Title

Land Use and Water Quality on California's Central Coast: Nutrient Levels in Coastal Waterways

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Publication Date
2003

The CENTER for AGROECOLOGY & SUSTAINABLE FOOD SYSTEMS
UNIVERSITY OF CALIFORNIA, SANTA CRUZ | RESEARCH BRIEF #2, WINTER 2003

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Research Brief #2

Land Use and Water Quality on California's Central Coast: Nutrient Levels in Coastal Waterways

An increased focus on addressing nonpoint source (NPS) pollution[1] throughout the U.S. has raised awareness of agriculture's impact on water quality. Growers are being asked to voluntarily limit the effects of their operations on adjacent waterways through programs such those initiated by county Farm Bureaus. If pollution cannot be voluntarily controlled, growers may face mandatory regulatory actions in the future.

Maintaining water quality is an ongoing challenge in the Monterey Bay watershed, where industry, urban development, and farming all affect sensitive waterways. Excess nitrogen and phosphorous, herbicides, insecticides, and sediments that end up in sloughs and wetlands surrounding Monterey Bay have compromised water quality, contaminated shellfish, birds, and other wildlife, and generated unsafe levels of nitrate in drinking water.

Although nutrient contamination is well recognized, to date there have been few efforts to link water quality with land uses such as urban development and farming in the region. To determine the way that land uses affect nitrogen and phosphorous concentrations in central coast waterways, researchers Marc Los Huertos, Lowell Gentry, and Carol Shennan have monitored water flow and sampled water quality in the Pajaro River and in other Pajaro Valley and Elkhorn Slough watershed creeks and agricultural drainages, for the past two water years (October 2000–September 2002). The research takes place through the UC Santa Cruz Center for Agroecology and Sustainable Food Systems (the Center) and is part of a larger U.S. Department of Agriculture grant awarded to Center director Shennan (see box, next page). This water quality monitoring program was developed in cooperation with the Santa Cruz County Farm Bureau, local Resource Conservation Districts, and other groups (see box, page 4).

We are particularly interested in the concentrations of two nutrients, nitrogen (nitrate-N) and phosphorus (ortho-P, also known as soluble reactive phosphorus), that are components of non-point source (NPS) pollution originating from urban and agricultural land uses. What are reasonable concentrations of these nutrients? The drinking water standard for nitrate-N is 10mg/L (ppm). Higher levels are considered a human health risk.

Even at levels well below the drinking water standards, nitrate can adversely affect ecosystem function. Elevated nitrate levels can lead to harmful "blooms" of algae and other plants that eventually starve wildlife of the light and oxygen they need. No numeric drinking water standard has yet been set for ortho-P, but even low concentrations (0.1 ppm) can result in algal blooms, thus compromising ecosystem quality.

Nitrogen and phosphorous fertilizers are used extensively in the watersheds' row crop operations. Our results show that the concentrations of these nutrients increase as waterways pass through agricultural areas—the first clear evidence collected in this region that agricultural activities are an important source of nutrient contamination.

One goal of this research is to inform the agricultural community of current conditions so that they can decide what steps should be taken to reduce agriculture's impact on water quality while continuing to farm profitably. We also work with growers to develop practices designed to decrease nutrient runoff from their farms. In this research brief, we present nitrate and phosphorous concentration data collected during the 2000-01 and 2001-02 water years for Corralitos Creek, the Pajaro River, and Watsonville Slough.

PROCEDURES

We collected water samples twice weekly at 35 sites located throughout the Pajaro River and Elkhorn Slough watersheds. These sites were selected to target major water sources of the Monterey Bay that have important consequences for wetland and near-shore habitat. In addition to biweekly sampling, several locations were sampled more frequently to capture storm event variability. For brevity we report data for sampling sites on Corralitos Creek, the Pajaro River, and Watsonville Slough. Results from these sites demonstrate the overall patterns observed throughout the watersheds.

CORRALITOS CREEK

We sampled Corralitos Creek at Las Colinas, Brown Valley, Varni, and Green Valley Roads, and below the confluence on Salsipuedes Creek at Highway 129. The watershed above Las Colinas Road is dominated by redwood forest; sampling there showed very low nitrate-N concentrations (<0.1 ppm). As Corralitos Creek passes through orchards and areas of vegetable production, nitrate-N concentrations increased at Green Valley Road, where a high of 7.7 ppm was recorded in May 2001 (Figure 1). This nitrate increase between Las Colinas and Browns Valley is likely due to agricultural sources, but domestic septic systems may also contribute N.

Below Green Valley Road, nitrate concentrations increased dramatically. This increase occurs below the point where Corralitos Creek drains into College Lake (the source of water in Salispuedes). A nitrate reading of 20.4 ppm in July 2002 suggests that the intensive agricultural operations upstream of our sampling site contributed to high nitrate concentrations via irrigation runoff.

Phosphorous concentrations (reported as ortho-P) were unexpectedly high at Las Colinas Road, a site with little adjacent disturbance from human activities. Concentrations above 0.05 are rare in undisturbed waterways, thus we were surprised to find concentrations that were often above 0.1 ppm (Figure 2). Samples taken at Green Valley tend to be lowest in ortho-P, with levels increasing at sites downstream of College Lake. This increase may reduce water quality in the creek, but seems relatively minor in comparison to the concentrations at the Las Colinas Road site. In future work we will be investigating why the headwaters of Corralitos Creek, which originate in an undeveloped forest (redwood/oaks), have relatively high ortho-P concentrations.

PAJARO RIVER

The Pajaro River is one of the most important waterways entering the Monterey Bay. It provides a critical wildlife corridor and a migration route for steelhead. Water from the Pajaro River also seeps into the Pajaro Valley's porous creek and river channels and is an important source of groundwater recharge.

Research on water quality and ways of decreasing nonpoint source pollution from the region's farms is part of the Center's Central Coast Research Project, an effort funded by the US Department of Agriculture. The project explores ways to improve the sustainability of the food and agricultural system on the California central coast. Also included in the Central Coast study is research on food systems and alternative food initiatives.

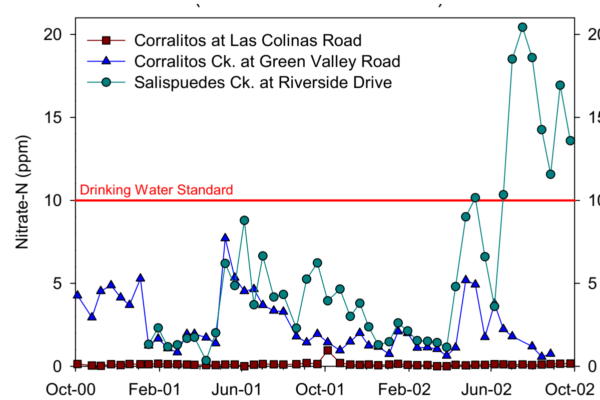

Figure 1. Nitrate-N concentrations in Corralitos and Salsipuedes Creeks, 2000-2002 water years.

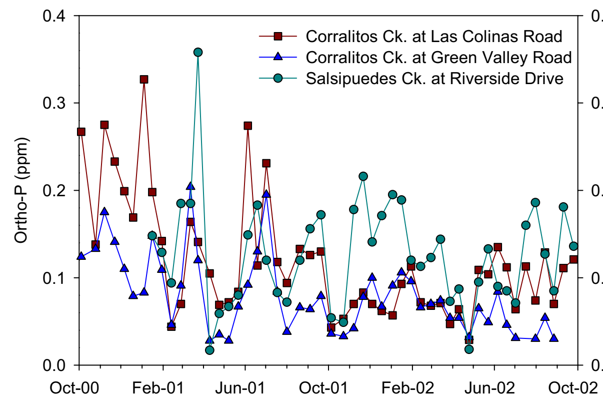

Figure 2. Ortho-P concentrations in Corralitos and Salsipuedes Creeks, 2000-2002 water years.

By the time the Pajaro River enters the Pajaro Valley from Santa Clara and San Benito Counties it carries relatively high amounts of nitrate-N. Through the 2000-01 water year, the average nitrate-N concentration at Chittenden Gap, several kilometers upstream of the Pajaro Valley, was 6.2 ppm and 6.8 ppm in 2001-02. As rainfall ceased, nitrate concentrations at the Chittenden Gap increased each year to peak in late summer or early fall (20.4 ppm nitrate-N in August 2001 and 25.2 ppm in September 2002; Figure 3).

Nitrate concentrations generally declined as the Pajaro River passed Murphy's Crossing (Figure 3). Nitrate concentrations declined at the Main Street sampling site as well, in part because this site is downstream of the confluence of the Pajaro River and Salsipuedes Creek, which generally has a lower nitrate level and hence a diluting effect on the Pajaro River. Water flowed throughout the year at Chittenden and at Main Street in Watsonville, but the riverbed went dry in July at Murphy's Crossing (a point approximately half way between Chittenden and Main Street), and did not resume flow before the end of the water year. During low flow periods, the nutrient concentrations at Main Street become uncoupled from the Pajaro River

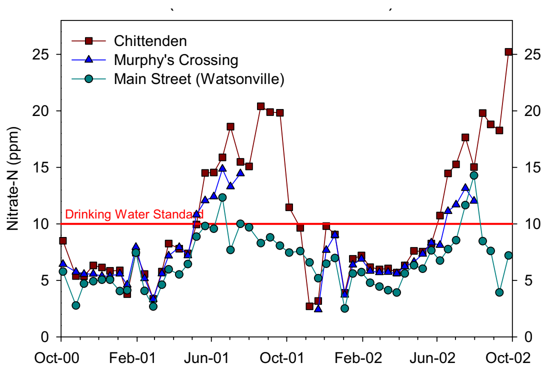

Figure 3. Nitrate-N concentrations in the Pajaro River, 2000-2002 water years.

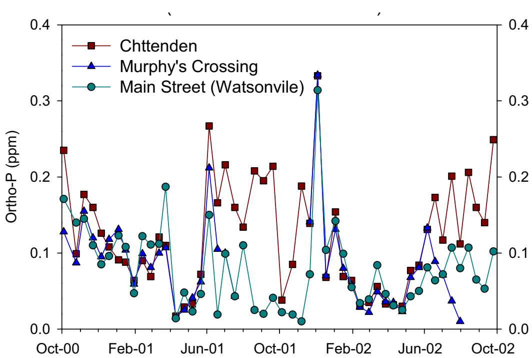

Figure 4. Ortho-P concentrations in the Pajaro River, 2000-2002 water years.

and are dependent on Salsipuedes Creek. A similar pattern occurred for ortho-P concentrations between sites (between 0.5 and 0.35), but as with Corralitos Creek, seasonal patterns of nutrient concentrations were not detected (Figure 4).

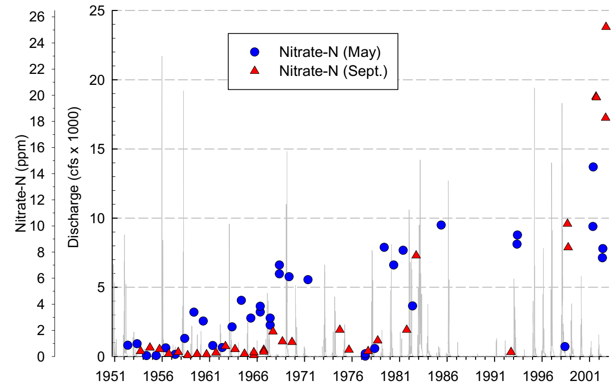

Figure 5. Rates of water flow (represented by gray lines) and nitrate concentrations in the Pajaro River at Chittenden Gap, 1951–2001.

Flow levels of the Pajaro River at Chittenden Gap have been measured for many years, and in addition to our work over the past two years, water quality has been measured there by several agencies. Although sampling has been sporadic and it is difficult to determine trends in water quality with any certainty, our analysis of previously collected data along with the results we recorded indicate changes in the seasonal patterns of nitrate increases. Nitrate concentrations measured in September and May have generally increased each year (Figure 5). Low nitrate levels were recorded on several May sampling dates, but these seem to occur during drought periods when the watershed's creeks are nearly dry and did not reach the Pajaro River. However, during the 1950s and 1960s, nitrate concentrations were highest in May, but no concentration increases in September were observed.

WATSONVILLE SLOUGH

We sampled several locations on Watsonville Slough as it passes through surrounding agricultural fields. Nitrate-

Table 1. Average bi-monthly Nitrate-N concentrations (ppm) in Watsonville Slough (average concentrations from 2 samples per month). (NS=not sampled).

Location	Oct 2000	Dec 2000	Feb 2001	April 2001	June 2001	Aug 2001	Oct 2001	Dec 2001	Feb 2002	April 2002	June 2002	Aug 2002
Errington Road	0.4	0.5	0.8	<0.1	0.4	<0.1	1.1	1.2	0.2	0.5	0.5	0.1
Lee Road	22.6	3.4	3.6	4.2	21.1	15.4	10.1	3.8	3.0	7.1	9.3	14.5
RR tracks	5.5	2.3	2.2	2.0	13.0	10.1	0.5	16.0	4.1	0.8	7.4	0.3
San Andreas Road	13.3	16.0	4.1	2.0	3.0	17.4	20.8	31.9	3.3	8.6	21.1	23.2
Shell Road	20.3	22.3	9.4	6.8	6.5	23.2	27.7	42.2	5.2	17.7	31.4	27.8

Table 2. Average bi-monthly Ortho-P concentrations (ppm) in Watsonville Slough (average concentrations from 2 samples per month). (NS=not sampled).

Location	Oct 2000	Dec 2000	Feb 2001	April 2001	June 2001	Aug 2001	Oct 2001	Dec 2001	Feb 2002	April 2002	June 2002	Aug 2002
Errington Road	0.35	0.18	0.19	0.04	0.16	0.16	0.08	0.69	0.27	0.38	0.24	0.05
Lee Road	0.12	0.17	0.21	0.05	0.10	0.06	0.04	0.65	0.23	0.19	0.14	0.17
RR tracks	0.16	0.18	0.48	0.45	0.41	0.31	0.12	NS	0.61	0.48	0.51	0.59
San Andreas Road	0.13	0.16	0.35	0.36	0.10	0.07	0.03	0.65	0.40	0.24	0.14	0.19
Shell Road	0.17	0.22	0.45	0.34	0.14	0.11	0.08	0.70	0.37	0.24	0.07	0.10

N concentrations were low at the upstream location at Errington Road but increased downstream at Lee Road (Table 1). High levels were also found at San Andreas Road and Shell Road—both in areas of agricultural activity—suggesting an agricultural source.

Ortho-P concentrations were relatively high in the slough even at Errington Road (Table 2). They generally decline at Lee Road because of dilution from another water source, then increase again farther downstream due to agricultural activity. The highest concentrations occurred during December 2001. The city of Watsonville also appears to be an important source of ortho-P during that time; although the specific source is not clear, it may include runoff from food processing facilities, streets, or gardens.

At times Watsonville Slough contained nitrate concentrations that exceeded the drinking water standard (10 ppm), which may have a significant impact on the health of the slough ecosystem. For example, the dissolved oxygen content in the summer months dropped below critical support levels for aquatic organisms, a condition that may be caused by high nutrient concentrations in the water column. Water velocity is generally low in the slough and there are several sources of water, including Struve Slough, West Branch, Hanson Slough, and Harkins Slough, all of which make identifying the specific sources of nutrients difficult.

SUMMARY

The dominance of agriculture and the locations of our sampling sites leave little doubt that agricultural practices are a major source of the elevated nutrients recorded at each stream sampled. The nutrient concentrations justify actions that farmers have already taken to improve water quality. Nutrient concentrations at the levels we found may lead to possible health hazards for humans and damage aquatic ecosystems.

The major source of nitrate in the Pajaro River is from the upper part of the watershed—Santa Clara and San Benito Counties—that also encompass major agricultural areas. Nutrient concentrations do increase, however, as waters pass through agricultural areas in the Pajaro Valley. Watsonville Slough has very high nutrient concentrations as agricultural drainage water enters the slough.

There are a number of questions that need to be addressed to help growers respond to data such as these. One interesting facet has been the change in seasonality of the high nitrate concentrations. In the 1950s and 1960s, the highest concentrations were found in May, while more recently we have found that the highest nitrate levels occur in the fall, usually in September. We do not know why this change in seasonality has occurred; it may be related to changes in crops or management practices, but we hope to address this question in the next several years.

In addition, the relationship between groundwater and surface waters plays a central role in how agricultural water moves. Water, either from irrigation or precipitation, infiltrates the soil to varying degrees depending on numerous conditions. Some of this infiltrated water moves into unconfined aquifers while some moves laterally and reemerges in surface water. Understanding the patterns of flow between surface and groundwater, and the nutrient levels in both water sources, is critical for development of appropriate pollution control strategies. We will be testing different management strategies over the next few years

By better understanding the major factors that affect nutrient concentrations in streams, we can develop realistic goals and management options that growers may use to protect water quality and continue producing the high quality products for which the central coast is noted.

– Marc Los Huertos, Lowell Gentry, Carol Shennan

[1] *Nonpoint source pollution refers to pollution that occurs when water runs over land or through the ground, picks up pollutants, and deposits them in surface waters or introduces them into groundwater.*

WATER QUALITY PROTECTION—A COOPERATIVE EFFORT

This water quality project has been developed in collaboration with many groups in a larger effort by the central coast farming community. Many of the sample locations were chosen in collaboration with the Santa Cruz County Farm Bureau and we are working with them on ways to communicate the results to their members. Other groups involved in the project include:

- Agricultural Land Base Association (ALBA)
- California State University Monterey Bay
- Community Alliance with Family Farmers
- Elkhorn Slough Foundation
- Natural Resource Conservation Service
- Resource Conservation Districts
- UC Santa Cruz Earth and Marine Sciences Department

In several watersheds, growers have united to form watershed working groups; for these groups our results will provide some of the baseline data for their activities. Finally, we are providing research results and technical expertise to the recently formed Agricultural Water Quality Alliance (AWQA) partners. This is a consortium made up of government agencies, Farm Bureaus, UC Cooperative Extension, and the National Marine Sanctuary, formed to implement a voluntary program to address water quality in the six counties with watersheds that empty into the Monterey Bay Sanctuary.

The Center for Agroecology & Sustainable Food Systems (CASFS) is a research, education, and public service program dedicated to increasing ecological sustainability and social justice in the food and agriculture system. Located at the University of California, Santa Cruz, CASFS collaborates with growers, researchers, policy makers, non-governmental organizations, and others on research projects to promote sustainable farming and food systems. This Center Research Brief is part of a series reporting on CASFS research efforts. For more information on the researach covered in this Brief, or on the Center's activities, contact us at CASFS, 1156 High St., University of California, Santa Cruz, CA 95064, 831.459-3240, www.ucsc.edu/casfs.