The Effects of Stream Restoration on Habitat Quality

Lisa Hauck

Abstract Many stream restoration projects do not include a requirement for long-term monitoring after the project has been completed, resulting in a lack of information about the success or failures of certain restoration techniques. This study examines habitat quality of four urban streams – Wildcat Creek, Baxter Creek, Alhambra Creek and Peralta Creek – in the East Bay region of California before and after restoration to determine the success of the project. The studied streams were restored between one and six years ago using a variety of restoration techniques. Habitat quality was assessed in restored reaches of streams using the U.S. Environmental Protection Agency's Rapid Bio-assessment Protocols and compared with information about, and photographs of, the stream before it was restored. Results of this study showed that while some aspects of habitat quality were improved at the studied sites, not all aspects of the restoration projects were successful in all cases. This study shows the importance of performing long-term monitoring after the completion of a restoration project. Monitoring can reveal whether or not habitat quality has improved, whether or not the goals of the project have been met and guide ongoing restoration efforts.

Introduction

As society has become more aware of, and more concerned about, our impact on the environment, the idea that people need to minimize their effect on their surroundings has become more popular. One way to reduce, or counteract the impact we have on the environment is to perform restoration projects in a degraded area, such as a stream. Stream restorations have been performed for a variety of reasons, including economic improvement, aesthetic improvement, recreational improvement, and habitat improvement.

It has been found that habitat restorations are not always successful in improving species populations in streams, and it can often take multiple projects to detect a significant increase in the density of target organisms (House 1996). When a lot of money is put into a large-scale project, such as restoring a stream, it is especially important that results are monitored to ensure that goals have been achieved. Kondolf and Micheli (1995) note that post-restoration monitoring is extremely important in such a project, and recommend a decade-long monitoring program that also takes into account the historical conditions of the stream. Long-term monitoring is important because the conditions of a stream immediately after restoration do not always indicate what conditions of the stream will be like in the future (Korsu 2004).

While restoration projects often have a goal of increasing the abundance of stream life, the effect on populations is rarely monitored. Because natural processes of a stream, such as increased flow during the rainy season, can often interfere with improvements made during restoration and counteract the benefits, it is essential to monitor the success of the project in increasing stream life (Moerke and Lamberti 2003). Determining that a natural process is contributing to the decreasing life in a stream can lead to the enactment of a new restoration that will help keep high population numbers over time.

While the importance of monitoring a restoration project over a period of time has been shown, it does not often occur. A survey of select Washington streams reported that only 18% of restoration projects mandate long-term monitoring. Additionally, only six of nine government projects had a requirement for monitoring (Bash and Ryan 2002).

Restoration projects meant to improve water and habitat quality are especially important to monitor as their results can help to determine whether or not certain techniques are successful. Davis et al. (2003) found that most stream restorations that have a goal of improving ecological conditions do not even monitor to see if these conditions are actually achieved. In order for a restoration project to be successful, knowledge of how outside variables affect the stream is required (Bohn and Kershner 2002). When a restored stream is monitored over an extended period of time, it can be determined which factors have the biggest impact on a stream. This information will allow for the evaluation of which restorative techniques produce the most success in achieving the goals of the project. Future projects will then be able to use the techniques that are most efficient and achieve the more successful results (Roni et al. 2002).

There are many factors that can be monitored to determine the level of success that a restoration project has. Determining what factors should be measured generally depends on the goals of the restoration project. Shields et al. (2003) studied a stream that had been restored to increase fish population. Their monitoring took into account the number of fish present in the stream as well as the quality of the habitat they had. This study was able to evaluate the success of the project based on the initial goals.

Restoration projects often have a goal of returning a stream its natural conditions. Nijboer (2004) studied the presence of *Agapetus fuscipes* (Trichoptera: Glossomatidae) in restored streams. *Agapetus fuscipes* is an indicator of natural conditions, and can therefore show how successful a restoration project has been at recreating this. The long-term monitoring of this project revealed that water quality improvement is a major factor in restoring the natural conditions of a stream.

The United States Environmental Protection Agency has a standardized way to analyze habitat quality based on Rapid Bioassessment protocols. This protocol analyzes a variety of habitat parameters and gives each a number score between 0 and 20. Parameters include th amount of native vegetation, percent cover, and substrate, all of which give an indication of the quality of habitat of a stream. Addition of all the scores for each factor gives an overall number for each site, with a higher score indicating a higher quality habitat. This allows for comparison between sites, and using this protocol is especially beneficial because it is the standard method for analyzing habitat quality throughout the nation (Purcell 2002), allowing results to be compared to comparable studies.

This project will study four restored streams in the East Bay region of California based on these protocols. Habitat assessments will be compared to assessments of pre-restoration conditions, and it will be determined whether or not the restoration project was successful in improving habitat quality.

Methods

The study sites of this project were chosen with the help of the University of California Water Resources Archives through the use of The Natural Resource Projects Inventory (NRPI). NRPI is an electronic resource that keeps record of all conservation and restoration projects that occur in the state of California. Projects are logged in the data base and information about the project is made public. Geographic information about the site is given, and project goals are detailed. Photographs of the sites taken prior to restoration were obtained from the Urban Creeks Council of California.

Sites that had an initial goal of improving riparian and in-stream habitat were considered for this study. Of those sites, the streams which had the most information about pre-restoration conditions, including photographs and written information, were selected.

Study Sites A reach of Wildcat Creek (Fig. 1) that was studied was restored near the city offices in San Pablo, California in 2005. This restoration was performed by the Urban Creeks Council of California and had the goal of improving riparian and in-stream habitat for birds and steelhead trout. As part of the project, invasive plant species were removed from the banks and replaced with native plants to help prevent erosion.

Another site that was studied was a reach of Baxter Creek located in Booker T. Anderson, Jr. Park in Richmond, California (Fig. 2). This restoration project was completed in 2000. The goal of the project was to improve the degraded stream. The stream channel was regraded, and its sinuosity was increased. Native trees were planted to help stabilize the previously non-vegetated banks.

The third site studied was a reach of Alhambra Creek located at the Martinez Adult Education Campus in Martinez, California (Figure 3). This project was completed in 2004 with the collaboration of a variety of groups. The goals of this restoration were to improve riparian and fish habitat and to reduce erosion. Failed gabions were replaced, and banks were removed of non-native plant species and replaced with native plants. A trail was also created to allow for public access to the stream without the destruction of riparian habitat.

Figure 1. The location of the studied reach of Wildcat Creek in San Pablo, California. (Maquest.com)

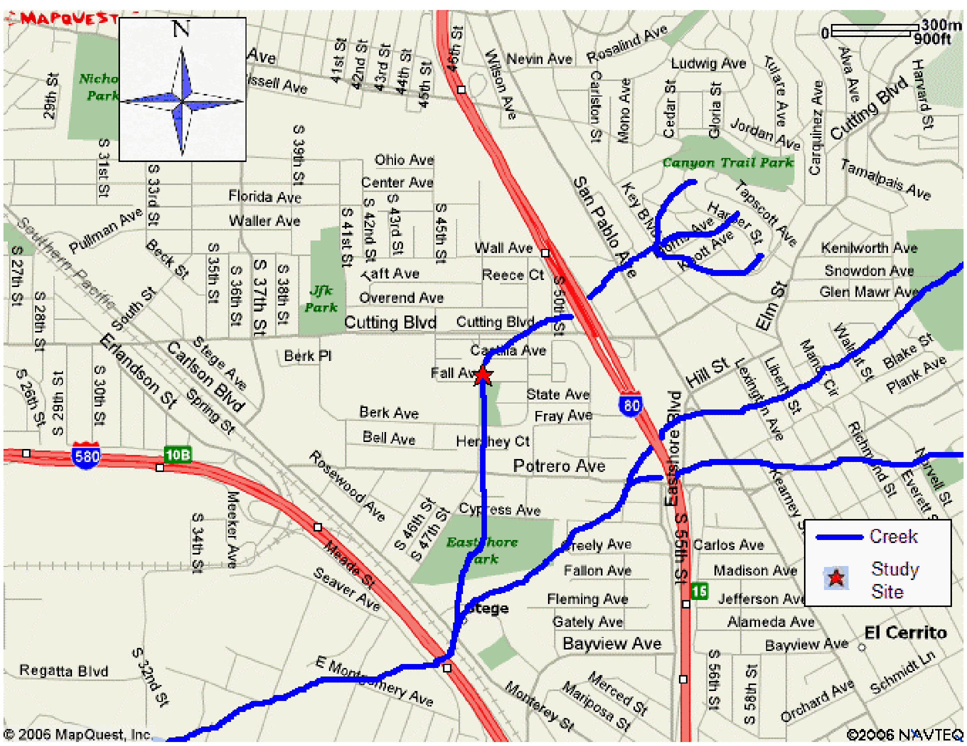

Figure 2. The location of the studied reach of Baxter Creek in Richmond, California. (Mapquest.com)

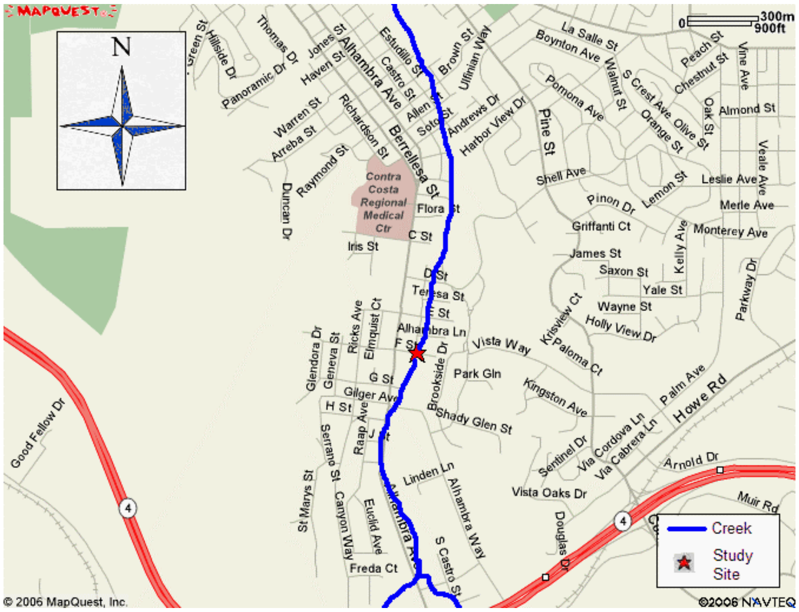

Figure 3. The location of the studied reach of Alhambra Creek in Martinez, California (Mapquest.com)

The final site studied was a reach of Peralta creek located in Cesar Chavez Park in Oakland, California (Fig. 4). This project was completed in 2003 by the Urban Creeks Council of California. Goals included controlling erosion and improving flood capacity as well as improving riparian habitat. Banks were regraded, a bypass culvert was removed, and a bridge was replaced. Non-native Acacia and Eucalyptus trees were replaced with willow trees and native grasses.

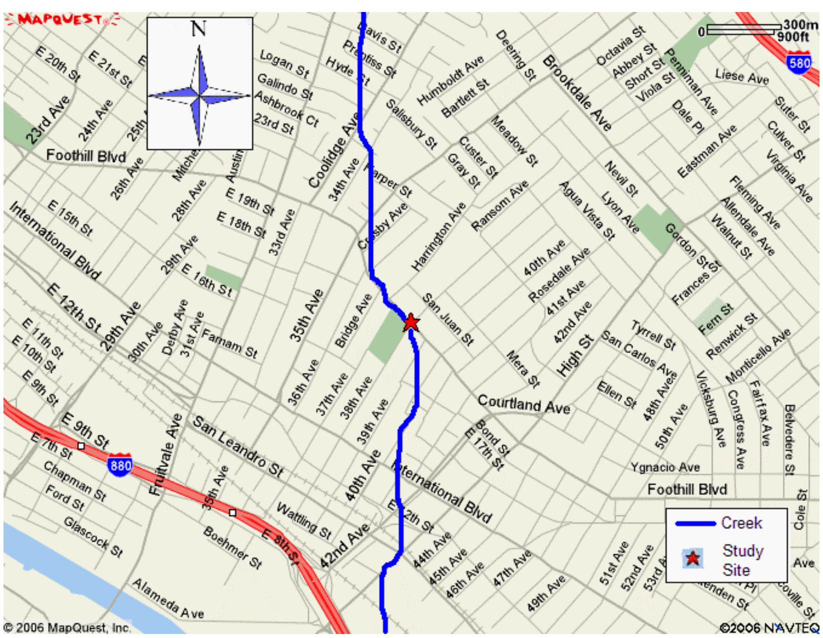

Figure 4. The location of the studied reach of Peralta Creek in Oakland, California (Maquest.com)

Stream Monitoring Habitat Quality of the streams was assessed based on the U.S. Environmental Protection Agency's Rapid Bioassesment Protocols which is standard used across the country (Hannaford et al. 1997). This allows results to be compared to a number of different studies, and a number of different streams.

The Rapid Bioassessment Protocols are a series of ten habitat parameters that are evaluated at each reach of a stream that is to be studied. These parameters include Epifaunal Substrate/Available cover, Pool Substrate Characterization, Pool Variability, Sediment Deposition, Channel Flow Status, Channel Alteration, Channel Sinuosity, Bank Stability (Right and Left Bank Scored separately), Vegetative Protection (Right and Left Bank Scored separately), and Riparian Vegetative Zone Width (Right and Left Bank Scored separately). Additionally, each parameter has a description of optimal, suboptimal, marginal and poor conditions. Based on these descriptions, each parameter is given a score between 0-20. After each parameter is measured, all the scores are added together to give the reach a total score indicative of the overall habitat quality.

Habitat quality scores for the streams after restoration were obtained in person by visiting the streams and recording the scores. Habitat quality scores for the streams prior to restoration were obtained by looking at photographs of the stream prior to restoration and recording the score based on what was seen.

A photograph of wildcat creek under current conditions was analyzed and the score was compared to the analysis performed in person. Table 1 shows that there is no difference between scores collected in person and scores collected through photograph analysis.

Table 1. Comparison of Scores collected by Photograph analysis and scores collected in person at Baxter Creek

Habitat Condition	**Score (Photograph)**	**Condition Category**	**Score (Collected in Person)**	**Condition Category**
Sediment Deposition	15	Suboptimal	15	Suboptimal
Channel Flow Status	12	Suboptimal	12	Suboptimal
Channel Alteration	10	Marginal	10	Marginal
Channel Sinuosity	4	Poor	4	Poor
Bank Stability (Left)	9	Optimal	9	Optimal
Bank Stability (Right)	7	Suboptimal	7	Suboptimal
Vegetative Protection (Left)	8	Suboptimal	8	Suboptimal
Vegetative Protection (Right)	2	Marginal	2	Poor
Riparian Veg Zone Width (Left)	5	Marginal	5	Marginal
Riparian Veg Zone Width (Right)	1	Poor	1	Poor
Total Score	**73**		**73**	

After total habitat quality scores were obtained for restored and non-restored reaches of the streams. Not all parameters were able to be scored for pre-restoration sites due to the use of photographs. Results were compared using only scores that were obtained for both conditions.

In addition to producing number scores for the habitat quality of each stream that was studied, additional information about habitat was collected at each site to account for factors that are not included in the Rapid Bioassessment Protocols such as the presence of native plants and the absence of invasive species. Pictures were taken at each site to further allow for comparison of habitats, and the presence of wildlife at the different sites. Information about which invasive plants were extracted from each site and which native plants they were replaced with was used to monitor whether or not the natives are still living at the site and if the invasives came back. Collection of this additional data not only allows for a broader idea about the habitat quality, but it also allowed for collection data that was specific to the restoration goals of each individual stream. By concluding that habitat either has or has not improved, it will be determined whether or not the stream restoration was successful in improving habitat quality in the stream and riparian zones.

Results

When comparing habitat quality of restored streams to their pre-restoration conditions, all of the restored sites showed improvement in habitat quality score (Fig. 5). Scores for all parameters measured in Wildcat Creek (Table 2) improved or remained the same after restoration. Condition categories prior to restoration ranged from poor to suboptimal prior to restoration and from poor to optimal after restoration.

Scores for all parameters measured in Baxter Creek (Table 3) improved except for left bank stability which received a 2 prior to restoration and a 1 after restoration. Condition categories ranged from poor to marginal prior to restoration, and from poor to optimal after restoration.

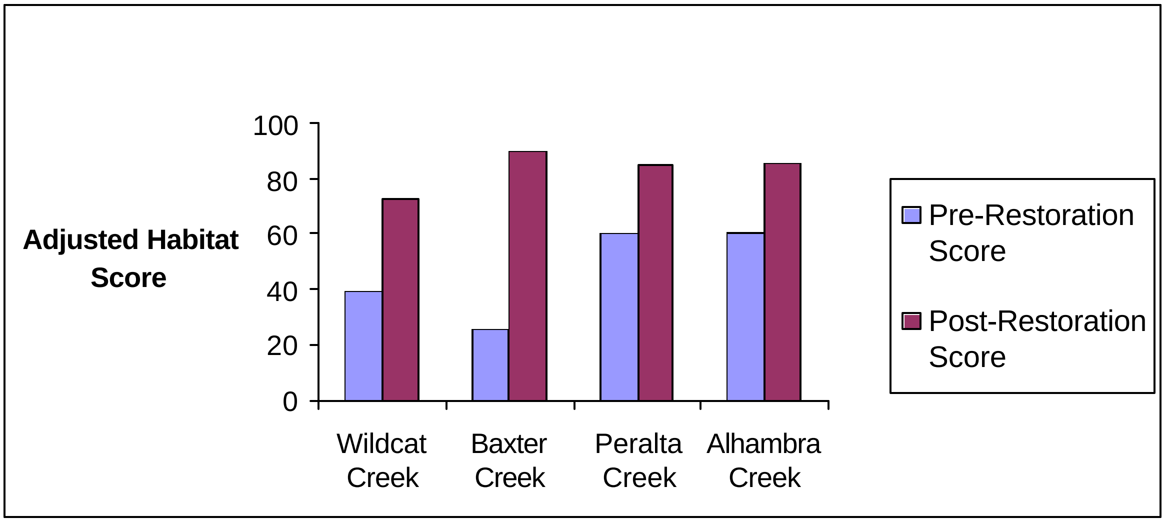

Figure 5. A comparison of habitat quality before and after restoration in the four studied creeks, adjusted to only account for parameters measurable for both conditions.

Both streams had wildlife present, including ducks and birds. While invasive species, such as English Ivy, had begun to grow back at Baxter Creek, native plants were the dominant species in terms of percent cover at the site.

Table 2. Habitat Scores for all parameters measured within Wildcat Creek.

Habitat Parameter	**Score (Pre-Restoration)**	**Condition Category**	**Score (Post-Restoration)**	**Condition Category**
Epifaunal Substrate			15	Suboptimal
Pool Substrate			15	Suboptimal
Pool Variability			14	Suboptimal
Sediment Deposition	4	Poor	15	Suboptimal
Channel Flow Status	9	Marginal	12	Suboptimal
Channel Alteration	10	Marginal	10	Marginal
Channel Sinuosity	5	Poor	4	Poor
Bank Stability (Left)	2	Poor	9	Optimal
Bank Stability (Right)	6	Suboptimal	7	Suboptimal
Vegetative Protection (Left)	1	Poor	8	Suboptimal
Vegetative Protection (Right)	0	Poor	2	Poor
Riparian Veg Zone Width (Left)	2	Poor	5	Marginal
Riparian Veg Zone Width (Right)	0	Poor	1	Poor
Total Score	**39**		**117**	
Adjusted Score	**39**		**73**	

Table 3. Habitat Scores for all parameters measured within Baxter Creek

Habitat Parameter	Score (Pre-Restoration)	Condition Category	Score (Post-Restoration)	Condition Category
Epifaunal Substrate			16	Optimal
Pool Substrate			15	Suboptimal
Pool Variability	7	Marginal	8	Marginal
Sediment Deposition	4	Poor	17	Optimal
Channel Flow Status	7	Marginal	7	Marginal
Channel Alteration	1	Poor	12	Suboptimal
Channel Sinuosity	2	Poor	10	Marginal
Bank Stability (Left)	2	Poor	1	Poor
Bank Stability (Right)	3	Marginal	8	Suboptimal
Vegetative Protection (Left)	0	Poor	5	Marginal
Vegetative Protection (Right)	0	Poor	7	Suboptimal
Riparian Veg Zone Width (Left)	0	Poor	8	Suboptimal
Riparian Veg Zone Width (Right)	0	Poor	7	Suboptimal
Total Score	**26**		**121**	
Adjusted Score	**26**		**90**	

The total score for habitat quality in Alhambra Creek (Table 4) improved after restoration. However, scores for some individual parameters remained the same, such as channel flow status, channel alteration, and channel sinuosity. Condition Categories prior to restoration ranged from poor to optimal prior to restoration and from Marginal to Optimal after restoration. The total score for habitat quality in Peralta Creek (Table 5) improved, but some individual habitat parameter scores, including sediment deposition, channel alteration and channel sinuosity, remained the same. Scores prior to restoration ranged from poor to suboptimal prior to restoration and ranged from poor to optimal after restoration.

Table 4. Habitat Scores for all parameters measured within Alhambra Creek

Habitat Parameter	Score (Pre-Restoration)	Condition Category	Score (Post-Restoration)	Condition Category
Epifaunal Substrate			12	Suboptimal
Pool Substrate			15	Suboptimal
Pool Variability			13	Suboptimal
Sediment Deposition	8	Marginal	10	Marginal
Channel Flow Status	12	Suboptimal	12	Suboptimal
Channel Alteration	18	Optimal	18	Optimal
Channel Sinuosity	18	Optimal	18	Optimal
Bank Stability (Left)	1	Poor	6	Suboptimal
Bank Stability (Right)	1	Poor	4	Marginal
Vegetative Protection (Left)	2	Poor	4	Marginal
Vegetative Protection (Right)	0	Poor	5	Marginal
Riparian Veg Zone Width (Left)	1	Poor	3	Marginal
Riparian Veg Zone Width (Right)	0	Poor	6	Suboptimal
Total Score	**61**		**126**	
Adjusted Score	**61**		**86**	

Table 5. Habitat Scores for all parameters measured within Peralta Creek

Habitat Parameter	Score (Pre-Restoration)	Condition Category	Score (Post-Restoration)	Condition Category
Epifaunal Substrate			14	Suboptimal
Pool Substrate			17	Optimal
Pool Variability			8	Marginal
Sediment Deposition	15	Suboptimal	15	Suboptimal
Channel Flow Status	6	Marginal	14	Suboptimal
Channel Alteration	11	Suboptimal	11	Suboptimal
Channel Sinuosity	4	Poor	4	Poor
Bank Stability (Left)	3	Marginal	5	Marginal
Bank Stability (Right)	5	Marginal	9	Optimal
Vegetative Protection (Left)	6	Suboptimal	8	Suboptimal
Vegetative Protection (Right)	4	Marginal	9	Optimal
Riparian Veg Zone Width (Left)	2	Poor	3	Marginal
Riparian Veg Zone Width (Right)	4	Marginal	7	Suboptimal
Total Score	**60**		**124**	
Adjusted Score	**60**		**85**	

Discussion

All four streams that were studied showed improvement in overall habitat quality. However, no site improved habitat quality for all parameters studied. In fact, Baxter Creek received a worse score for bank stability on the left bank, even though improving bank stability was one of the goals of the project.

These results show that the restoration projects performed at Baxter Creek, Wildcat creek, Alhambra Creek and Peralta Creek were successful in improving overall habitat quality. The fact that native species were dominant over invasive plants at all sites in terms of percent cover is important to note, because this provides better habitat to wildlife that is native to the area. In addition to encouraging wildlife to reside in or near the stream, a successful restoration project can bring the attention of the community to a newly improved stream, and promote awareness of practices that are degrading to habitat quality.

It is important to note that even when studying restored streams, all sites still received scores of either poor or marginal for certain parameters. While the projects were successful in improving habitat quality, there are still many improvements that can be made. It is also important to note that only small reaches of the streams are being restored, and therefore unrestored reaches upstream of the restored site can influence and degrade habitat conditions.

Results of this study cannot be taken to mean that stream restorations as a whole are always successful in improving habitat quality, only that the restoration projects at these sites were successful. When monitoring to see whether or not a restoration project was successful, it is important to keep in mind the goals of the project. The procedures used to improve habitat quality in both project were successful in improving habitat quality parameters beyond those that were included in the project goals. However, the fact that bank stability decreased on the left bank of Baxter Creek, due to evidence of erosion, should be taken into account when looking at the results. Because increasing bank stability was a goal of the original project, it is possible that additional steps should be taken to improve this aspect of the creek. The techniques used to try to improve bank stability in this project should also be reviewed in accordance with this, and other similar projects. This can determine whether or not it is the most appropriate technique to be used at Baxter Creek or other comparable sites.

It is important to include a monitoring aspect for every stream restoration project that is performed. Every stream is different, and even different reaches within the same stream are different, and will react differently to restoration procedures. If noticed that a specific goal of a project has not been reached, measures can be taken to perform additional procedures to eventually reach that goal. Determining which procedures are or are not successful in a particular project can assist in the success of future projects.

One of the problems encountered during this study was the fact that detailed records about habitat quality are not collected for most streams prior to restoration. Finding pre-restoration data for streams proved to be difficult, and eventually photographs were found to be the best indication of habitat quality prior to restoration. However, not all components of the habitat quality, specifically the in-stream habitat quality, could be conveyed through the photographs. In the future, it would be useful if extensive records were kept about what the habitat quality of the stream was like before the restoration project was performed.

Future projects in the area might include monitoring a restoration project along a timeline to determine the success of restoration over time. This would consist of taking a detailed analysis of the stream before the restoration is implemented, then monitoring the stream at different points: six months after completion of project, one year after completion, five years after completion, ten years after completion, and so on. Such a project would give a better understanding about how habitat quality is maintained over time. This would also reveal whether a restoration project is initially successful in the early years, but then experiences degradation, or if it takes a longer period of time for the restoration to translate into improved habitat quality.

While results of this study were unable to produce general conclusions about stream restorations as a whole, it was found that the sites studied, Baxter Creek, Wildcat Creek, Peralta Creek and Alhambra Creek showed significant improvement in overall habitat quality based on the US Environmental Protection Agency's Rapid Bioassesment Protocols. Because not all habitat quality parameters were improved after the restoration projects were completed, this project shows the importance of monitoring the habitat quality of a stream after the completion of a project to assure that all the goals of the restoration are met.

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