ACKNOWLEDGEMENTS

I began this study humbly enough in the spring of 2000 as part of my graduate research at UC Santa Barbara. That spring and summer I conducted rapid bioassessment-based field surveys in several streams along the Santa Barbara coast. Originally, the purpose of my research was to characterize the effects of human disturbance on local stream ecosystems, and determine which biological parameters (e.g., abundance, diversity, species composition, etc.) are the most reliable indicators of local stream ecosystem integrity. After the first field season I got in touch with Mr. Rob Almy of County of Santa Barbara, Project Clean Water (PCW) to see if they (i.e., PCW) had interest in funding this type of research in future years. PCW's mission is to assess the severity and causes of local water quality impairment, and develop and implement strategies and actions to improve local water quality. Mr. Almy immediately saw the potential for bioassessment to help PCW assess and monitor water quality and biological integrity in local streams, and to help evaluate the effectiveness of their efforts to improve water quality and restore stream habitats over the long-term. After a few meetings we developed a conceptual scope of work for an annual stream bioassessment program, which we later refined into a detailed work plan. In 2001 PCW funded a second year of work. This was the official beginning of the Santa Barbara County Creeks Bioassessment Program (Program). In 2002, PCW was joined by the City of Santa Barbara in funding a third year of work. PCW and the City are committed to funding the Program again in 2003.

Completion of this study has required a great deal of effort, and would not have been possible if not for the contributions of many people. Sincere thanks to Dr. Scott Cooper, my advisor at UCSB. This study grew out of Scott's ideas, and his guidance throughout has been of critical importance. Sincere thanks also to the County of Santa Barbara and more recently the City of Santa Barbara for funding and taking ownership of the Program. The ongoing, voluntary commitment of the local community and government agencies to assess and restore our streams and coastal water quality is commendable. Special thanks PCW's Rob Almy, Cathleen Garnand, Tommy Liddell, Willie Brummett, and Darcy Aston, whose vision, hard work, and enthusiasm of have been essential to establishing the Program and completing the work. Jill Zachary, Steve Mack, and George Johnson with the City of Santa Barbara were instrumental in getting the City involved in the Program. City staff has also made valuable contributions towards completing the work. Sheila Wiseman provided independent review of the BMI identifications, and generously donated her time and talents to produce the water color painting of Mission Creek that appears on the cover, and several BMI drawings that appear throughout the report. Dr. John Melack, Dr. Dave Herbst, and Dr. Allan Stewart-Oaten of UCSB all provided valuable peer review of the draft report. Conception Coast Project completed the GIS analysis for the study.

Thanks also to several contributors in past years of the study. The City of Carpinteria funded bioassessment surveys in Carpinteria Creek in 2000 as part of the Carpinteria Creeks Preservation Program. Simon Poulter of Padre Associates, Inc. contributed to the conceptual development of the Program. Padre administered contracts for the 2001 and 2002 field surveys. Lou and Donna Courtois administered the remainder of the 2001 study through Aquatic Consulting Services, Inc. Darren Howe contributed excellent work towards the study in 2001, and dedicated his personal time to help with a few field surveys in 2000.

Jeff Brinkman, Ecology Consultants, Inc.
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EXECUTIVE SUMMARY

INTRODUCTION

This report presents the results of the 2002 Santa Barbara County Creeks Bioassessment Program (Program) effort. The Program is envisioned by its participants the County of Santa Barbara Project Clean Water (PCW) and City of Santa Barbara as a long-term effort to assess and monitor the integrity of local stream communities as they respond through time to changing environmental conditions shaped by natural processes and human factors. The Program focuses on the use of benthic macroinvertebrates (BMIs) as indicators of stream community integrity. Individual goals that support the Program mission are as follows:

1. Determine the strength and nature of natural relationships between local stream biota and physiochemical parameters including stream temperature, water chemistry, stream discharge, microhabitat (e.g., riffles vs. pools), stream width, elevation, gradient, stream order, catchment area, and climatic trends.
2. Determine the strength and nature of relationships between local stream ecosystem integrity and human disturbances including urban development, agricultural development, cattle grazing, physical habitat alterations (e.g., channelization), increased sedimentation, altered hydrology, and water pollution.
3. Determine which biological parameters are the most reliable indicators of local stream ecosystem integrity.
4. Determine how local stream biota responds through time to changing human influences, including changes in land use and stream habitat restoration and water quality improvement efforts.

STUDY AREA AND METHODOLOGY

The Program has involved the study of 17 coastal watersheds in southern Santa Barbara County and western Ventura County over a three-year period from 2000 through 2002. Physiochemical and biological data have been collected and analyzed annually from numerous individual stream reaches throughout the study area. Data was gathered through a combination of rapid bioassessment field surveys, laboratory analysis of water and BMI samples, spatial data analysis using geographic information system (GIS) software, and review of topographic maps and aerial photographs. Numerous physiochemical and biological parameters were calculated for each study reach based on the data collected. After the data set was finalized, statistical tests including analysis of variance (ANOVA) and multiple regression analysis were used to characterize relationships among biological parameters, physiochemical parameters, and different types and intensities of human disturbance.

STUDY RESULTS AND DISCUSSION

The following summarizes the results of the study in the context of the first three Program goals. The fourth goal deals with long-term responses of the stream biota to changing human land use and stream habitat/water quality restoration efforts, which have not been studied thus far.

Natural Relationships between Biological and Physiochemical Parameters

About half of the biological community parameters and 40 percent of the BMI taxa evaluated had significant (i.e., $p \leq 0.05$) or marginally significant (i.e., $0.05 < p \leq 0.10$) natural relationships with physiochemical variables. This included a mix of community diversity and composition parameters, and individual BMI taxa with representatives from several insect orders and non-insect groups. Of the seven physiochemical variables considered, stream temperature and elevation appeared to have the greatest influence on the stream biota, with lesser influence from stream order, specific conductance, pH, stream gradient, and stream discharge (Q). The range of Q evaluated in these analyses was narrow, representing base flow conditons.

There were subtle differences in BMI composition between the streams studied in Ventura County (Matilija and Sespe Creeks) and those in southern Santa Barbara County. Most of the BMI taxa found in Sespe and Matilija Creeks also occurred in one or more of the southern Santa Barbara County streams. However, there were several taxa found only in Matilija Creek and/or Sespe Creek. This suggests there is a slight regional distinction in stream biota between the Ventura County and Santa Barbara County streams.

There were significant or marginally significant differences between riffles and pools for three of the 17 biological community parameters and about one-third (17 of 53) of the individual BMI taxa evaluated. This suggests that using a multi-habitat sampling approach (i.e., sampling riffles and pools) in local streams is important. Using a single habitat sampling protocol such as the California Stream Bioassessment Protocol, which involves sampling riffles only, would provide less information about the BMI community (i.e., pool-residing taxa), despite a comparable investment of time and resources required to complete the sampling.

There was little year-to-year variability in most physiochemical and biological parameters, despite 2000 and 2001 being somewhat normal rainfall years and 2002 being a dry year. Because this study was conducted over three years only, the influences of long-term climatic trends (i.e., extended wet and dry periods) have not been documented.

Relationships between Local Stream Ecosystem Integrity and Human Disturbance

The exploratory statistical analyses conducted in this study showed that nearly all of the biological community parameters and many individual BMI taxa were significantly or marginally significantly related to human disturbance. In general, disturbed study reaches were degraded in terms of ecosystem integrity as evidenced by:

- Higher steam temperature, specific conductance, and nutrient levels;
- Lower diversity of BMIs and aquatic vertebrates;
- Lower composition of disturbance-sensitive BMIs, and;
- Higher composition of disturbance-tolerant BMIs.

The analysis indicates that urban-impacted sites were typically more degraded in terms of water quality and biological parameters compared to agriculture-impacted sites. Differences between undisturbed and lightly/moderately disturbed sites were in most cases slight and not statistically significant.

This study could not completely separate the natural influences of physiochemical parameters on the stream biota from those of human disturbance. However, the analyses did show many significant relationships between degraded biological parameters and increasing human disturbance within a subset of study reaches having a fairly narrow range of physical

characteristics (i.e., stream order, elevation, and gradient). Also, relationships between biological parameters and human disturbance were generally much stronger and applied to more biological parameters compared with natural relationships between stream biota and physiochemical parameters. Based on the analyses, it appears obvious that anthropogenic disturbance results in the degradation of local stream ecosystems.

Biological Indicators of Local Stream Ecosystem Integrity

This study identified more than 50 biological parameters that showed significant or marginally significant relationships with human disturbance. These biological parameters are all potential indicators of stream ecosystem integrity. The most reliable, widely-useful biological indicators of stream ecosystem integrity are those that are ubiquitous, have strong relationships with human disturbance, and do not have strong natural relationships with physiochemical parameters. Nine of the biological indicators identified in this study fit these criteria: insect family diversity, percent EPT, Tricoptera, Elmidae, Diptera, Tipulidae, *Hexatoma*, Odonata, and *Cordulegaster dorsalis*. The remaining biological indicators all had significant or marginally significant natural relationships with at lease one physiochemical parameter. There will be many situations where these biological parameters can be used as reliable indicators of stream ecosystem integrity. However, they should be used with caution to ensure that the natural influences of physiochemical parameters are not confused with those of human disturbance.

Another important finding of the analyses is that analogous BMI community parameters based on genus-level and family-level identifications (e.g., insect genera diversity vs. insect family diversity, genera biotic index score vs. family biotic index score, etc.) provided an almost identical ability to detect and indicate relationships between biological parameters, physiochemical parameters, and human disturbance. A substantial amount of time equaling approximately 40 percent of the total laboratory BMI sorting/identification effort was dedicated to keying out BMIs from family to genus. This accounted for approximately 15 percent of the total costs of the Program. Based on this, identifying BMIs to genus is neither necessary nor cost-effective to achieving the Program goals. This conclusion is supported by convincing statistical analyses based on a robust data set collected over a three year period.

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

The three-year Program effort has already provided a great deal of insight into relationships between biological parameters, human disturbance, and natural physiochemical parameters in local streams. The study has also identified more than 50 potential biological indicators of local stream ecosystem health. There are however still questions posed by the Program Goals that remain partially or wholly unanswered, especially as they relate to (1) influences of the natural ranges of physiochemical parameters on local stream biota; (2) relationships between stream biota and specific human stressors (e.g., increased sedimentation, hydrologic alterations, streambed and bank alterations, water pollutants, etc.), and; (3) long-term responses of the stream community to (a) climatic trends and (b) changing human land uses and stream habitat/water quality restoration efforts. These goals can only be met through continued, long-term monitoring of local streams.

Another goal that should be added to the Program scope is to develop a BMI-based Index of Biotic Integrity (IBI). An IBI incorporates several individual biological parameters representing various aspects of biological community structure (i.e., e.g., diversity, composition, density) into an overall score, or measure, of biological integrity for a study site. Scores are based on comparisons with at a previously studied set of reference (i.e., least disturbed) and test (i.e.,

highly disturbed) streams. By translating complex biological data into an overall composite measure of biological integrity, an IBI score can serve as a powerful tool for communicating the biological status of water resources to a wide audience, and an important basis of environmental management decisions.

Based on the above, the following recommendations for further study are offered for the 2003 Program effort:

- Continue monitoring the established study reaches, and expand the number of study reaches as funding permits. Additional study reaches should be selected carefully to improve the range of physiochemical parameters and types of human disturbance collectively represented in the study reaches. Types of study reaches that are generally lacking from the current data set include (1) undisturbed lowland coastal streams and (2) disturbed higher elevation mountain streams. Adding more of these types of study reaches to the data set and subsequent analyses will provide a more complete characterization of the relationships between biological parameters, human disturbance, and natural physiochemical parameters in local streams.
- As funding permits, combine bioassessment surveys with intensive water quality testing and/or bioassays. This will facilitate the characterization of relationships between individual water pollutants and biological parameters, and the identification of biological indicators for specific pollutants.
- Identify BMIs to the family level only. The analyses show that family-level and genus-level identifications of BMIs provide essentially the same ability to detect relationships between biological parameters, human disturbance, and physiochemical parameters. The money saved from not identifying BMIs from family to genus can be better spent assessing additional study reaches or conducting more intensive water quality testing and/or bioassays.
- Develop a BMI-based IBI for local streams. After the 2003 field season, cumulative data collected through the Program should be sufficient to develop a fairly robust IBI. The analyses for the 2003 Program effort can be tailored to develop and test the IBI without an increase in the total cost of conducting the Program.

Given the multitude of factors affecting stream ecosystems, it will probably never be possible to account for and totally separate all the natural and human influences. Still, the information gained from continuing this Program and other local stream assessment efforts is providing us with the ability to better recognize the effects of anthropogenic disturbances on local stream ecosystems, determine how water quality and stream ecosystems can be restored, and monitor the effectiveness of restoration efforts. Long-term stream monitoring will help advance the sciences of stream assessment and restoration, eventually leading to healthier streams.

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