COASTAL ENVIRONMENTAL QUALITY INITIATIVE PROGRAM
Graduate Student Fellowship Application
University of California Marine Council (UCMC)

FINAL REPORT

Title: **Understanding Nutrient Loading to the Coastal Zone from Urban Watersheds**

Project Reference #: 02T CEQI 08 0097

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Period of the project:
January 1, 2002 through **December 31, 2003** with a
No-Cost Extension from **December 31, 2003** to **December 31, 2004**

Funding amount: **$50,000.00**

SUMMARY

Watershed scale nutrient loading was measured and characterized for the dominant land use types in the three principal watersheds of the Carpinteria Valley, California, near the city of Santa Barbara. These coastal watersheds were thought to be representative of Mediterranean like climates in their runoff patterns and land use types. This final report presents background information showing research objectives, a project description, the principal findings and products (publications, presentations and outreach), key references, participants (Appendix A) and a financial report (Appendix B).

BACKGROUND

Understanding nutrient export from a watershed requires careful assessment of the hydrologic conditions, catchment lithology, soil types, and human activities, such as land use practices found in the basin (Johnes, 1996; Carpenter et al., 1998). Point and non-point sources can be natural or anthropogenic and tracking their cumulative influence on stream nutrient loading requires high frequency stream monitoring both for discharge and stream chemistry (Smith et al., 1987; Winter and Duthier, 2000). Excessive nutrient concentrations in streams can increase aquatic biomass production and degrade aquatic ecosystem conditions specifically by altering dissolved oxygen concentrations, light attenuation to the benthic community and stream chemistry (Schlesinger, 1997). Eutrophication, a natural process, is accelerated by excessive nutrient inputs particularly from urban and agricultural development where impairments can compromise ecosystem functionality and human beneficial uses such as recreation, food, and aesthetics (Rast and Lee, 1983; Correll, 1998; Howarth et al., 2000; Bay et al., 2003; Schiff and Sutula, 2004).

Southern California coastal watersheds are particularly vulnerable to impairments to stream chemistry and hydrologic characteristics given the rapid urban growth of the region (Bhaduri et al., 1997; Worrall and Burt, 1999; Brun and Band, 2000; Beighley et al., 2003; Warrick and Milliman, 2003). Discharge, solute export and sediment loading to the sea from coastal watersheds with Mediterranean climates have been studied in several locations in Southern California such as the Santa Monica Bay, Santa Ana River, Newport Bay, and the entire Southern California Bight (Leecaster et al., 2002; Ackerman and Schiff, 2003; Bay et al., 2003; Kent and Belitz, 2004). Coastal watersheds in Spain have also been studied to look at similar environmental concerns (Avila et al., 2002; Butturini and Sabater, 2002). In each case nutrient data were collected but often the research focus was on other toxic substances such as pathogens, heavy metals and organophosphates depending on the identified impairment. High frequency stream sampling to determine event-based and annual nutrient export has been done on a rare occasion in southern California, specifically in highly urbanized areas (Bay et al., 2003; California Department of Transportation, 2003; Schiff and Bay, 2003; Keller et al., 2004).

PROJECT DESCRIPTION

The objectives of this project were to measure, characterize, and model nutrient loading by land use in three coastal Mediterranean watersheds in the Santa Barbara area. The research incorporated high frequency sampling strategy of specific land uses. Stream monitoring was done over a three year period from October 2000 to September 2003, this grant funding the last two years. 2889 samples were collected at fourteen sampling sites (Figure 1) by researchers, volunteers (see participant list in Appendix A), and automatic samplers (ISCO, Inc.) (Table 1). Annual and event-based nutrient loadings were determined for the dominant land use classes in three principal watersheds of the Carpinteria Valley. Santa Monica (SM), Franklin (FK), and Carpinteria (CP) creek watersheds have distinctive characteristics but are representative of the regional mosaic of land uses and hydrologic regime of a Mediterranean like climate.

Figure 1: Sampling sites with associated land uses monitoring sites in the Carpinteria Valley near Santa Barbara, CA.

Table 1: Stream discharge and rainfall for the three years of the study.

	Number of Storms[1]	Number of Samples[2]			Annual Rainfall[3] (cm)			Annual Runoff (cm)			Runoff/Rainfall (%)		
		SM	FK	CP	SM	FK	CP	SM	FK	CP	SM	FK	CP
WY2001	14	70	71	71	79.7	61.1	79.2	17.9	16.3	19.4	0.2	0.3	0.2
WY2002	13	105	397	287	28.0	21.3	27.8	1.7	7.0	1.0	0.1	0.3	0.04
WY2003	11	291	738	859	70.6	59.7	70.1	6.8	13.8	4.1	0.1	0.2	0.1

1. Storm: rainfall > 0.25 cm
2. Total number of samples: 2889
3. Distributed Rainfall

Discharge at each sampling point was determined by recorded stage data from pressure transducers fixed to the channel bottom, which were converted to flow through stage-discharge relationships developed for each site in HEC-RAS (Hydrologic Engineering Center, US Army Corps of Engineers) using channel surveys centered around the sampling points. When specific flow data was unavailable, hydrologic data from other, nearby areas was used to best estimate the flow regime. Each stream water sample was analyzed for ammonium (NH_4), nitrate (NO_3), and phosphate (soluble reactive phosphorus, PO_4-SRP) by colorimetric determination using standard methods on a Lachat-Zellweiger auto-analyzer (Grasshoff, 1976; USEPA, 1983; Willason and Johnson, 1986; Lachat Instruments Inc., 1995; Lachat Instruments Inc., 1996a; Lachat Instruments Inc., 1996b). Total dissolved nitrogen (TDN) and total dissolved phosphorous (TDP) were determined by persulfate digestion (Valderrama, 1980). Dissolved organic nitrogen (DON) was computed as the difference between TDN and dissolved inorganic nitrogen (DIN, nitrate and ammonium). All analytical work was done at various laboratories at UC Santa Barbara in collaboration with the Santa Barbara Coastal Long Term Ecological Research project (SBC-LTER, NSF grant number OCE99-82105).

PRINICIPAL FINDINGS

There were several components needed to calculate and analyze trends in nutrient export by land use class. An important first step in the research was to conduct a land use classification for the study area as no spatial land cover data were available for the specific years of the study and at the desired spatial resolution. On-screen or heads-up digitizing was done using high resolution aerial photographs (Air Photo, USA), Anderson Level II land use classification (Anderson et al., 1976), and then aggregated by the six dominant land use classes determined for the project (chaparral/forest, avocado, nursery, greenhouse, residential and commercial). There were six additional minor classes (water, riparian, rangeland, other agriculture, highway, and concrete-lined channel) to complete the survey for the three watersheds in the project area. The distribution of land use by sampling area was tabulated and summarized in Table 2. The larger the percentage of a specific land use within a sub-catchment, the greater its homogeneity and the possibility of identifying a specific nutrient export signal from that land use. The secondary and tertiary land use categories had less nutrient loading potential than the target. The land use class "other agriculture" was typically low impact field crops or orchards. Impervious surface extent was estimated by land use type in accordance with references of comparable land use classes and personal observation (Soil Conservation Service, 1986; USACE, 2000).

Table 2: Land use distribution by percentage for each sampled sub-catchment. Secondary and tertiary land uses were shown for reference. There were three upper basin (chaparral/forest) sites, one on Santa Monica Creek and two on Carpinteria Creek.

Land Use	Area (ha)	Target land use (%)	Secondary land use (%)		Tertiary land use (%)		Impervious (%)
Chaparral/Forest-SM	902	98	1	(riparian)	0	-	0
Chaparral/Forest-CP1	1232	97	2	(riparian)	0	-	0
Chaparral/Forest-CP2	1874	98	2	(riparian)	0	-	0
Avocado	721	49	12	(other agriculture)	9	(residential)	11
Greenhouse	21	92	6	(avocado)	2	(nursery)	79
Nursery	79	35	27	(avocado)	15	(other agriculture)	17
Residential	7	99	1	(other agriculture)	0	-	30
Commercial	40	73	27	(residential)	0	-	70

Distributed rainfall was derived for each sub-basin, the contributing area to any given stream sampling point, as this was the critical input for stream discharge. The process used an interpolation technique that utilized historically based rainfall contours from the Precipitation-Elevation Regression and Independent Slopes Model (PRISM) dataset (Daly et al., 1994; Daly, 1996) and existing rainfall gauging data provided by the County of Santa Barbara and the Santa Barbara Coastal Long Term Ecological Research project (SBC-LTER). The PRISM rainfall contours (isohyets) and derived Thiessen polygons around each gauging station were used to distribute and scale the available data (Figure 2).

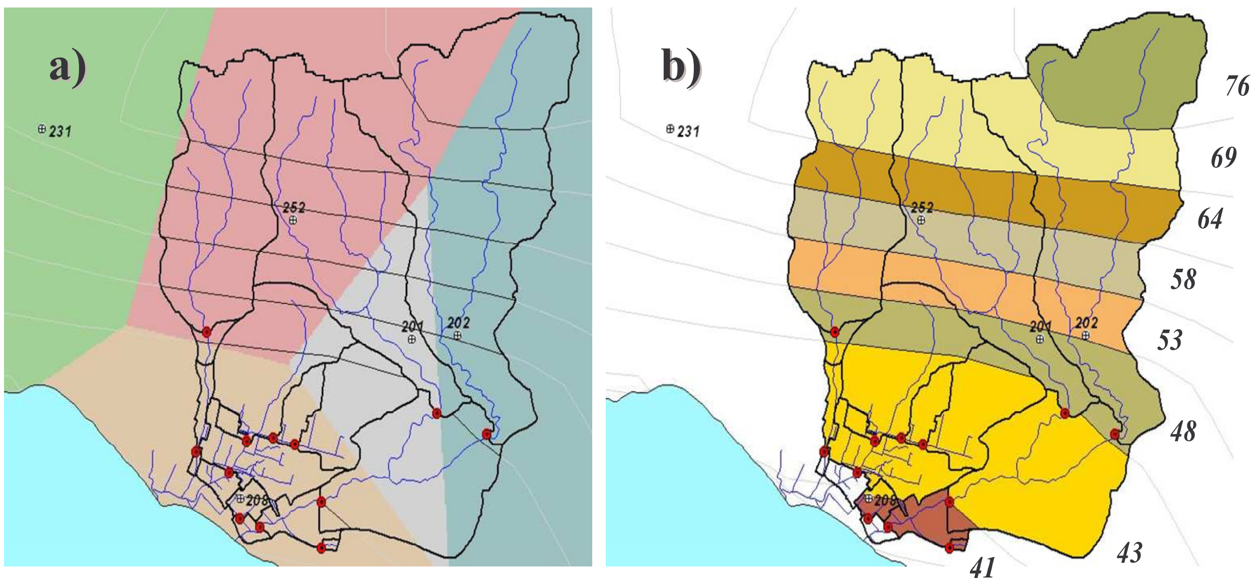

Figure 2: Distributive rainfall for each sub-basin in black were determined using rainfall monitoring stations (numbered sites), a Thiessen polygon distribution (a), and PRISM isohyets in centimeters (b). The red dots are stream sampling sites.

Annual stream discharge, baseflow, and stormflow were calculated for each sampling site in the study area, discharge being the principal driver for nutrient export. As an example, annual runoff for the three watershed is presented in Figure 3. Runoff variability between each site was influenced by catchment size, elevation, soils, land use, and extent of impervious surfaces (Beighley et al., 2003). Water Year 2002 (WY, October first to September 30th) was a drought year with less than 50% of the average annual precipitation (19 cm of the 41 cm long-term 57-year average for the coastal plain) and WY2003 was above normal rainfall at 55 cm. Distributed rainfall amounts for each watershed of the study are shown for comparison.

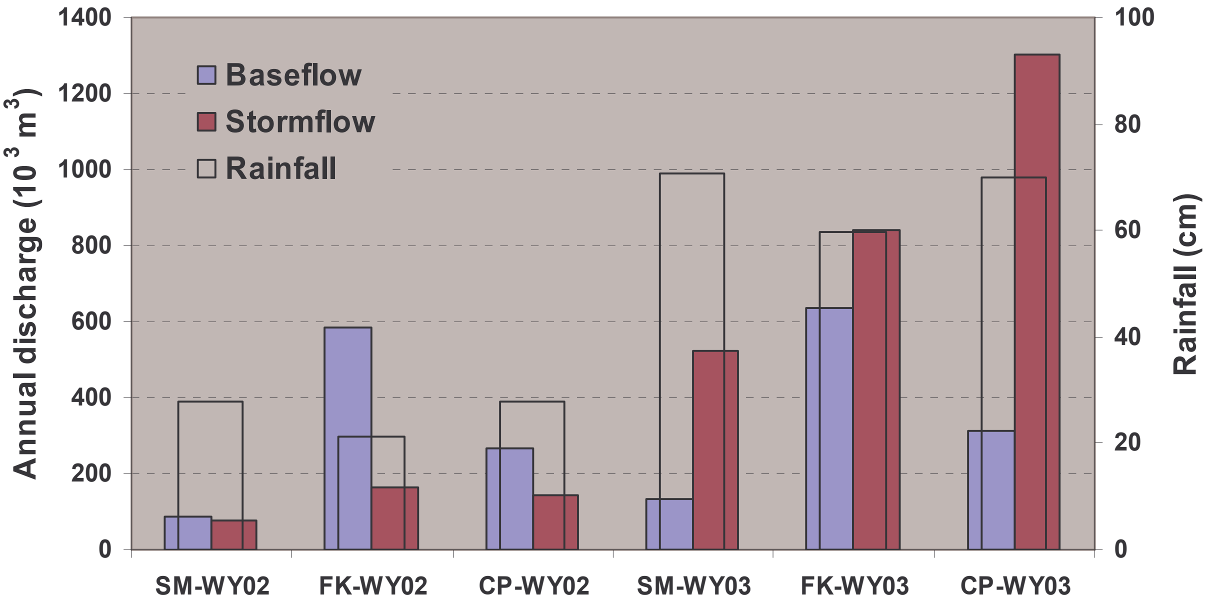

Figure 3: Baseflow and stormflow in thousands of cubic meters at the outlet sites for each watershed in the study area; Santa Monica, Franklin, and Carpinteria creek watersheds. Distributed rainfall in centimeters shows the differences between a drought year and a year with above average precipitation.

Nutrient or fertilizer application rates were determined for each land use class by multiple interviews of landowners or property managers such that an average of fertilization practices could be used in any modeling effort to simulate ambient conditions. This approach was thought to be superior to literature values that would not have been specific to the local climate or land use classes of the project area. Nineteen individual interviews, at least three per land use class, were conducted for the five dominant land use types found in the Carpinteria Valley; the sixth being chaparral/forest. There was a wide variety of fertilization techniques used (granular broadcasting, fertigation, aerial spraying, slow release, mulching) and owners/managers/growers recorded their activities in equally diverse ways (by bags, weight, volume, rows, individual plants, area). Table 3 summarizes the results at a monthly time-step, the minimum reasonable period of time for a highly variable activity. Although this project was focused on nitrogen (N) and phosphorous (P) species, potassium (K) was included in the interview dataset for further research where N-P-K ratios might be needed.

Table 3: Fertilizer application rates by land use class. All values are mass loading per hectare.

LU Class	Nutrient	Product	Annual (kg ha^{-1})	Months of year (kg ha^{-1} mon^{-1}): 1	2	3	4	5	6	7	8	9	10	11	12
Avocado:	Nitrogen (N)	Young (<4yrs)	22	0	0	0	0	3	3	5	3	5	3	0	0
		Mature (>8yrs)	51	0	0	0	0	15	4	11	4	11	4	0	0
	Phosphorous (P)	Young (<4yrs)	2	0	0	0	1	1	0	0	0	0	0	0	0
		Mature (>8yrs)	12	0	0	0	1	8	1	1	1	1	0	0	0
	Potassium (K)	Young (<4yrs)	14	0	0	0	0	1	0	13	0	0	0	0	0
		Mature (>8yrs)	29	0	0	3	3	12	0	11	0	0	0	0	0
Greenhouse:	N	Cut+Potted Flowers	364	33	28	42	32	30	33	30	32	29	25	26	24
	P	Cut+Potted Flowers	216	18	17	17	19	18	18	18	20	18	17	18	18
	K	Cut+Potted Flowers	430	35	34	34	38	37	36	37	40	38	34	34	34
Nursery:	N	General	390	31	28	41	33	33	39	37	39	32	27	25	23
	P	General	104	8	7	8	9	9	10	10	12	9	8	7	7
	K	General	201	12	12	13	19	19	21	23	25	20	15	12	11
Commercial:	N	General	16	1	0	3	2	1	3	0	0	3	2	0	3
	P	General	7	0	0	1	1	0	1	0	0	1	2	0	1
	K	General	10	1	0	1	2	1	2	0	0	2	2	0	2
Residential:	N	General	79	0	0	16	6	10	7	14	6	12	7	0	3
	P	General	28	0	0	6	2	4	3	5	2	4	3	0	0
	K	General	50	0	0	9	4	7	5	8	4	8	5	0	1

We gathered wet atmospheric deposition data for each storm of the water year at several elevations in the study region. Average annual wet deposition loading rates ranged from 0.1-0.2, 0.1-0.4, 0.2-0.7 and 0.03-0.05 kg/ha for ammonium, nitrate, dissolve organic nitrogen and phosphate respectively. Annual average dry deposition loading is usually the largest component of the total annual nutrient deposition in the western United States, decreasing with distance from a large urban center (Fenn et al., 2003). Given the long dry season and the absence of prevailing winds from a large metropolitan area, dry deposition was estimated at twice that of wet annual deposition. More complete atmospheric monitoring data would be needed to better characterize atmospheric nutrient deposition rates, particularly for dry and fog deposition (Fenn et al., 2000).

Stream discharge and chemical data from each sampling site were combined to generate hourly nutrient flux models (Robinson et al., 2002). Table 4 presents annual nutrient export by area. The greenhouse nitrate annual flux was five times higher than at the nursery site and well over an order of magnitude higher for phosphate. The commercial site was four times higher than the residential export for nitrate but showed just the opposite trend for phosphate. Loading from the avocado and chaparral/forest sites were low in general, with greater flux during the second year when there was more upper basin runoff from an above average rainfall year. Annual cumulative nutrient export and discharge varied at each sampling site, for example the greenhouse sub-catchment (Figure 4) with nutrient-rich runoff, a significant amount of impervious surfaces, and a steep storm hydrograph.

Table 4: Annual nitrate and phosphate loading to the streams in moles per hectare for the six land use classes during the two years of the study.

	Greenhouse (kg/ha)	Nursery (kg/ha)	Commercial (kg/ha)	Residential (kg/ha)	Avocado (kg/ha)	Chaparral/Forest (kg/ha)
Nitrate-2002	48	11	3	1	< 1	< 1
Nitrate-2003	80	17	3	1	< 1	< 1
Phosphate- 2002	9	< 1	< 1	1	< 1	< 1
Phosphate-2003	16	< 1	< 1	2	< 1	< 1

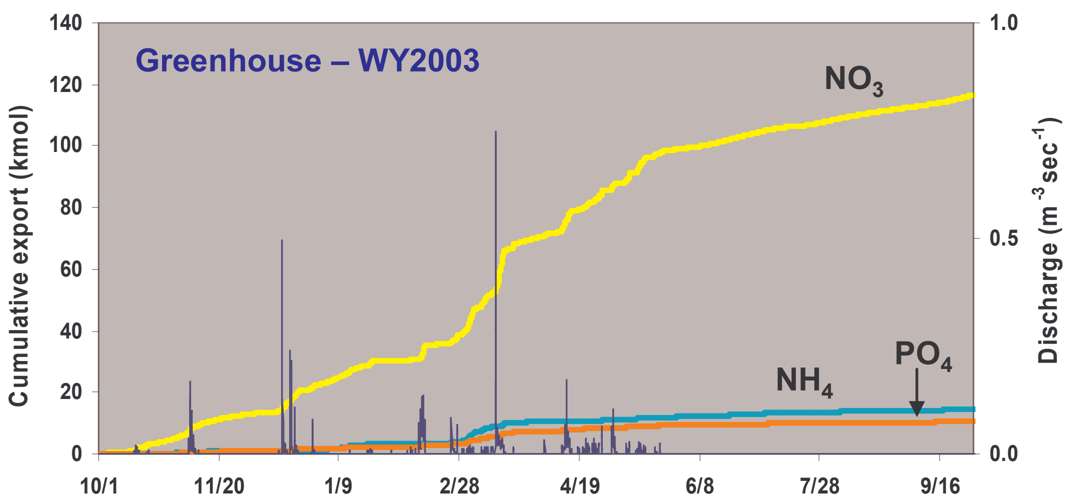

Figure 4: Annual cumulative nutrient flux and discharge for the greenhouse sub-catchment (17 ha) on Franklin Creek from WY2003.

To investigate potential relationships between the chemical and hydrologic response during rainfall events, nitrate and phosphate export from every storm with rainfall greater than 0.25 mm were estimated for the six dominant land use classes in WY2002 and WY2003 (Figure 5). Export was normalized by drainage area and runoff for comparison, and was expressed in g $ha^{-1}mm^{-1}$. Differences in export were discernable between each land use class for WY2002, and were relatively consistent from storm-to-storm with low standard errors. With these identifiable differences, even a simple coefficient model for predicting nutrient export, with no provision for storm intensity or recovery between storms, may prove useful. In general, nutrient export from urban and agricultural land uses were comparatively high, seasonal and event first flush stream chemical signals (the initial storm after an extended dry period either at the onset of the wet season or after a long period between storms) were evident, the length of the antecedent dry period influenced the magnitude of the first flush signal, and the larger the impervious surface extent the more dilute the cumulative storm runoff.

These patterns continued through WY2003, a year with approximately four times the runoff, albeit less distinct specifically for the avocado site. The larger storms of WY2003 led to reductions in nutrient concentrations from the more intensive land uses, while a large end-of-rainy-season storm produced an appreciable increase in nitrate export from upper-catchment chaparral. The storm-to-storm phosphate relationships were an order of magnitude less than nitrate and were not as clear, indicating greater inter-storm variability. However, distinct phosphate export differences between the land use classes were maintained in both years.

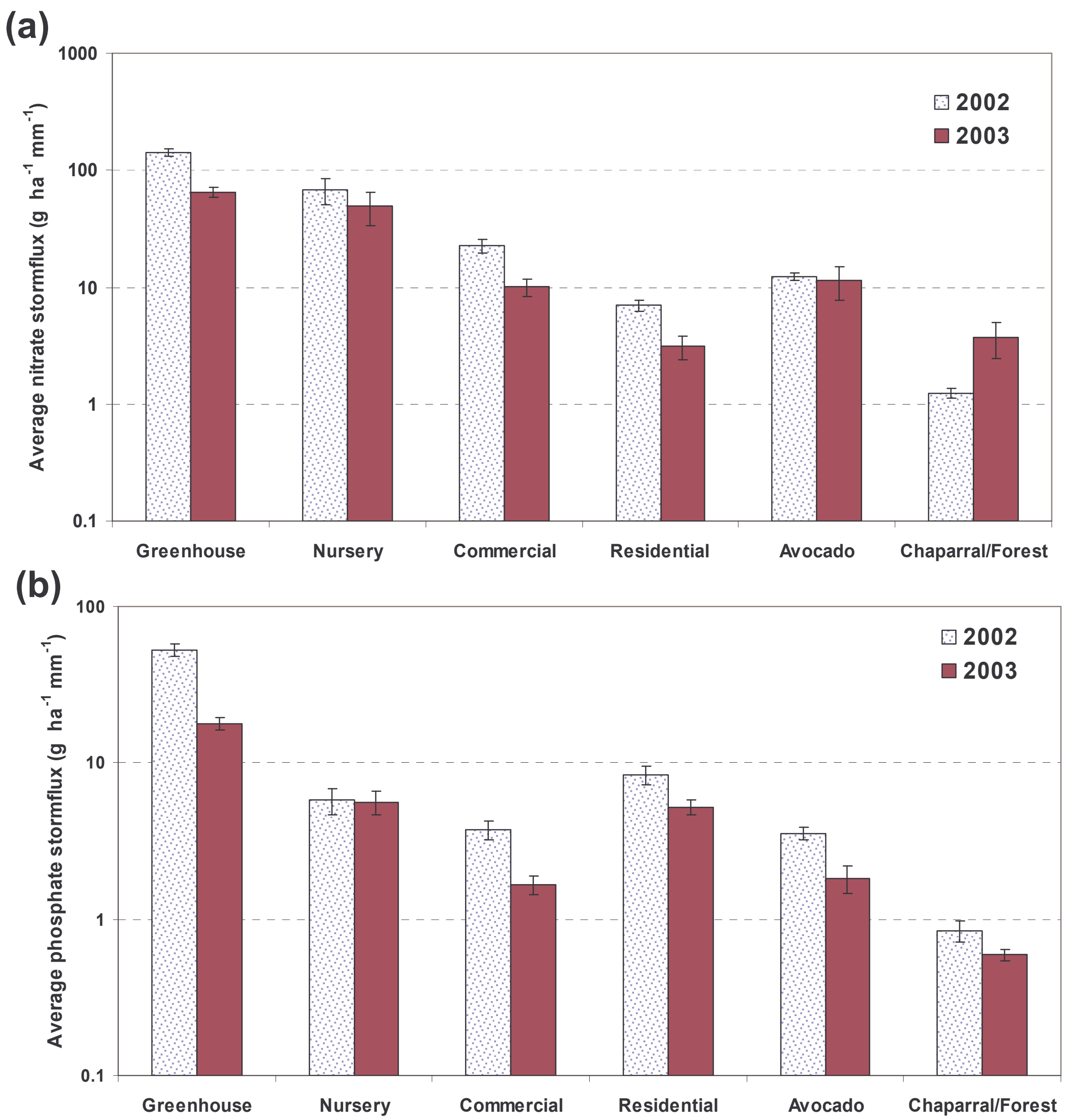

Figure 5: Average (a) nitrate and (b) phosphate storm export for the six principal land uses in WY2002 and WY2003. Export has been normalized for drainage area and runoff, and is expressed in units of grams of N or P per ha per mm of runoff. The error bars indicate the standard error of the storm flux from individual storms.

PRODUCTS

The following is a list of publications, presentations given (speaker, author of a poster, or featured researcher in an educational video (Jason Program)), and outreach conducted in support of the project.

PUBLICATIONS (to date):

Robinson, Timothy H., Al Leydecker, Arturo A. Keller, and John M. Melack. (in press). Steps towards determining nutrient export in coastal California streams with a Mediterranean climate. **Agricultural Water Management**.

Robinson, Timothy H., Al Leydecker, John M. Melack and Arturo A. Keller. 2005. Nutrient Concentrations in Coastal Streams and Variations with Land Use in the Carpinteria Valley, California. California and the World Ocean '02, Revisiting and Revising California's Ocean Agenda, Conference Proceedings. Orville Magoon, Hugh Converse, Brian Baird, Bif Jines, and Melissa Miller-Hessen (Editors). American Society of Civil Engineers. Santa Barbara, California. October, pp 811-823.

Keller, Arturo A., Yi Zheng, and Timothy H. Robinson. 2004. Determining Critical Water Quality Conditions for Inorganic Nitrogen in Dry Semi-urban Watersheds**. Journal of American Water Resources.** American Water Resources Association, Middleburg, Virginia. June, 40(3): 721-735.

Robinson, Timothy H., Al Leydecker, Arturo A. Keller, and John M. Melack. 2003. Nutrient Export Coefficient Modeling in Mediterranean Coastal Streams. VI Inter-Regional Conference on Environment–Water, Land and Water Use Planning and Management, Conference Proceedings. Centro Regional de Estudios de Agua, Universidad de Castilla-La Mancha, Albacete, Spain.

Robinson, Timothy H., Al Leydecker, John M. Melack and Arturo A. Keller. 2002. Nutrient Concentrations in Southern California Streams related to Landuse. Coastal Water Resources, AWRA 2002 Spring Specialty Conference, Conference Proceedings, John R. Lesnick (Editor). American Water Resources Association, Middleburg, Virginia, TPS-02-1, pp 339-343.

PRESENTATIONS:

Speaker: Carpinteria Creek Watershed Coalition annual community meeting. (10/04), "Water Quality Conditions and Forecasts for Carpinteria Creek", Lions' Club, Carpinteria, California.

Speaker: AGU 2003 Fall Meeting (12/03), "Nutrient Flux from Mediterranean Coastal Streams: Carpinteria Valley, California", San Francisco, California.

Speaker: Channel Islands Chapter of the California Native Plants Society monthly seminar (11/03), "Nutrient Loading to Export Coefficient Modeling of Mediterranean Coastal Streams", Santa Barbara Botanical Gardens, Santa Barbara, California.

Poster: Annual Meeting of the American Water Resources Association (11/03), “Nutrient Loading to Export Coefficient Modeling of Mediterranean Coastal Streams”, San Diego, California.

Speaker: LTER Science/Policy Seminar (10/03), “Nutrient TMDL for the Santa Clara River Watershed”, UC Santa Barbara, Santa Barbara, California.

Poster: LTER All Scientist Meeting (9/03), “Nutrient Loading to Mediterranean Coastal Streams and Nutrient Export Coefficient Modeling”, Seattle, Washington.

Speaker: VI Inter-Regional Conference on Environment–Water, Land and Water Use Planning and Management (9/03). Nutrient Export Coefficient Modeling in Mediterranean Coastal Streams. Centro Regional de Estudios de Agua, Universidad de Castilla-La Mancha, Albacete, Spain.

Poster: SBC-LTER Mid-Term Review (6/03), “Nutrient Loading to Mediterranean Coastal Streams and Nutrient Export Coefficient Modeling”, UC Santa Barbara, Santa Barbara, California.

Speaker: Southern California Society of Environmental Toxicology and Chemistry 2003 Annual Meeting (5/03), “Nutrient Loading to Mediterranean Coastal Streams and Nutrient Export Coefficient Modeling”, UC Santa Barbara, Santa Barbara, California.

Poster: Southern California Society of Environmental Toxicology and Chemistry 2003 Annual Meeting (5/03), “Development of a Nutrient TMDL for the Santa Clara River Watershed”, UC Santa Barbara, Santa Barbara, California.

Speaker: Wetlands Restoration Ecology seminar (11/02), “Nutrient Loading in Coastal Streams, Variation with Land Use in the Carpinteria Valley”, UC Santa Barbara

Speaker: Carpinteria Salt Marsh Docents monthly seminar (10/02), “Nutrient Loading in Coastal Streams, Variation with Land Use in the Carpinteria Valley”, Carpinteria

Speaker: California and the Worlds Oceans ‘02 Conference (10/02), “Santa Barbara Coastal Long Term Ecological Research (LTER): Nutrient Concentrations in Coastal Streams and Variations with Land Use in the Carpinteria Valley, California”, Santa Barbara

Speaker: Watershed Science Group Lecture Series (10/02), “Nutrient Loading in Coastal Streams, Variation with Land Use in the Carpinteria Valley”, UC Santa Barbara

Poster: Southern California Wetlands Recovery Project 2002 Symposium (10/02), “Nutrient Concentrations in Coastal Streams, Variations with Land Use in the Carpinteria Valley, California”, Ventura.

Speaker: Coastal Water Resources, American Water Resources Association 2002 Spring Conference (5/02), “Nutrient Concentrations in Southern Californian Streams Related to Land Use”, New Orleans.

Speaker: Santa Barbara Coastal LTER Seminar (5/02), “Nutrient Concentrations in Southern Californian Streams Related to Land Use”, UC Santa Barbara

Poster: University of California Toxic Substances Research & Teaching Program, Annual Symposium (4/02), “Nutrient Concentrations in Southern Californian Streams Related to Land Use”, Long Beach.

Speaker: PhD Seminar (4/02), “Nutrient Concentrations in Coastal Streams, Variation with Land Use in Carpinteria Valley”, Bren School of Environmental Science and Management, UC Santa Barbara.

Presenter: Jason XIV: From Shore to Sea (2/02). Educational Video produced by the JASON Foundation for Education, Needham Heights, Ma.

OUTREACH ACTIVITIES:

The project required community buy-in to obtain property access, volunteers, technical agricultural advice, urban infrastructure location, and stream monitoring equipment installation. The following is a list of activities done to achieve these goals:

- Carpinteria Creek Watershed Coalition (CCWC, committee member since 2001): served on several sub-committees (technical advisor and co-coordinate the “In the Watershed” column for the Carpinteria Coastal View News). The “In the Watershed” column has now run eight articles now from six different UC Santa Barbara researchers; Stu Levenbac, Julie Simpson, Ed Beighley, Al Leydecker (2 articles), Hunter Lenihan, and Tim Robinson (2 articles). I wrote the Hydrology section and contributed/edited the Water Quality section of the Watershed Plan for Carpinteria Creek (one of my research catchments), a large effort to document the environmental state of Carpinteria Creek and to set directives for preservation and restoration.
- Santa Clara River Watershed Monitoring Program: Wrote the Watershed Monitoring Plan and Watershed Program Quality Assurance Project Plan for the Friends of the Santa Clara River, grant recipient from the Regional Water Quality Control Board to monthly monitor water quality in the river. SBC-LTER will be collaborating with this effort to gather nutrient flux data throughout the watershed.
- Santa Barbara Channel Keepers: assist in their monthly sampling effort on the Ventura River as well as Santa Barbara County Snap Shot Sampling Day (5/04).
- Regional Water Quality Control Board (Summer and Fall, 2003): served on the technical review panel of the Agricultural Waiver and Stream Monitoring Program.
- Santa Barbara Channel Keepers: assist in their monthly sampling effort on the Ventura River as well as Santa Barbara County Snap Shot Sampling Day.
- UC Santa Barbara Research Mentorship Program (Summer, 2003): mentored a student working on water quality issues here in the Santa Barbara area.

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APPENDIX A

PARTICIPANTS

There were many participants in this project. Most were stream samplers (marked Samplers) who would take water quality samples at all hours of the day and night. Other participants were UC Santa Barbara analytical laboratory staff and field technicians (marked UCSB). All have been listed by Water Year (October-September).

Water Year 2000-2001 (October-April)
Tim Robinson (UCSB)
Al Leydecker (UCSB)

Water Year 2001-2002 (October-April)
Don Risdon (sampler)
Al Clark (sampler)
Suzanne Lieberman (sampler)
Lisa Killion (sampler)
Darcie Goodman (sampler)
Andrew Nimmer (sampler)
Cheryl Powers (sampler)
Andre Barkley (sampler)
Dale Zurawski (sampler)
Tim Robinson (UCSB)
Allen Doye (UCSB)
Frank Setaro (UCSB)
Scott Coombs (UCSB)
Al Leydecker (UCSB)

Water Year 2002-2003 (October-April)
Don Risdon (sampler)
Diane Talgo (sampler)
Wendy Stanford (sampler)
Lisa Killion (sampler)
Tim Richards (sampler)
Josh Malman (sampler)
Vera Bensen (sampler)
George Johnson (sampler)
Darcy Aston (sampler)
Betty Songer (sampler)
Tom Glasgow (sampler)
Andre Barkley (sampler)
Carl Stucky (sampler)
Cheryl Powers (sampler)
Tim Robinson (UCSB)
Allen Doye (UCSB)
Frank Setaro (UCSB)
Scott Coombs (UCSB)
Al Leydecker (UCSB)