setting up a D-frame net 0.5 meters downstream from the sampling site; all the larger rocks in the sample quadrant were picked up and rubbed by hand for one minute then, for an additional thirty seconds the sediment in the quadrant was kicked around. This dislodged the macroinvertebrates and allowed them to flow downstream into to the net. The captured organisms were then transferred to a plastic containers filled with ethanol to allow for transfer to a lab to be identified under a microscope. The organisms were classified as morphospecies with the aid of a classification key (Merritt 1996). The total number of macroinvertebrates, richness, and diversity was calculated for all species and EPT. The diversity was calculated using a Simpson's Diversity Index.

Statistical Techniques The means of the number of individuals, species richness, and diversity were compared between restored and unrestored stretches within each creek for all macroinvertebrates and EPT. This comparison was drawn using a Mann-Whitney U-Test for data that was not normally distributed and a t-test for normally distributed data.

Results

In order to rule out the possibility of weather or seasonal patterns obscuring differences between the restored and unrestored sites, comparisons were made using normally distributed data and a t-test in which pairs were selected by collection date. The results indicate that weather did not influence the data (P= 0.4977 for all macroinvertebrates and P= 0.44 for EPT).

The statistical tests ran for Cordonices Creek illustrate that there is no significant difference in the number of individuals, species richness, and diversity for both all macroinvertebrates and EPT (see Table 1 and Table 2).

	Restored	Unrestored	Statistic	P-Value
# of Individuals	8.1 +/- 12.8	10.95 +/- 18.4	u=179.0	0.7573
Species Richness	1.9 +/- 2.2	2.0 +/- 2.3	u=176.0	0.694
Diversity	1.6 +/- 1.8	1.3 +/- 1.1	u=190.0	>0.99

Table 1. Data collected and results of Mann-Whitney U-Tests for all macroinvertebrates in Cordonices Creek. The values are mean +/- standard deviation, n=5.

	Restored	Unrestored	Statistic	P-Value
# of Individuals	7.9 +/- 12.2	9.2 +/- 14.3	U=196.0	0.9138
Species Richness	1.8 +/- 1.9	1.9 +/- 1.8	U=200.0	>0.99
Diversity	2.0 +/- 2.7	1.2 +/- 1.2	U=189.0	0.766

Table 2. Data collected and results of Mann-Whitney U-Tests for EPT in Cordonices Creek. Values are mean +/- standard deviation, n=5.

The statistical tests ran for Cerrito Creek also show that there is no significance difference in the number of macroinvertebrates, species richness, and diversity for both all macroinvertebrates and EPT (see Tables 3 and 4).

	Restored	Unrestored	Statistic	P-Value
# of Individuals	11.9 +/- 9.2	9.3 +/- 8.4	T=0.717	0.4807
Species Richness	3.9 +/- 2.2	3.4 +\- 2.4	T=0.534	0.5989
Diversity	2.3 +/- 1.5	2.9 +/- 2.0	u=64.0	0.6442

Table 3. Data collected and results of statistical tests for all macroinvertebrates in Cerrito Creek. T-tests were used for # of individuals and species richness. A Mann-Whitney U-Test was run for diversity. Values are mean +/- standard deviation, n=3.

	Restored	Unrestored	Statistic	P-Value
# of Individuals	9.9 +/- 8.7	7.8 +/- 7.8	u=63.5	0.6236
Species Richness	2.8 +/- 1.6	2.3 +/- 1.6	u=57.5	0.4025
Diversity	2.2 +/- 1.2	2.1 +/- 1.4	u=71.0	0.954

Table 4. Data collected and results of Mann-Whitney U-Test for EPT in Cerrito Creek. Values are mean +/- standard deviation, n=3.

The lack of significance in the data collected indicates that restoration does not have a detrimental or beneficial effect on creek health.

Discussion

Although there was no significant difference between the restored and unrestored stretches of both creeks, there was an interesting pattern in the data. In Cordonices Creek the number of macroinvertebrates and species richness was higher in the unrestored stretch than in the restored stretch. However, the diversity was higher in the restored stretch. This pattern also held for EPT. In Cerrito Creek, however, the number of macroinvertebrates and species richness was higher in the restored stretch, but the diversity was higher in the unrestored stretch for all macroinvertebrates. For EPT, the restored stretch had higher values for all three parameters.

Some possible reasons for this pattern are the time since restoration, the type of restoration that occurred on each creek, and the length of each stretch sampled. The pattern in the data is interesting because it might provide a connection between time since restoration, the type of restoration, and creek health. The time since restoration could be a possible explanation for this pattern because Cordonices Creek was restored five years prior to Cerrito Creek. This time difference and the higher values for the restored stretch indicate that at first creek restoration restores creek health, in terms of number of macroinvertebrate and species richness, but as time passes the effectiveness of restoration wears off and the creek becomes degraded again. The data illustrates, however, that restoration has a positive effect on diversity. A higher diversity in the restored stretch of Cordonices Creek, but not Cerrito Creek could indicate that a higher diversity might not be an immediate repercussion of restoration but take years to become established.

The pattern in the data illustrates a connection between type of restoration and creek health because of the varying intensities of creek restoration that occurred on these two creeks. Cordonices Creek underwent daylighting, a very intense restoration project in comparison to the revegetation that occurred on Cerrito Creek. A difference in intensity of restoration and data could indicate that the population of macroinvertebrates does not reestablish itself to the same number and species richness as a less intense restoration project. However, it appeared that intensity of restoration might have a positive effect on diversity, especially that of EPT.

Another possible reason could be that when a creek is in a culvert, there is no habitat for macroinvertebrates. Therefore, when the creek is daylit, there is new sediment for the macroinvertebrates to inhabit. It could be that it takes macroinvertebrates a while to establish themselves in a new habitat, therefore, the number of macroinvertebrates and species richness would be lower than in the unrestored stretches. Diversity on the other hand would, at first, be positively affected by restoration but then declines as the creek becomes degraded again.

The length of the stretches of both creeks that were sampled is another possible factor for the lack of significance in the data. The stretch of Cordonices Creek that was sampled was much longer than the Cerrito Creek stretch. The difference in length would affect the number of macroinvertebrates, species richness, and diversity in each sample because a longer stretch gives the macroinvertebrates more habitat to spread out over, whereas in Cerrito Creek, there were only short sections for the macroinvertebrates to inhabit. This would cause more macroinvertebrates to be caught per sample in Cerrito Creek than in Cordonices Creek.

Another factor that needs to be taken into account is the difference of environment for the two creeks. Cordonices Creek has a few businesses on one bank and on the other bank are baseball diamonds. There is also housing, but it is set far from the creek. Cerrito Creek on the other hand has high density housing on one side, BART tracks running over the creek, and a shopping center on the other side. Thus, the amount of pollution in the creek would be higher in Cerrito Creek than in Cordonices Creek. This factor would also affect the number, species richness, and diversity of macroinvertebrates in each creek.

However, these explanations are based solely on the use of macroinvertebrates as indicators of creek health. There are many other aspects of a creek that also indicate creek health. Just because the macroinvertebrates sampling does not show an improvement in creek health, other aspects of the creek could have benefited from the restorations. The effectiveness of restoration also varies as the different reasons for restoring a creek vary. For example, if a creek was revegetated, then the vegetation of the creek should be studied as a monitor of creek health instead of the macroinvertebrates.

Conclusion

It can be concluded from this study that creek restoration does not have an effect on creek health. However, this conclusion is based on only one aspect of a creek. In order to see a pattern in the effects of restoration on creek health more studies similar to this one should be performed, or, other aspects of creeks should be evaluated after restoration. These other aspects could include, but are not limited to, pH, vegetation, and sediment type. These other aspects should be evaluated at the same time in order to give a creek wide assessment of creek health.

This study was conducted to see if a pattern in data could be established as to the effects of creek restoration on creek health. The lack of significance in this study does not add any more information as to the impacts of creek restoration on creek health. The varying conclusions of other studies and the lack of significance in this study still gives no clear answer to the question, does creek restoration effect creek health?

Acknowledgments

I would like to thank Susan Schwartz for her help in the initial setup of this project and Matt Orr, John Latto, and Manish Desai for their help and guidance over the past year.

References

Biggs, Jeremy, Atony Corfield, Per Gron, Hans Ole Hansen, David Walker, Mericia Whitfield and Penny Williams. 1998. Restoration of the rivers Brede, Cole and Skerne: a joint Danish and British EU-LIFE demonstration project, V-Short-term impacts on the conservation value of aquatic macroinvertebrate and macrophyte assemblages. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 8: 241-255.

Brooks, Shane A., Margaret A. Palmer, Brad J. Cardinale, Christopher M. Swan, Suzanna Ribblett. 2002. Assessing Stream Ecosystem Rehabilitation: Limitations of Community Structure Data. *Restoration Ecology*. 10: 156-168.

Ebersole, Joseph L., William J. Liss. 1997. Restoration of Stream Habitats in the Western United States: Restoration as Reexpression of Habitat Capacity. *Environmental Management*. 21: 1-14.

Environmental Protection Agency. www.epa.gov, accessed February 4, 2003.

Friends of Five Creeks. www.Fivecreeks.org, accessed October 2002.

Gortz, Per. 1998. Effects of stream restoration on the macroinvertebrate community in the River Esrom, Denmark. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 8: 115-130.

Laasonen, Pekka, Timo Muotka, and Ilkka Kivijarvi. 1998. Recovery of macroinvertebrate communities from stream habitat restoration. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 8: 101-113.

Maridet, L., M. Philippe, J.G. Wasson, and J. Mathieu. 1996. Spatial and temporal distribution of macroinvertebrates and trophic variables within the bed sediment of three streams differing by their morphology and riparian vegetation. *Archiv fur Hydrobiologie*. 136: 41-64.

Merritt, Richard W, Kenneth W. Cummins. 1996. *An Introduction to the Aquatic Insects of North America*.

Schwartz, Susan. Personal Contact. October 7, 2002.

Sweeny, Bernard W. 1993. Effects of Streamside Vegetation on Macroinvertebrate Communities of White Clay Creek in Eastern North America. *Proceedings of The Academy of Natural Sciences of Philadelphia*. 144: 291-240.

Wallace, J. Bruce and Jackson R. Webster. 1996. The Role of Macroinvertebrates in Stream Ecosystem Function. *Annual Review of Entomology*. 41: 115-139.