Water Resources Center

Annual Technical Report

FY 2000

Introduction

The UC Center for Water Resources is a multicampus research unit and special program within the University of California's Division of Agriculture and Natural Resources. The major function is to support research and extension activities which will contribute to the efficient management of water resources within the state. Meeting the needs of the urban, agricultural and wildlife sections from both water quality and quantity considerations is a goal of the Center. The Center has linkages to faculty on all nine campuses in the UC system and to extension personnel in each of the 58 counties. The Center can be reach by email at cwres@ucr.edu and can be viewed on the web at http://waterresources.ucr.edu

Research Program

The Water Resources Center funded 17 new and continued 14 for a total of $791,856 with nearly every UC Campus participating. Following is a list of the newly funded projects (July 1, 2000). The research categories -- Hydrology, Climatology & Hydraulics (I); Aquatic Ecosystems (II); Water Quality (III); Water Development & Management Alternatives (IV); Water Law, Institutions & Policy (V) were all represented.

The Influence of Introduced Trout on the Diversity and Structure of native Aquatic Invertebrate Communities in High Sierran Streams, D. Herbst UC Santa Barbara (II)

Freshwater Mussels in California's North Coastal Streams: Current Status and Geomorphic Controls, K. Cuffey UC Berkeley (II)

Modeling and Optimization of Water Quality in a Large-Scale Regional Water Supply System, W. Yeh UCLA (IV)

Tunable Immunosorbents for the Remediation of Atrazine- and Simazine-Contaminated Water, W. Chen UC Riverside (III)

Multilateral Negotiation: Coalition Formation and California Water Policy, R. Goodhue UC Davis (V)

Examining the Relative Influence of Riparian and Upland Landcover and Landuse on instream Habitat: Improved Methods for the Russian River Basin, N. Kelly UC Berkeley (II)

Application of Acoustic Pressure Waves in Aquifer Remediation and Mobilization of Entrapped Organic Liquids, C. Chrysikopoulos UC Irvine (III)

Hydrodynamics of Shallow Water Habitats in the Sacramento-San Joaquin Delta, M. Stacey UC Berkeley (I)

Conservation Genetics of the Tidewater Goby-Eucyclogobius newberri, D. Jacobs UCLA (II)

Negotiating Contentious Claims to Water: Shifting Institutional Dynamics for the Allocation of Water Between the Eel and Russian River Basins, J. Gilless UC Berkeley (V)

Hydrodynamic Design in Coastal Wetland Restoration: Topography Optimization and Stability Assessment by Adjoint Sensitivity Method, B. Sanders (I)

Is Urban Runoff a Source of Human Pathogenic Viruses to Recreational Beach Waters?, S. Jiang UC Irvine (III)

Assessment of the Structure and Function of Natural Hydraulic Jumps, G. Pasternack (I)

Biodegradation of Estrogenic Compounds and Its Enhancement in a Membrane Bioreactor, S. Hermanowicz (III)

Assessing the Response of Degradative Biofilms to Groundwater Pollutants, J. Keasling (II)

Effects of Fine Sediment Storage on Food Web Structure and Juvenile Salmonid Reading in North Coast California Rivers, M. Power UC Berkeley (II)

An Evalution of Invasive Species in Lake Tahoe: The Potential Impact of Bass species onthe lake Ecosystem and Mercury Food Web Transfer, D. Slotton UC Davis (II)

Basic Information

Title:	Feasibility of Using Bioaugmentation with Bacterial Strain PM1 for Bioremediation of MTBE-Contaminated Vadose and Groundwater Environments
Project Number:	UCAL-W-924
Start Date:	7/1/1999
End Date:	6/30/2001
Research Category:	Water Quality
Focus Category:	Groundwater, Non Point Pollution, Treatment
Descriptors:	MTBE, Bioremediation, Biodegradation, Microorganisms, Groundwater
Lead Institute:	University of California
Principal Investigators:	Kate M. Scow

Publication

1. Hristova, K.R., C. M. Lutenegger and K. M. Scow, 2001. Detection and Quantification of MTBE-degrading Strain PM1 by Real-Time TaqMan PCR. Appl. Environ. Microbiol. (submitted)
2. Schwartz, E. and K. M. Scow. 2001. Repeated inoculation as a strategy for the remediation of low

concentrations of phenanthrene in soil. Biodegradation (i press).
3. Bruns, MA, J.R. Hanson, J. Mefford, K. M. Scow and L. Alvarez-Cohen, 2000. Isolate PM1 populations are dominant and novel methyl tert-butyl ether-degrading bacteria in compost biofilter enrichments. Environ. Microbiol. 3:220-225
4. Deeb, R. A., H. Y. Hu, J. R. Hanson, K. M. Scow and L. Alvarez-Cohen, 2000. Substrate interactions in BTEX and MTBE mixtures by an MTBE-degrading isolate. Environ. Sci. Technol. 35:312-317
5. Deeb, R. A., K. M. Scow and L. Alvarez-Cohen, 2000. Aerobic MTBE biodegradation: An examination of past studies, current challenges and future research directions. Biodegradation, 11:171-186.
6. Scow, K. M., E. Schwartz, M. Johnson, and J. L. Macalady, 2000. Measurement of microbila diversity. In: Encyclopedia of Biodiversity (in press).
7. Scow, K. M., 1999. Soil microbiology. In: Encyclopedia of Microbiology, Academic Press (in press).
8. Schwartz, E., S. V. Trinh, and K. M. Scow, 2000. Measuring growth of a phenanthrene degrading bacterial inoculum in soil with a quantitative competitive polymerase chain reaction method. FEMS Microb. Ecol. 34:1-7.
9. Macalady, J. L., E. Mack, D. Nelson and K. M. Scow, 2000. Sediment microbial community structure and mercury methylation in mercury-polluted Clear Lake, CA. Appl. Environ. Microbiol. 66:1479-1488.
10. Fitzgerald, G., K. M. Scow and J. Hill, 2000. Fallow season straw and water management effects on methane emissions in California rice. Global Biogeochemical Cycles 14:767-776.
11. Calderon, F. J., L. E. Jackson, K. M. Scow and D. E. Rolston, 2000. Microbial responses to simulated tillage in cultivated and uncultivated soils. Soil Biol. Biochem. 32:1547-1559.
12. El-Farhan, Y., K. M. Scow and D.E. Rolston, 2000. Kinetics of trichloroethylene cometabolism and toluene biodegradation: model applicaton to soil batch experiments. J. Envrionmental Qual. 29:778-786.

Water Resources Center Progress Report (6/15/01)

Title: Feasibility of using bioaugmentation with bacterial strain PM1 for bioremediation of MTBE-contaminated vadose and groundwater environments.

Investigator.: Kate M. Scow, Professor
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Key words: MTBE, bioremediation, biodegradation, microorganisms, groundwater

Text:

Extensive contamination of groundwater by MTBE has triggered the exploration of different technologies for in situ removal of the pollutant. After laboratory studies showed that bacterial strain PM1 is capable of rapid and complete MTBE biodegradation, the organism was used in an *in-situ* bioaugmentation field test at Port Hueneme Naval Base, Oxnard, CA. Two small pilot test plots (A and B) located down gradient from an MTBE source were injected with pure oxygen at two depths. One plot (B) was also inoculated with Strain PM1. Within one month of oxygen release, high concentrations of dissolved oxygen were measurable in most shallow and some deep wells. MTBE concentrations upstream from Plots A and B ranged from 1.5 to 6 mg per L. In the downstream wells (and immediately upstream near the oxygen release wells), MTBE concentrations decreased substantially in Plots A and B after a few months in the shallow depths and remained low for the following year. In the deeper zone, downstream MTBE concentrations decreased substantially in Plot A (uninoculated) but only slightly in Plot B (inoculated). Difficulties with oxygen release to the deeper zone of Plot B, as evidenced by low dissolved oxygen concentrations; was likely responsible for the observed low rates of MTBE removal. Well pump tests indicated that groundwater flow was substantially lower in the shallow than deep zones, and lower in Plot B than A.

A unique aspect of this project is our ability to monitor the survival and movement of Strain PM1, as well as measure changes in the native microbial community during bioremediation. DNA primer sequences specific to PM1 were identified and synthesized for use in both denaturing gradient gel electrophoresis (DGGE) and intergenic transcribed spacer (ITS) analysis. A quantitative PCR method (Taqman PCR) was also developed to measure the density of PM1. TaqMan assay could quantify strain PM1 in both laboratory and field samples with a detection limit of 2 cells PM1/ ml in pure culture or 180 cells PM1/ml in a bacterial mixture. Increases in the population density of PM1 corresponded to removal of MTBE in microcosms. ITS PCR detection (detection limit ~ 10^3 cells/ml) of strain PM1 in groundwater correlated with TaqMan results. PM1 was present in both Plot B and Plot A (10^2 to 10^5 CFU/ml) as evidenced by both PCR methods. PM1 densities were higher (up to 1 log order) in Plot B than Plot A, and higher in deep than shallow depths. Detection of PM1 in groundwater samples from outside the field plots suggests PM1-like organisms are naturally occurring in MTBE-contaminated

groundwater at Port Hueneme. Our findings also suggest that native microorganisms can remove MTBE as effectively as Strain PM1 (in presence of oxygen).

The overall significance of our study is that bioremediation, both through inoculation or stimulating native organisms, shows promise as a technology for cleaning up MTBE-contaminated groundwater. We have also found a naturally occurring PM1-like organism in MTBE-contaminated groundwater and will next determine its contribution to MTBE degradation.

Publications and Presentations

Publications:

Hristova, K. R., C. M. Lutenegger, and K. M. Scow. 2001. Detection and Quantification of MTBE-degrading Strain PM1 by Real-Time TaqMan PCR. Appl. Environ. Microbiol. (submitted).

Schwartz, E., and K.M. Scow. 2001. Repeated inoculation as a strategy for the remediation of low concentrations of phenanthrene in soil. Biodegradation (in press).

Bruns, MA; Hanson, JR; Mefford, J; Scow, KM. 2001. Isolate PM1 populations are dominant and novel methyl tert-butyl ether-degrading bacteria in compost biofilter enrichments. Environ. Microbiol. 3:220-225.

Deeb, R.A., H.Y. Hu, J. R. Hanson, K.M. Scow, and L. Alvarez-Cohen. 2000. Substrate interactions in BTEX and MTBE mixtures by an MTBE-degrading isolate. Environ. Sci. Technol. 35:312-317.

Deeb, R.A., K.M. Scow, and L. Alvarez-Cohen. 2000. Aerobic MTBE biodegradation: An examination of past studies, current challenges and future research directions. Biodegradation 11:171-186.

Scow, K.M., E. Schwartz, M.Johnson, and J.L. Macalady. 2000. Measurement of microbial diversity. In: Encylopedia of Biodiversity. (in press).

Scow, K.M. 1999. Soil microbiology. In: Encyclopedia of Microbiology. Academic Press (in press).

Schwartz, E., S.V. Trinh, and K.M. Scow. 2000. Measuring growth of a phenanthrene degrading bacterial inoculum in soil with a quantitative competitive polymerase chain reaction method. FEMS Microb. Ecol. 34:1-7

Macalady, J.L., E. Mack, D. Nelson, and K.M. Scow. 2000. Sediment microbial community structure and mercury methylation in mercury-polluted Clear Lake, CA. Appl. Environ. Microbiol. 66:1479-1488.

Fitzgerald, G., K.M. Scow, and J. Hill. 2000. Fallow season straw and water management effects on methane emissions in California rice. Global Biogeochemical Cycles 14:767-776.

Calderon, F.J., L.E. Jackson, K.M. Scow, and D.E. Rolston. 2000. Microbial responses to simulated tillage in cultivated and uncultivated soils. Soil Biol. Biochem. 32:1547-1559.

El-Farhan, Y., K.M. Scow, and D.E. Rolston. 2000. Kinetics of trichloroethylene cometabolism and toluene biodegradation: model application to soil batch experiments. J. Environ. Qual. 29:778-786.

Presentations:

Bioremediation of MTBE through Bioaugmentation at Port Hueneme Naval Facility. Invited talk at the Sixth International Symposium of In Situ and On-Site Bioremediation, San Diego, 6/4/01

Molecular Characterization of MTBE-Degrading Isolate, Strain PM1. Poster at the Sixth International Symposium of In Situ and On-Site Bioremediation, San Diego, 6/4/01

Bioremediation of the MTBE at Port Hueneme. Invited talk at Port Hueneme Advisory Committee. 3/19/01.

Biodegradation of the Fuel Additive, MTBE, in Groundwater. Invited talk at the University of California, Riverside. 5/31/01

Microbial Ecology of MTBE Biodegradation. Invited talk at the Ecology Graduate Group Odyssey, Tahoe City, CA. 9/18/00.

Training: This project has provided support (direct funding and indirect) for: 1 postdoctoral fellow (Hristova), 3 graduate students at UCD (Smith, Smith, Gandhi) and 6 undergraduate students (Watanabe, Scott, Smith, Adamson, Lu, Sugitani).

Collaborative Efforts: A number of collaborations have been supported or initiated by this project. My lab continues to collaborate with Doug Mackay from U. of Waterloo, Canada, in a biostimulation study at Vandenburg Air Force Base and Prof Mackay provides advice on hydrological issues at Port Hueneme. We are also collaborating with Mike Hyman at NC State on MTBE metabolism and with Rula Deeb (Lisa Alvarez-Cohen's lab at UC Berkeley) on BTEX interactions with MTBE biodegradation.

Basic Information

Title:	An Integrated Modeling Franework for Analyzing Wetlands Policies: Balancing Ecosystem Services and Economic Factors
Project Number:	UCAL-W-926
Start Date:	7/1/1999
End Date:	6/30/2001
Research Category:	Not Applicable
Focus Category:	Law, Institutions, and Policy, Wetlands, Economics
Descriptors:	Wetlands, Optimization, Cost-Effectiveness, Ecosystem Services
Lead Institute:	University of California
Principal Investigators:	Marca Weinberg

Publication

PROJECT NUMBER AND TITLE

W-926

An Integrated Modeling Framework for Analyzing Wetlands Policies: Balancing Ecosystem Services and Economic Factors

INVESTIGATORS

Marca Weinberg, Economic Research Service, U.S. Department of Agriculture and adjunct faculty U.C. Davis, Department of Environmental Science and Policy

Stephen C. Newbold, U.C. Davis, Department of Environmental Science and Policy

KEY WORDS

Wetlands, optimization, cost-effectiveness, ecosystem services

The purpose of this project is to develop a framework for incorporating considerations of ecosystem services into wetland management. This process consists of two stages: (1) estimating relationships between landscape configuration and the provision of key ecosystem services from wetlands, and (2) incorporating these functions into a spatial optimization model to prioritize locations for the protection and restoration of wetlands. The management of wetlands is important for water policies in general, and in the Central Valley of California in particular, because: they affect water quality by serving as sinks or sources of nutrients and sediments; they are important for flood management by affecting the timing and intensity of flood waves, thereby mitigating flood damages; and they have implications for regional water allocations since healthy wetland systems depend upon adequate water supplies. This project focuses on two key ecosystem services: habitat for waterfowl and other bird species that breed in the Central Valley, and water quality benefits of wetlands.

In the first year of the project we created a prototype spatial optimization model and applied it to a stylized landscape loosely representative of California's Central Valley. This was a necessary first step as it allowed us to determine the general level of applicability of the approach. We also performed several simulation exercises to investigate the potential importance of spatial effects and decision rules on management effectiveness.

In this second year of the project we have developed models of habitat preferences for a number of birds that breed in the Central Valley. Using data from the North American Breeding Bird Survey, the National Wetlands Inventory, and land use surveys performed by the California Department of Water Resources, we estimated statistical models that describe relationships between the amount and configuration of major land use types and bird abundances. Several species show significant dependence on landscape configuration at the scale modeled. The abundance of breeding mallards and the overall richness of bird species in particular show clear relationships to various land use types, including significantly positive, though decreasing, responses to the area of wetlands. Wetlands management in the Central Valley focuses in part on supplementing waterbird habitat since the region supports a high proportion of waterfowl and shorebirds utilizing the Pacific flyway during fall migration. Our results contribute to this general focus on waterfowl, and add important information about breeding preferences of resident mallards. In addition, the breeding bird richness model provides a more general assessment of the avian habitat support functions provided by wetlands. These two models in particular will form the basis of the "habitat benefits" component of the site prioritization model.

We are currently developing models to describe how wetlands can contribute to the enhancement of water quality in the region. These models will be completed in the coming months. To finish the project two additional tasks must be accomplished. First, we will estimate the costs of protection and restoration of wetlands in the study area, and second, we will incorporate all of the elements – habitat, water quality, and costs – into the spatial optimization framework. With the resulting model we can then identify those sites that, if successfully restored to wetlands, should yield the greatest environmental benefits (specifically habitat and water quality benefits) from a limited budget. By the end of the project we will have developed a new tool for wetlands management, and we will have generated a set of general recommendations for the Central Valley of California. Future work will focus on expanding the model to include other ecosystem services, such as flood control benefits of wetlands.

PUBLICATIONS

A conference paper entitled "Integrated modeling for watershed management – Multiple objectives and spatial effects" was presented at the Integrated Decision-Making for Watershed Management Symposium, held on January 7-9, 2001 in Chevy Chase, MD (http://www.conted.vt.edu/watershed.htm). The paper is currently in review for publication in a special issue of the Journal of the American Water Resources Association.

TRAINING ACCOMPLISHMENTS

One PhD student has worked on this project: Stephen C. Newbold, UC Davis, Department of Environmental Science and Policy. This project will serve as Newbold's dissertation.

ADDITIONAL FUNDING

After receiving Water Resources Center funding this project was selected for funding by EPA under a joint NSF/EPA call for proposals: Decision-making and Valuation for Environmental Policy. EPA has provided supplemental funding for the first two years of the project, and will provide full funding for a third year. The total amount of the award is approximately $125,000.

Basic Information

Title:	Development of a Rapid, Sensitive, and Quantitative Method to Detect Infective Hepatitis A Virus in Water
Project Number:	W-932
Start Date:	7/1/1999
End Date:	6/30/2001
Research Category:	Not Applicable
Focus Category:	Methods, Non Point Pollution, None
Descriptors:	Drinking water, Ground Water, Recycled water, artificial recharge, Hepatitis A Virus, Pathogens, Viruses, Microbiology, Monitoring, Measurement Methods
Lead Institute:	University of California
Principal Investigators:	Marylynn V. Yates

Publication

PROJECT NUMBER AND TITLE: Development of a rapid, sensitive, and quantitative method to detect infective hepatitis A virus in water (HQ-96GR02659)

PRINCIPAL INVESTIGATORS:

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KEY WORDS: drinking water, ground water, recycled water, artificial recharge, hepatitis A virus, pathogens, viruses, microbiology, monitoring, measurement methods

TRAINNG: Oymon Leong, M.S. student

Microorganisms are responsible for more than 90% of the reported waterborne disease outbreaks in the United States; enteric viruses, such as hepatitis A virus, are identified as causing almost 10% of these. However, in 50% of the outbreaks, no causative agent is identified due to limitations in our ability to isolate and detect viruses in water samples. Historically, consumption of contaminated ground water has been the source of one-half of the reported outbreaks; in recent years, that fraction has risen to more than two-thirds. The most frequently reported source of contamination in these outbreaks is domestic sewage from septic tanks, leaking sewer lines, cesspools, etc. As a result of the continuing waterborne disease outbreaks, and the growing fraction of them associated with consumption of ground water, the USEPA is finalizing a regulation, the Ground Water Rule, to minimize the risk of acquiring a microbial illness from ground water. This regulation will require all public water systems that use ground water as a source to assess the potential for fecal contamination of the water.

The lack of standardized methods that can be routinely performed in a short time period to detect and quantify infective hepatitis A viruses has limited the amount of information available on the occurrence of these viruses in drinking water and other environmental samples. Thus, an assessment of the risk of hepatitis A virus infection as a result of exposure to ground water that is impacted by artificial recharge with recycled water is not possible at this time. The methods developed in this study should improve our ability to provide quick and efficient results for the detection and quantitation of infective hepatitis A virus in samples from environmental waters. In light of the impending Ground-Water Rule, this method will provide a tool that can be used to quickly assess the potential impacts of artificial recharge. The methods can be adapted to facilitate the detection of other microorganisms in water, improving our ability to calculate risks from those organisms as well.

The goal in the first year was to develop a molecular beacon-based reverse transcription polymerase chain reaction (RT-PCR) assay for the detection of hepatitis A virus. The initial efforts were centered on the selection of primers and the design of molecular beacons. A primer set was developed in order to amplify a highly conserved region of the VP3 capsid region of the hepatitis A virus. A molecular beacon was designed to complementarily target the internal region of the PCR amplicon (the product of the PCR amplification). A 2-step RT-PCR assay was developed for the detection of hepatitis A virus, and experiments were conducted to confirm that the entire process did, indeed, detect hepatitis A viruses.

There are other viruses that can be amplified using the same RT-PCR protocol. These include enteroviruses (i.e., polioviruses, coxsackieviruses, and echoviruses), which are also commonly found in contaminated water and are known to cause diseases such as aseptic meningitis, myocarditis, and encephalitis. Two such viruses are Echovirus 11 and Coxsackie virus B6. To investigate whether the molecular beacon would detect these two viruses (and therefore lack the degree of specificity required), RT-PCR assays were conducted with Echovirus 11 and Coxsackie virus B6 as the test viruses. The results of our experiments demonstrated that the molecular beacon is specific to only hepatitis A virus, as no increase in fluorescence was detected with either Echo or Coxsackie virus as the test viruses. More importantly, even though amplicons were detected with the Echovirus 11 and Coxsackie virus B6 using visualization on agarose gels (the standard method for detection of PCR product), they were not detected by the molecular beacon, again confirming its superior specificity.

In the second year of the project, we will determine the sensitivity of the real-time RT-PCR assay. A calibration curve of the critical cycle, defined as the cycle at which a significant increase in fluorescence is first recorded, vs initial virus concentration will be constructed. After successfully demonstrating the selectivity and sensitivity of the assay, we will combine the assay with immunomagnetic separation of hepatitis A virus. These results will be compared with cell culture results (the "gold" standard used for quantification of the infective viruses) and in order to establish a quantitative viability test for hepatitis A virus.

Basic Information

Title:	Habitat Features and Aquatic Health: Evaluating California's Stream Bioassessment Procedure inNatural and Artifical Streams in a Grazed Eastern Sierra Valley
Project Number:	UCAL-W-925
Start Date:	7/1/1999
End Date:	6/30/2001
Research Category:	Not Applicable
Focus Category:	Methods, Water Quality, Sediments
Descriptors:	Aquatic Ecology, Macroinvertebrates, Bioassessment, Aquatic Habitat, Salmonids
Lead Institute:	University of California
Principal Investigators:	Kenneth W. Tate

Publication

PROJECT TITLE

Habitat features and aquatic health: Evaluating California's Stream Bioassessment Procedure in natural and artificial streams in grazed Eastern Sierra valley

INVESTIGATORS

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REPORT ON PROGRESS DURING JULY 1, 2000 - JUNE 30, 2001

This project explores a central question in the development and use of macroinvertebrate-based stream bioassessment procedures: to what extent do habitat features, particularly those easily influenced by human activity, correlate with "healthy" aquatic biota? A second, but equally important, question is whether macroinvertebrate-based stream bioassessment procedures designed for citizen monitoring in fact provide any information about water quality and aquatic health beyond what can be obtained using simple chemical parameters and visual stream assessment methods.

We approached these questions by examining macroinvertebrate communities in 15 natural and man made streams flowing through Bridgeport Valley in the eastern Sierra. In 1999, 30 study sites with 3 replications per site (n=90) were established, and stream physical and chemical features were evaluated using standard methods. Teams of observers rated the sites using he Natural Resource Conservation (NRCS) Visual Stream Assessment Procedure, the EPA's Rapid Bioassessment Protocol's Habitat Assessment, and the Proper Functioning Condition method developed by the Bureau of Land Management. Temperature loggers were placed upstream and downstream of each site. Macroinvertebrates were collected in August using methods from the California Department of Fish and Game's Stream Bioassessment Procedure for Citizen Monitors, and bank surveys for fish were conducted.

During the winter and spring of 2000, macroinvertebrate samples collected during 2000 were identified to the family level. 1999 water quality, habitat assessment, and stream temperature data were entered and checked during the winter of 2000. Macroinvertebrate collections and assessments were repeated during the summer of 2000 at 14 of the sites (n=42) used in 1999 to evaluate inter-annual variability. Water quality and temperature data were collected during the summer of 2000 at these sites. All taxonomic identification of macroinvertebrate samples and

data entry was collected this winter. We are currently analyzing water quality, stream temperature, habitat assessment and macroinvertebrate data from 1999 and 2000 to evaluate the original study questions. Complete analysis will be interpreted and presented in the final report.

Preliminary analysis provides insight into the "health" of Bridgeport Valley macroinvertebrate communities. Pooling all data across sites in 1999, we found that 69% of the macroinvertebrates sampled were larval-stage EPT (Ephemeroptera, Plecoptera, & Trichoptera) taxa (Figure 1). EPT taxa, commonly called mayflies, stoneflies, and caddesflies, acquire dissolved oxygen through external gills or by cutaneous respiration and therefore require low sediment levels and adequate oxygen levels. These taxa are very sensitive to water quality impairment by land use, and a high percentage of EPT taxa is indicative of favorable water quality and aquatic habitat conditions. Coleoptera (beetles) made up 15% of the samples, 99% of which were from one family (Elmidae). This family and most Coleoptera acquires oxygen in a similar manner to EPT taxa, but have protective respiratory mechanisms that make them less sensitive to impaired water quality and habitat. A small portion (< 15%) of Coleoptera sampled were adults, which have various strategies of obtaining oxygen that allow them to tolerate lower oxygen levels. In contrast, most larvae from the Diptera family (flies), which represented 16 % of the Bridgeport taxa, can tolerate poor water quality conditions, particularly low oxygen levels. Dominance by Diptera at a site often indicates poor water quality and habitat conditions.

PUBLICATIONS AND PRESENTATIONS

Publication and presentation of the results of this project will occur during the Fall of 2001, once data analysis has been completed. Information from this study will be presented to local natural resources managers and regulators in the Bridgeport area, as well as Statewide, via the UC DANR Rangeland Watershed Workgroup and other venues. Results will be made available Nationally via presentations at professional conferences and peer-reviewed scientific journals.

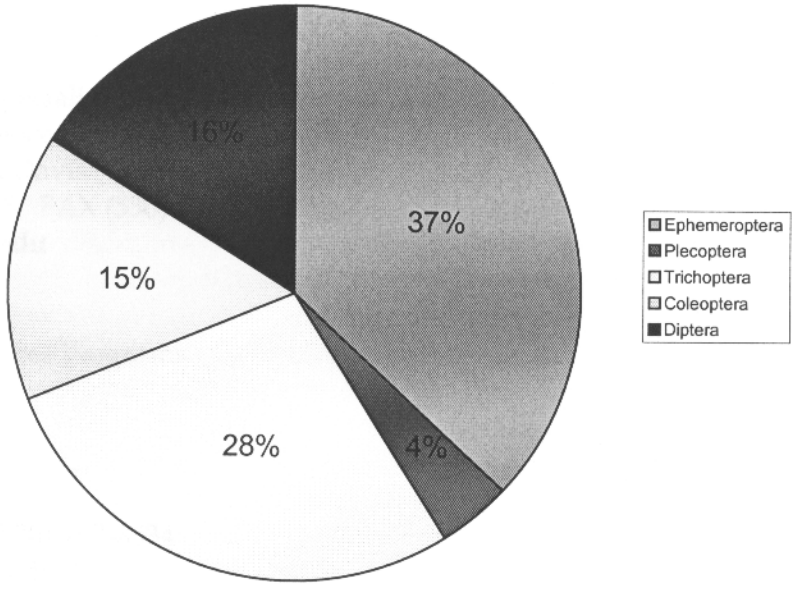
TRAINING ACCOMPLISHMENTS

There is one Ph.D. Candidate and one M.S. Candidate actively involved in the project. They have been trained in both field and laboratory components of the project. Three undergraduate interns have been involved in the project, being trained on the laboratory components of the project. Several UCCE Natural Resources Advisors have also been involved in the project, being trained on field methods.

ADDITIONAL FUNDING

Preliminary data collected with WRC funding was critical in allowing us to successfully compete for funding from NASA for a project to utilize remote sensing to evaluate irrigation management on stream "health". *Tate, K.W., L.K. Vance, Z. Wan, P. Gong, G. Biging, and R. Gildersleeve. 1999-2002. Using Remote Sensing to Evaluate the Impacts of Flood Irrigation of Meadows in the East Walker River Basin of California. NASA NRA-98-OES-09. $543,490.*

Figure 1: Macro-invertebrate Communities of Bridgeport Valley Streams



Basic Information

Title:	Landscape Level Controls on Nitrate-Nitrogen in Forested and Chaparral Catchments of Southern California
Project Number:	W-931
Start Date:	7/1/2000
End Date:	6/30/2002
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Geomorphological Processes, Water Quality
Descriptors:	Water Quality, Watershed Management, Nitrogen Retention, Drinking Water, Biogeochemistry, Atmospheric Deposition, Nonpoint Source Pollution, Landscape Hydrology
Lead Institute:	University of California
Principal Investigators:	Thomas Meixner

Publication

1. Allen, E. B., A. G. Sirulnik, L. Egerton-Warburton, S. N. Kee, A. Bytnerowicz, P. E. Padgett, P. J. Temple, M. E. Fenn, M. A. Poth, and T. Meixner, 2000. Air Pollution and Vegetation Change in Southern California Shrublands, In: Planning for Biodiversity: Bringing Research and Management Together. USDA Forest Service pacific Southwest Research Station, Riverside, California (in press).
2. Meixner, T., E. B. Allen, K. Tonnessen, M. Fenn and M. Poth 2001. Atmospheric Nitrogen Deposition: Implications for Park Managers, Submitted to Park Science.

Landscape Level Controls on Nitrate-Nitrogen in Forested and Chaparral Catchments of Southern California

Thomas Meixner, Dept. of Environmental Sciences, UC-Riverside

The mountains of southern California receive among the highest rates of N deposition in the world (~40 kg ha^{-1} yr^{-1}) and as a result streamwater NO_3^- concentrations in smog-impacted summer-dry montane ecosystems in the Los Angeles Air Basin are the highest in North America for natural catchments . The problems near Los Angeles indicate the future of forests and other ecosystem types near urbanizing areas in the western United States, as emissions of NO_x and NH_3 increase. Few studies have addressed ecosystem processing of chronic N deposition in semiarid systems, but the available data clearly indicate the limited capacity of these systems to retain N within the terrestrial ecosystem. Existing data indicates that watersheds closer to the smog of Los Angeles have higher NO_3^- concentrations than streams that are farther away. However, in the Devil Canyon catchment in the western San Bernardino Mountains, 100 km east of Los Angeles, NO_3^- concentrations are extremely variable. Although N deposition should be similar throughout the Devil Canyon watershed, NO_3^- concentrations vary by several orders of magnitude among the sampling sites. This variability provides a unique opportunity to determine the biogeochemical and hydrologic factors that exert the greatest control on NO_3^- export from semiarid forested catchments with elevated N deposition.

During the past year we have conducted detailed water quality sampling at 9 streams in the Devil Canyon watershed. We have three major findings. First, we have observed that as streamflow increases that nitrate and DOC concentrations both increase also. In a couple of the smaller streams there is a noticeable first "flush" of NO_3^- and then a decrease as stream flow continues at a higher level than during fall and summer low flows. While the increase in nitrate in the larger streams may indicate a flushing process, we do not see a decrease in concentrations as the rainy season progresses indicating that a flushing process is not responsible for the increases in NO_3^- that we observe. Second, the strong correlation of DOC and nitrate may indicate a denitrification control on stream nitrate concentrations. This concept of a denitrification control on stream nitrate and DOC concentrations is further bolstered by longitudinal surveys and mass balance analyses that indicate that plant uptake and denitrification in the riparian zone are responsible for the decline in NO3- concentrations rather than a pure dilution process. Third, perennial streams have high NO_3^- concentrations while ephemeral streams do not. This difference points to groundwater as the source of the high levels of NO_3^- we observe in the perennial streams. Furthermore the evidence indicates a decoupling of the impact of N deposition on terrestrial and aquatic systems in Mediterranean climates. The primary reason for the decoupling involves the asynchrony between when atmospheric deposition occurs (summer), the time period of maximum soil nitrate availability and leaching (winter), and the time of maximum plant N demand (spring).

Our results also have important implications for wildlife managers and water resources agencies as they make decisions on how to respond to increases in atmospheric deposition. For wildlife managers these results indicate that the streams with the best habitat, those with large and consistent flows, are those most likely to be impacted by the effects of N deposition. For water resource managers our results indicate that the times when they are most likely to get water for recharge or for filling reservoirs, periods of high flow, are also the periods which are expected to have the highest nitrate concentrations indicating less of a chance to use waters

draining deposition impacted watersheds to dilute groundwater impacted by historic agricultural groundwater contamination.

Publications/Presentations –

1) Meixner, T., M. Fenn and M. Poth 2001. Controls on N Deposition Impacts in Semi-Arid Catchements. *EOS, Transactions, American Geophysical Union*, 82(20), S140-141, 2001. Paper was presented in Boston, Massachusetts at the spring meeting of the American Geophysical Union, on May 28, 2001.

2) Meixner, T., E. B. Allen, K Tonnessen, M. Fenn and M. Poth, Atmospheric Nitrogen Deposition: Implications for Park Managers, Submitted to Park Science, 2001

3) Allen, E.B., A. G. Sirulnik, L. Egerton-Warburton, S. N. Kee, A. Bytnerowicz, P. E. Padgett, P. J. Temple, M. E. Fenn, M. A. Poth and T. Meixner. In press. Air Pollution and Vegetation Change in Southern California Shrublands. Proceedings of the Symposium on "Planning for Biodiversity: Bringing Research and Management Together" Feb. 29-Mar. 3, 2000 USDA Forest Service Pacific Southwest Research Station, Riverside, California.

Training-

One graduate student, Jeff McGovern and two undergraduate students, Megan Robinson and Bridgette Valeron were supported off of this grant. Jeff is working on the biogeochemical processes occurring in the riparian zone of the watershed and particularly surface water groundwater interactions that affect water quality. Jeff is a graduate student in Chemical and Environmental Engineering and will graduate 2 years from now. Megan has been working on nutrient budgets for the watersheds we are monitoring in addition to overseeing and analyzing results from longitudinal surveys. Bridgette has been aiding in field work and analyzing stream samples for DOC.

Additional Funding

I was awarded an NSF CAREER award on the topic "Evaluation of Biogeochemical Watershed Models: How Do We Know When A Model is Wrong?" ($250,000 over 5 years). One component of this award was to develop a watershed biogeochemistry research group at UC-Riverside. The WRC support showed that I was on my way to establishing such a group at UCR. This fall my forest service collaborators and I intend to submit a proposal to the USDA to follow up on the work we have been conducting in Devil Canyon on a broader basis. It is doubtful that any of the data collected or the insight it provides into watershed biogeochemistry in semi-arid systems could have been made without the WRC funding.

Basic Information

Title:	Dynamic Chemical Loads as a Function of Land-Use Changes in a Watershed
Project Number:	HQGR0089
Start Date:	9/1/2000
End Date:	8/31/2002
Research Category:	Not Applicable
Focus Category:	Surface Water, Solute Transport, Management and Planning
Descriptors:	
Lead Institute:	University of California
Principal Investigators:	Arturo A Keller

Publication

TITLE: Dynamic Chemical Loads as a Function of Land-Use Changes in a Watershed

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Key Words: Fertilizers Nutrients, Pesticides, Toxics, Buffer Strips, Contaminant Transport, Decision Models, Land Use, Landscape Management, Land-Water Interactions, TMDL, Water Quality Modeling, Watershed Management

Focus Categories: NPP, WQL, MOD

The basins model is about 80 per cent ready and the MMS model is approximately 50 per cent ready.

There have been no publications to date

Training: Eight graduate (masters) students and one PhD student have been directly involved in the implementation of watershed models.

Information Transfer Program

The Water Resources Center, through the main office, has filled approximately 118 requests for publications and mailed out annual publications to approximately 550 recipients. The Water Resources Center Archives (WRCA), has filled approximately 16,000 transactions.

The Water Resources Center Archives has been successful in obtaining two grants. The Librarians Association of the University of California has provided the funding for the WRCA to compile a comprehensive list of California's water and irrigation districts and to survey those agencies to identify significant historical documents. The San Francisco Foundation awarded the WRCA funds to develop an on-line information resource. The Archives will create a web page featuring 15 projects funded by the Foundation's San Francisco Bay Fund.

The Center for Water Resources continues its outreach efforts through the newsletter (Currents) and website. The newsletter is mailed to over 3,500 recipients and is available on-line. The website has received hundreds of visitors and continues to be used as a communication tool.

The Center continues an active program of sponsoring conferences and workshops on important topics. Planning has begun on the 23rd Biennial Groundwater Conference to be held in October, 2001. The Center has begun co-planning and co-sponsoring an international symposium on Sustained Management of Irrigated Land for Salinity and Toxic Element Control along with the International Union of Soil Science, Sub-Commission A and the Bouyoucous Conference, Soil Science Society of America, the Kearney Foundation and the George E. Brown Jr. Salinity Laboratory, USDA-ARS.

USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	11	0	0	0	11
Masters	6	8	0	0	14
Ph.D.	2	1	0	0	3
Post-Doc.	1	0	0	0	1
Total	0	0	0	0	29

Notable Awards and Achievements

Additional funding received by the Water Resources Center’s funded projects amounts to just over $2.77 million.

36 presentations have been completed on the research.

The funded research has garnered 47 publications to date.

Dr. Sedlak’s research (Pharmaceutically-Active Compounds in Alternative Water Supplies, W-882 July 1, 1997 - June 30, 1999) was featured on KRON, Berkeley, California and Los Angeles and Sacramento television affiliates.

Publications from Prior Projects