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Socioeconomic Factors and Water Quality in California

By **Y. Hossein Farzin**, Department of Agricultural and Resource Economics, University of California

Kelly A. Grogan, Food and Resource Economics Department, University of Florida

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By Y. Hossein Farzin, Department of Agricultural and Resource Economics, University of California
Kelly A. Grogan, Food and Resource Economics Department, University of Florida

Summary

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Keywords: Water Quality Indicators, Socioeconomic Variables, EKC, Agriculture, Industry

JEL Classification: Q53, Q56, Q58, C23

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Address for correspondence:

Y. Hossein Farzin
Department of Agricultural and Resource Economics
University of California
Davis CA 95616
USA
E-mail: farzin@primal.ucdavis.edu

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Y. Hossein Farzin*

Department of Agricultural and Resource Economics
University of California, Davis, CA 95616, U.S.A.
farzin@primal.ucdavis.edu

and

Kelly A. Grogan

Food and Resource Economics Department
University of Florida, Gainseville, FL 32611, U.S.A.
kellyagrogan@gmail.com.

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Abstract

We investigate the relationships between water quality and socioeconomic factors in California at the county level for the years 1993 to 2006 using 24 water quality indicators coming from seven different types of water bodies. We estimate these relationships using three classes of models: the traditional per capita income-pollution level -Environmental Kuznets Curve (EKC)-specifications, a more inclusive model containing main socioeconomic variables such as agricultural intensity, land use, ethnic composition, population density and educational attainment, and a model that includes the socioeconomic variables while accounting for spatial correlations too. For most water quality indicators, we do *not* find support for EKC specifications. For pollutants like phosphorus and total suspended solids, the level of agricultural activity is a significant determinant of water quality in California, but for other surface water pollutants commonly considered agricultural pollutants, such as ammonia and nitrate, the level of agricultural activity is *not* statistically significant. We find that education, ethnic composition, age structure, land use, population density, and water area are all significantly correlated with various indicators of water quality.

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Socioeconomic Factors and Water Quality in California

1. Introduction

As in many parts of the world, clean water is a vital, but threatened, resource in California. The results of a U.S. EPA assessment of water quality in California in 2004 found that: (1) about 93% of the state's water is "impaired," a term that means the body of water cannot be used for at least one of its designated uses (these uses may include recreation, commercial fishing, agricultural water supply, drinking water supply, and wildlife habitat, among others), (2) about 5% of assessed water bodies are "threatened," indicating that there is a high probability that their designated uses will no longer be viable in the future, and (3) only about 3% of the water bodies assessed in the state are labeled good enough to be used for all of their designated uses with none of these uses threatened (U.S. EPA, 2004). Table 1 in the Appendix outlines common sources of a variety of water pollutants. Many different causes underlie these impairments, including factors related to agriculture, industry, households, and natural processes. The objective of this paper is to test hypotheses (discussed in detail in section 2) regarding the per capita income-pollution level (EKC) and several key socio-demographic-geographic factors affecting the quality of surface water in California. To test these hypotheses, we estimate statistical relationships between potential factors affecting water pollution and water quality indicators at the county level.

To date, little work has been done to identify the key factors affecting California water quality. Charbonneau and Kondolf (1993) argued that development in California tends to occur on prime agricultural land, pushing agricultural production onto more marginal lands and increasing the pollution resulting from agriculture. However, they did not have data to test their hypothesis. Byron and Goldman (1989) examined land use and water quality in the Lake Tahoe region. They considered. They found significant, positive relationships between nitrogen, total phosphorus, and suspended solids and the percentage of highly erodible land disturbed or covered by human activity. Their study, however, could not determine which human activities are more important in determining water quality. A study by Dwight et al. (2002) estimated the effects of urban river discharge on bacteria levels in ocean water on southern California beaches and found that this discharge and precipitation levels are strongly associated with bacteria levels.

A plethora of studies have tested the existence of the environmental Kuznets curve. The EKC theory posits that as income initially increases, environmental quality declines, but after a certain per capita income level, quality begins to and continues to improve as income increases. This relationship may occur because water quality is a normal good and as income increases, people demand more water quality (Grossman and Kruger, 1995). It may also occur because as areas get wealthier, they can invest in more pollution control technology (Nahman and Antrobus, 2005). Similarly, as income increases, the composition of aggregate production tends to shift from polluting industries like agriculture and industry to less polluting services, while importing goods whose polluting production processes take place elsewhere (Grossman and Kruger, 1995; Aldy, 2005). Furthermore, technological advances in production and pollution abatement, tightening of quality standards, and improvements in monitoring and enforcement of standards over time can all result in better water quality. While the macro level factors driving the environmental Kuznets curve hypothesis will not hold at the state-level, it is possible that even within the state of California, wealthier communities demand better water quality and have more resources to implement pollution abatement.

Four studies test for the environmental Kuznets curve for water quality or use within one state. Franczyk and Chang (2009) use OLS and spatial regression models to estimate the effects of income, precipitation, temperature, urban development, and farm and family size on water use at the county level in Oregon. They find a negative relationship between income and water use, but the effects of temperature and precipitation are larger in magnitude. They also conclude that OLS (Ordinary Least Squares) estimates are biased due to spatial correlation across counties. Paudel et al. (2005) and Paudel and Schafer (2009) test the effects of income and social capital, respectively, on water quality in parishes in Louisiana. Paudel et al. account for spatial effects by including the average level of income in surrounding parishes and find evidence of an environmental Kuznets curve relationship for concentrations of nitrogen, phosphorus, and dissolved oxygen. Paudel and Schafer employ a spatial autoregressive model containing an index of social capital and control for population density. They find a U-shaped relationship between nitrogen concentrations and the social capital index but find no relationship between concentrations of phosphorus or levels of dissolved oxygen and social capital. Gergel et al. (2004) use sediment records from Lake Mendota in Dane County Wisconsin to estimate historical levels (1900 – 2000) of phosphorus, cadmium, chromium, copper, lead, and sulfur and regress these levels on linear, quadratic, and cubic specifications of real wealth per capita. Only chromium exhibits a robust EKC relationship.

Our study is the first to consider water quality across the entire state of California and to examine a wider range of socioeconomic factors than those considered in previous studies. It includes water quality and socioeconomic data at the county level for the years 1993 to 2006. The water quality data cover 24 water quality indicators coming from seven different types of water bodies such as rivers, lakes, and estuaries. We estimate the relationship between these water quality indicators and the socioeconomic variables using three classes of models: the traditional EKC specifications, a more inclusive model containing a variety of socioeconomic variables, and a model that includes the socioeconomic variables while accounting for spatial correlation.

Our study goes beyond examining the effects of purely economic factors such as income and sectoral economic activities. It also investigates important questions such as: Is California agriculture the main culprit of the state's water pollution? Do California ethnic minorities (non-Caucasians) suffer from lower water quality than the white population? Do California counties with a better educated population enjoy better water quality? How are socio-demographic factors, such as population age and gender, and geographic considerations, such as water body types and adjacent county economic activity, correlated with indicators of water quality? Some of our empirical findings run counter to common intuition. For example, with the exception of ammonia, copper, and fecal coliform, we do not find support for the EKC relationship between per capita income and pollution for our California water indicators. Nor do we find support for the common presumption that agricultural activity is the principal culprit of some water pollutants normally associated with agriculture, such as nitrates, sulfates, ammonia, and copper. Perhaps surprisingly, we also find that for water quality indicators, such as cadmium and copper, some ethnic minorities, such as Native Americans and African Americans, experience better water quality than Caucasians do. Further, we do not find empirical support for the view that a population with a higher share of females enjoys better water quality than one with a higher male share.

The rest of the paper is organized as follows. Section 2 presents our water quality hypotheses to be tested and the data with which we test these hypotheses. Section 3 presents the three sets of empirical estimation models. In section 4, we present and discuss the estimation results. Conclusions are presented in Section 5.

2.1 Hypotheses

This paper tests three sets of hypotheses. First, we test the environmental Kuznets curve hypothesis so see whether a relationship exists between income and water quality at the county level in California. Since previous studies of the environmental Kuznets curve find turning points, if they exist, at per capita income levels below the per capita income levels of California counties, we may not find statistically significant relationships. However, if the Kuznets curve is, indeed, U-shaped and not a higher order polynomial, we should still find a positive relationship between income and water quality within our relatively wealthy sample.

The second set of hypotheses focus on the following socioeconomic and physical variables that may influence water quality:

- *Agriculture*: We suspect that those areas with higher intensity of agricultural production will have higher levels of agricultural pollutants.
- *Education*: Communities with high education levels and a higher valuation of education may be environmentally better informed and better understand the implications of water pollution, and consequently, counties with higher educational attainment may have better water quality

than those counties with lower educational attainment. This would be consistent with the findings of Farzin and Bond (2006).

- *Ethnic composition*: Several reasons exist why we might find negative relationships between minority ethnic groups and water quality. First, some ethnic groups may value the environment less than others, and consequently, demand less water quality improvement from their governments. Second, some ethnic groups with low per capita income may have a stronger preference for meeting basic needs than for improving water quality. Similarly, these ethnic groups may be more prominently employed by polluting industries, and consequently must also reside in these areas. Lastly, racism may play a roll in the placement of polluting industries or toxic wastes in areas predominantly occupied by minorities (Brulle and Pellow, 2006).
- *Gender composition*: Some work (e.g. Konisky et al., 2008; Fukukawa et al., 2007) suggests that women tend to care more about the environment than men, so we might find a negative correlation between the percent of a county that is male and water quality.
- *Water acreage*: If there are economies of scale in water pollution control (that is, the average cost of pollution control decreases with the quantity of water controlled for pollution) then counties with a large quantity of water may have better water quality. Conversely, if pollution control gets increasingly difficult and hence more expensive as water acreage increases, counties with a large quantity of water may have poorer water quality than those counties with smaller water acreage.
- *Types of water bodies*: Pollutants likely accumulate or, conversely, flush out of different types of water bodies differently. Ideally, we would allow for separate relationships between water quality and the socioeconomic variables for each type of body of water. However, too few variables exist for some pollutants and body of water types to perform this kind of analysis, so we include dummy variables instead.
- *Spatial correlation*: Lastly, we hypothesize that spatial correlation of water quality and socioeconomic variables exists across counties in California. For example, watersheds in

California do not follow county boundaries, so agricultural runoff containing nitrates or phosphates will likely make its way across county boundaries. Additionally, rivers directly connect the water quality of neighboring counties, and the water quality of upstream counties will directly affect the water quality of downstream counties.

2.2. Water Quality Data

Table 2 presents the summary statistics for water quality indicators. The water quality data for the study come from the EPA's Storage and Retrieval (STORET) database. This database collects water quality data from a wide variety of state and federal sources such as the California Department of Water Resources, the EPA National Aquatic Resource Survey, the California Surface Water Monitoring Program, the California State Water Resources Control Board, and the National Park Service. Due to the heterogeneity of sources, the sampling procedures may differ, increasing the random noise in the dataset. The data also do not represent a completely random sample, as one would hope to have. Sources may sample for a variety of reasons including monitoring potentially hazardous sites, monitoring already hazardous sites, or simply keeping an eye on water quality. As a result, poor quality sites may be overrepresented in the sample and high quality sites underrepresented.

Table 2: Summary Statistics for Water Quality Indicators

Pollutant	Units	Observations	Median	Standard Deviation
Ammonia	ug/l	95	0.00	0.08
Arsenic	ug/l	68	1.54	9.38
Cadmium	ug/l	81	0.0005	4.27
Chromium	ug/l	68	0.18	18.49
Copper	ug/l	96	2.02	42608.04
Dissolved Oxygen	mg/l	215	8.5	2.54

Fecal Coliform	cfu/100ml	56	10	719.80
Iron	ug/l	51	110	4886.97
Lead	ug/l	67	0	3.77
Magnesium	ug/l	55	3500	188152.20
Manganese	ug/l	65	22.23	201.50
Mercury	ug/l	56	0.48	7.09
Nickel	ug/l	58	1.91	21.05
Nitrate	ug/l	117	0.06	1.86
Nitrite	ug/l	68	0	2.43
pH		254	7.87	1.55
Phosphorus	mg/l	69	0.00	0.23
Selenium	ug/l	128	1	70.69
Specific Conductivity	S/cm	444	208	11883.52
Sulfate	mg/l	103	5	16028.32
Total Coliform	cfu/100ml	38	63.50	6083.08
Total Suspended Solids	mg/l	148	2.77	13420.28
Zinc	ug/l	53	2.29	222925.4

Source: Author's calculations based on: Environmental Protection Agency. *STORET Data Warehouse.* Available <http://www.epa.gov/storet/dw_home.html>.

Water quality levels that were recorded as "non-detect" and "present<QL," where "QL" means "quantifiable limit," in the STORET database were entered as zeros in our dataset, which may underestimate the amount of water pollution. Samples for which the water quality level was entered as "present>QL" in the STORET database were dropped since this classification provides no useful information. Only a small number fell into this final category. Each sample in the STORET database represents one water sample that was taken from a specific location. Since most of the socioeconomic data is available at the county level, all samples were aggregated up to the county level by water body type and pollutant. For example, if county x had fifteen samples of nitrate levels in rivers, the median of these 15 samples was calculated. Similarly, if county y had 32 samples of fecal coliform levels in lakes, the median of these 32 samples was calculated. Each observation in the analysis that follows captures the underlying samples in this manner.

2.3. Explanatory Variables

Table 3 presents summary statistics of the independent variables including per capita income (*Income*), population density (*Population Density*), measures of agricultural intensity (*Value of Crop, Value of Animal*), level of education (*Education)*, water area (*Water Acres*), water sampling intensity (*Moderately Low*, *Moderately High*, and *High Monitoring*), county composition with regards to ethnicity (*Percent Black*, *Percent Asian or PI*, *Percent Native American*, *Percent Hispanic*, and *Percent Other*), gender (*Percent Males)*, age (*Percent 0 to 4*, *Percent 5 to 17*, *Percent 18 to 40*, *Percent 65 or Older*), and water sample sites (*Rivers*, *Estuaries*, *Lakes*, *Oceans*, *Canals*, *Reservoirs*, *Springs*, *Drinking*, *Runoff*, and *Wetlands*).

Table 3: Summary Statistics for Socioeconomic Variables

Variable	Observations	Mean	Standard Deviation	Min	Max
Per Capita Income	2471	34768.270	12429.270	18750.720	79187.940
Population Density	2471	2.127	5.798	0.003	26.534
Value of Crop Production per Acre of County Land Area	2471	194.278	279.518	0.000	1574.796
Value of Neighboring Crop Production per Acre of County Land Area:					
1 Year Lag	2471	286.453	261.437	0.167	1068.019
2 Year Lag	2471	289.848	268.119	7.705	1055.36
3 Year Lag	2471	288.153	266.181	7.705	1127.339
Value of Animal Production per Acre of County Land Area	2471	53.811	93.081	0.000	1051.536
Value of Neighboring Animal Production per Acre of County Land Area:					
1 Year Lag	2471	71.210	82.205	4.384	472.420
2 Year Lag	2471	75.035	86.310	4.712	490.900
3 Year Lag	2471	73.170	83.146	4.712	459.931
Percent Eligible for UC or CSU Schools	2471	32.814	10.401	0.000	65.300
Percent of County Area Covered by Water	2471	0.137	0.202	0.002	0.799
Number of Samples per Acre of County Water	2471	0.005	0.082	0.000	3.814
New Immigrants as a Percent of the County’s Population	2446	0.005	0.004	0.000	0.018

Percent of the Population in Each County that is:					
White	2471	0.643	0.181	0.192	0.938
Black	2471	0.041	0.038	0.002	0.168
Asian or Pacific Islander	2471	0.074	0.082	0.003	0.324
Native American	2471	0.022	0.032	0.002	0.170
Hispanic	2471	0.202	0.143	0.021	0.748
Other	2471	0.019	0.009	0.003	0.044
Male	2471	0.506	0.018	0.487	0.647
0-4 years old	2471	0.068	0.015	0.002	0.109
5-17 years old	2471	0.188	0.034	0.004	0.257
18-40 years old	2471	0.329	0.049	0.007	0.443
41-64 years old	2471	0.298	0.049	0.005	0.404
65 or more years old	2471	0.123	0.028	0.002	0.215
Percent of Samples in Each County from:					
Rivers	2471	0.668	0.471	0.000	1.000
Estuaries	2471	0.103	0.304	0.000	1.000
Lakes	2471	0.080	0.272	0.000	1.000
Oceans	2471	0.020	0.139	0.000	1.000
Canals	2471	0.001	0.035	0.000	1.000
Reservoirs	2471	0.049	0.216	0.000	1.000
Springs	2471	0.052	0.222	0.000	1.000
Drinking	2471	0.009	0.096	0.000	1.000
Runoff	2471	0.014	0.118	0.000	1.000
Wetlands	2471	0.004	0.060	0.000	1.000

Agricultural production data come from the National Agricultural Statistics Service's County Agricultural Commissioners' Data, an annual report that contains the value of production by crop or animal product. The values of crop and livestock production at the county level were obtained from these reports. To measure the intensity of production, these values were divided by the total land area of each county.

The education data come from the California Department of Education's county reports. The measure of educational attainment used is the percent of graduating high school seniors who meet the eligibility criteria needed to attend a University of California (UC) or a California State University (CSU) school. This measure captures both the educational attainment of high school seniors as well as the quality of education and support provided to students.

The measure of water and land acreage in each county was obtained from data from the Department of Water Resources, Division of Planning and Local Assistance. Per capita income was obtained from the U.S. Department of Commerce's Bureau of Economic Analysis. This measure includes wages and salaries, supplements to wages and salaries, proprietor's income adjusted for inventory valuation and capital consumption, rental income, personal income receipts on assets, and transfers. It does not include government social insurance contributions.

The estimates of total population, the number of immigrants entering a county, the number of individuals at each age level, the number of individuals in main racial categories, and the number of males and females at the county level were obtained from the California Department of Finance's Demographic Research Unit. The immigration data were converted into a measure of the number of immigrants entering a county in a given year as a percent of the county's total population. The age data were converted into the percentage of individuals in various age groupings in each county. The racial and gender data were also converted into percentage terms.

Finally, we include controls for the type of body of water from which a given sample was taken. Samples were taken from rivers, lakes, estuaries, coastal ocean areas, reservoirs, springs, canals, drinking water sources, runoff, and wetlands.

3. Empirical Models

In studying the determinants of water quality in California, we consider factors both on the demand and supply sides. On the demand side, we focus on such socioeconomic variables as per capita income, ethnicity, education, gender, and age. We assume the quality of political institutions (degree of democracy) through which preferences for water quality are expressed to be the same across all counties in California.[1] Some demand side variables such as income, education, or ethnicity, appear to be endogenous; rich people with a strong preference for water quality may move to areas with higher water quality while poor people tend to trade

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[1] For a study of the effect of the openness and democratic degree of political regimes on environmental quality at the international level, see Farzin and Bond (2006).

environmental quality for income by residing in more polluted but less expensive areas. This argument is, however, likely true *within* counties. People may prefer to live in one town than another because of physical characteristics like water quality. At the county level, the presence of employment opportunities, family members or friends are much more likely to determine where people live than the county's water quality. On the other hand, rich people may positively influence water quality of their locale by being politically more influential, relative to poor people, to raise the water quality standards and the public budget allocations to pollution control efforts and monitoring and enforcement of the standards.

On the supply side, we focus both on the anthropogenic variables such as the type and intensity of economic activities (specifically the intensities of crop and livestock activities) and on the spatial and natural sources of water pollutants such as the types of water bodies (oceans, rivers, lakes, etc.). On the other hand, we take it as given that environmental regulations and standards for the pollutants with serious public health hazard to be more or less the same across the counties. While this is a reasonable assumption as far as the mandatory Federal and state minimum quality standards are concerned, it may not be true for less serious pollutants whose standards may be set by local public agencies, and consequently may vary across the counties. While one might suspect that regulations will be the main determinant of water quality and that water quality will be relatively homogeneous within California, the wide range of water quality levels observed suggests that this is not the case. Consequently, both the demand and supply side factors must be considered.

In this section, we present three sets of empirical models to test, using a reduced form of the supply and demand system.

3.1. The Relationship between Income and Water Quality

To test whether the environmental Kuznets curve, usually tested at the country level, holds at the county-level in California, we estimate the following set of models:

(1.a) $y_{i,t,s} = \beta_0 + \beta_1 income_{i,t} + \beta_2 income_{i,t}{}^2 + \beta_3 income_{i,t}{}^3 + \beta_s{}' S_{i,t} + u_i + \varepsilon_{i,t}$

(1.b) $y_{i,t,s} = \beta_0 + \beta_1 income_{i,t} + \beta_2 income_{i,t}{}^2 + \beta_3 income_{i,t}{}^3 + \beta_t t + \beta_s ' S_{i,t} + u_i + \varepsilon_{i,t}$

(1.c) $y_{i,t,s} = \beta_0 + \beta_1 income_{i,t} + \beta_2 income_{i,t}{}^2 + \beta_3 income_{i,t}{}^3 + \beta_{t1} t + \beta_{t2} t^2 + \beta_s ' S_{i,t} + u_i + \varepsilon_{i,t}$

Here, $y_{i,t,s}$ is the median of all samples taken of the pollutant of interest in county *i* in year *t* for site type *s*. The site type refers to the type of body of water from which the samples underlying the water quality statistic were taken. For example, $y_{i,t,s}$ might be the median level of nitrates in Fresno County lakes in 2001. $income_{i,t}$ is per capita income in county *i* in year *t*. $S_{i,t}$ is a vector of water body type dummy variables to control for the variation in pollution that *naturally* occurs between lakes, rivers, springs, and other water bodies.

We assume that the error term has two components: an unobservable component at the county level, u_i, that is constant across time and a random shock, $\varepsilon_{i,t}$, that is normally distributed with a mean of zero and a standard deviation of σ_ε. For now, we assume that neither error term is spatially correlated. We will relax this assumption in the third set of models. We run both fixed effects and random effects models and then test whether u_i is correlated with the independent variables using the Hausman test. All tables will show coefficient estimates from the models preferred by the Hausman test. The traditional EKC hypothesis predicts a quadratic relationship with $\beta_1 < 0$ and $\beta_2 > 0$, i.e. an inverted-U shape relationship. This implies that environmental quality deteriorates as income increases for lower levels of per capita income, but then improves as income increases for higher levels of income. To strengthen the test of the EKC hypothesis, we allow for a more flexible relationship by adding a cubic income term, thus expecting *a priori* that either $\beta_3 = 0$ or, otherwise, that the second turning point occurs at income per head levels outside of our sample data range.

It is possible that both water quality and income follow a similar time trend. To separate the effects of a similar time trend and actual correlation, a time trend is included in model 1.b to capture the net effects of all the factors which may independently of income influence water quality. Examples of such factors are policy-determined improvements in water quality standards, improvements over time in pollution abatement, monitoring, and enforcement technologies, and/or erosion over time of natural deposits and soil. Since the time trend might not be linear, we also add a quadratic time trend in 1.c.

3.2. The Effects of Socioeconomic Variables on Water Quality

The second set of models again uses the median level of the pollutant as the dependent variable and functions of income and a time trend in the independent variables, but these models also include a vector, $X_{i,t}$, that includes the socioeconomic-demographic variables described in the data section above. We hypothesize that the inclusion of additional socioeconomic-dempgraphic variables will eliminate many relationships found between income and water quality in the first set of models.

A measure of sampling intensity is included in $X_{i,t}$. Ideally, we would condition our analysis on the fact that a sample was taken using the Heckman two-step estimation procedure because areas sampled might be different than those areas that were not sampled. However, no data are available on variables that predict whether or not a county samples its water but do not also explain water quality. Instead of the two-step estimation, for each county, we generated a measure of the number of samples taken in a given year for a given pollutant and divided this number by the acres of water in that county. We then created dummy variables for each quartile of sampling intensity. We employed this dummy variable method because the relationship between sampling intensity and water quality is likely not constant for the entire range of sampling intensities. We expect little difference in the lower half of sampling intensities with more significant differences in the higher ranges of intensity. These dummy variables will control for differences between counties that sample frequently and those that sample infrequently. Our results, however, cannot be generalized to counties that do not sample since we have not accounted for inherent differences in these types of counties.

To allow for a more flexible relationship between the median pollutant levels and the independent variables, (2.a) below includes quadratic specifications for many of the independent variables, and (2.b) uses the log-log specification.

$$(2.a)\quad y_{i,t,s} = \beta_0 + \beta_1 income_{i,t} + \beta_2 income_{i,t}{}^2 + \beta_3 income_{i,t}{}^3 + \beta_x{}' X_{i,t} + \beta_t t + \beta_s{}' S_{i,t} + u_i + \varepsilon_{i,t}$$

$$(2.b)\quad \ln(y_{i,t,s}) = \beta_0 + \beta_1 \ln(income_{i,t}) + \beta_x{}' \ln(X_{i,t}) + \beta_t t + \beta_s{}' S_{i,t} + u_i + \varepsilon_{i,t}$$

Again, we assume a time-invariant unobservable component exists at the county level that is independent across counties, and we assume that a random shock exists at the county and year level. To test whether the county level unobservable is correlated with the independent variables, we again run both fixed effects and random effects models and use the Hausman test to determine which model is appropriate.

3.3. Spatial Correlation

Since watersheds usually do not coincide with county boundaries and since many water bodies span more than one county, spatial correlation likely exists in this dataset. Ideally, this issue would be addressed with spatial autocorrelation or moving average specifications. Unfortunately, this dataset has many holes across both time and space, so few observations exist for which water quality data for all of the neighboring counties also exist. Consequently, these types of estimations are impossible. We do, however, have agricultural production data for all counties and years. Using this data, we construct estimates of the intensity of agricultural activity in counties surrounding county *i*. $Crop_{-i,t-k}$ is the total value of crop production in all counties bordering county *i* divided by the total acreage of land in these counties for the year *t-k*. $Animal_{-i,t-k}$ is identical to $Crop_{-i,t-k}$ except that is contains the value of animal production. Three years worth of lagged values (k = 1, 2, or 3) and quadratic forms are included, as shown below. Since neighboring counties likely produce similar crops and animals, we did not include the current average value of crop and animal production in bordering counties. Neighboring counties will experience the same production shocks such as extreme weather or increased pest pressure as well as the same economic shocks like input price increases or changes in demand.

Lagged production values will provide an indicator of production that will not suffer from these correlations. Additionally, estimates of the mean residence time of water in stream systems and water basins smaller in size than any of the counties included in this analysis range from four months to 2.1 years (McGlynn et al. 2003; Sayama and McDonnell, 2009; Vitvar et al., 2002), suggesting that water movement across counties, aside from movement in river, will have a lagged impact on water quality. In (3.a) and (3.b), the subscripts have the same interpretation as before except that now *-i* includes all of the counties bordering *i*.

(3.a)

$$y_{i,t,s} = \beta_0 + \beta_1 income_{i,t} + \beta_2 income_{i,t}{}^2 + \beta_3 income_{i,t}{}^3 + \beta_x ' X_{i,t} + \gamma_c '\overline{Crop}_{-i,t} + \gamma_a '\overline{Animal}_{-i,t} + \beta_t t + \beta_{t2} t^2 + \beta_s ' S_{i,t} + u_i + \varepsilon_{i,t}$$

(3.b)

$$\ln(y_{i,t,s}) = \beta_0 + \beta_1 \ln(income_{i,t}) + \beta_x '\ln(X_{i,t}) + \gamma_c '\ln(Crop_{-i,t}) + \gamma_a '\ln(Animal_{-i,t}) + \beta_t t + \beta_{t2} t^2 + \beta_s ' S_{i,t} + u_i + \varepsilon_{i,t}$$

where $Crop_{-i,t} = \left(Crop_{-i,t-1}\ Crop_{-i,t-2}\ Crop_{-i,t-3}\right)'$, $\overline{Crop}_{-i,t}$ contains all of the terms in $Crop_{-i,t}$ as well as those terms squared, $Animal_{-i,t} = \left(Animal_{-i,t-1}\ Animal_{-i,t-2}\ Animal_{-i,t-3}\right)'$, and $\overline{Animal}_{-i,t}$ contains all of the terms in $Animal_{-i,t}$ as well as those terms squared. Since this third set of models only controls for the movement of agricultural pollutants across counties, we only estimate these models for pollutants for which an agricultural source exists.

One might argue that rivers will drive the spatial correlation between counties. Testing this hypothesis would provide interesting results about upstream-downstream relationships, but the lack of consistent sampling across time and space does not let us construct the spatial weighting matrix that such an analysis would require. Additionally, since our socioeconomic variables are at the county level, we are compelled to consider water quality at that level of aggregation too, which in turn does not lead to strict upstream-downstream relationships. Instead, a watershed concept is more appropriate, and the models we use try to approximate this kind of relationship.

4. Estimation Results and Discussion

In this section we present and discuss the selected estimation results of the three sets of empirical models.

4.1. The Relationship between Income and Water Quality

The first phase of the analysis asks whether or not the traditional environmental Kuznets curve specification holds for water quality in California using models 1.a-1.c, which exclude the sociodempgraphic variables. Table 4 contains the estimated coefficient values on the income and time variables for those pollutants for which an EKC relationship exists for at least one of the EKC models, using the correct random versus fixed effects specification.

For variables such as arsenic, total coliform, and zinc, the relationship between income and the median pollutant level is not robust to the addition of the time trend, suggesting that both income and median concentrations of these pollutants have similar time trends. For other variables, such as fecal coliform, nitrate, and pH, the relationship does not exist unless the time trends are included. This suggests that models that exclude time trends suffer from omitted variables bias. For ammonia, nickel, phosphorus, and specific conductivity, no time trend exists, so the EKC relationship is robust across all three specifications.

Some previous analyses of the EKC have failed to control for other factors, such as education or ethnic composition, which may affect water quality (Galeotti et al., 2006; Gergel et al., 2004; Jia et al. 2006). Our estimates of models 2.a and 2.b suggest that failing to control for these factors can result in falsely accepting the EKC hypothesis. As shown in Table 5, with the addition of covariates, relationships only exist between income and the median pollutant level for copper, fecal coliform, and ammonia. Furthermore, these three relationships were only found using model 2.a. No relationships exist between water quality and income using model 2.b. And ammonia is the only pollutant for which the type of relationship does not change from the relationship found in models 1.a and1.c. Figures 1 and 2 graphically show the relationship between income and ammonia and fecal coliform with a small subset of samples plotted. Fecal coliform also displays a downward time trend, and this trend is apparent in the graph when looking at plots for San Luis Obispo (SLO), and San Francisco counties. The lack of robustness found for the EKC models suggests that such a relationship is rarely present at the county level in California.

Table 5: Income Coefficient Estimates of Random Effects Regressions of Model 2.a. (Statistically Insignificant Models Not Shown)

Pollutant		(2.a)	Shape for Income Range
Ammonia	income	-5.25e-5**	Decreasing until $36,674
	income2	1.13e-9**	Increasing until $63,370
	income3	-7.53e-15**	Decreasing thereafter (reaches 0 at $76,966
	RE / FE	RE	
Copper	income	29.42*	Linear Increase
	income2	-5.10E-03	
	income3	2.79E-09	
	RE vs. FE	RE	
Fecal Coliform	income	-0.49**	Decreasing until $38,298
	income2	1.06e-5**	Increasing until $59,794
	income3	-7.25e-11**	Decreasing thereafter (reaches 0 at $65,973
	RE / FE	RE	

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Figure 1. The Relationship between Ammonia and Per Capita Income with Some Randomly Selected River Median Concentrations Plotted. (n = 95)

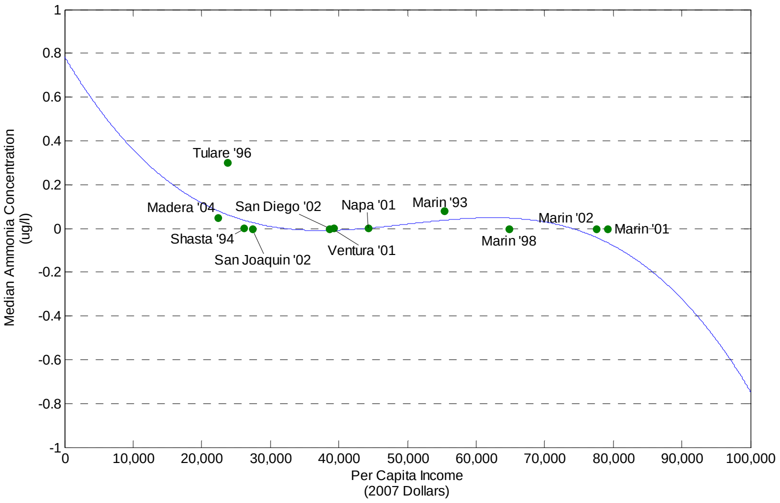
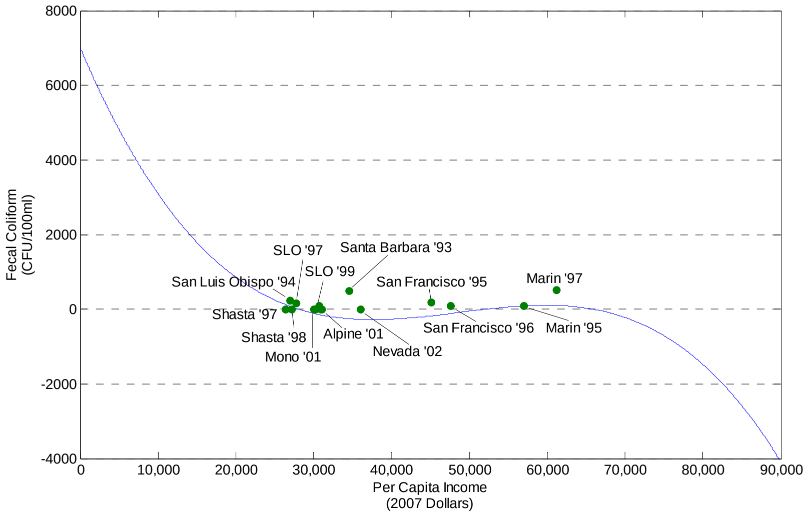


Figure 2. The Relationship between Fecal Coliform and Per Capita Income with Some Randomly Selected River Medians Plotted. (n = 58)



4.2. Effects of Socioeconomic Variables on Water Quality

The inclusion of other socioeconomic variables indicates that income is not the only determinant of water quality in California. Education, ethnic composition, age structure, land use, population density, and water area are all significantly correlated with various indicators of water quality (Tables 6 and 7).

Monitoring Intensity

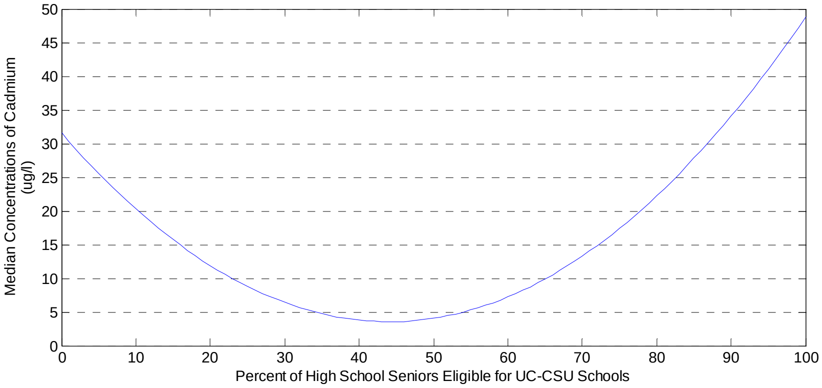
As discussed earlier, our dataset suffers from sample selection bias. Within our dataset, some counties have more samples contributing to the median level of the pollutant. There are two main reasons why sampling intensity may vary. First, some counties may sample more because they are more concerned about water quality than those counties who sample less. We would expect to see lower pollutant levels for counties sampling for this reason. We should find negative coefficients on the monitoring intensity dummy variables because these variables measure the effect of monitoring intensity relative to the first quartile of monitoring intensity. Second, counties may sample more because they have poor water quality that needs to be closely monitored. We would expect to see higher pollutant levels for counties sampling for this reason, and we should see positive coefficients on the monitoring intensity dummy variables.

Our results find evidence of the former phenomenon in the model for ammonia. We find evidence of the latter phenomenon occurring for about half of the pollutants examined. Table 5 and 6 show the coefficients for models 2.a and 2.b. Interestingly, the highest intensity of sampling is not correlated with the worst water quality for magnesium, phosphorus, total suspended solids, specific conductivity, and sulfate. For these pollutants, it appears that there are sites being sampled quite frequently and yet these sites have average or above average water quality, suggesting, in want of a better explanation, a possibility of inefficient use of resources.

The Effects of Education

Our model predicts a quadratic relationship between education and median levels of cadmium, copper, and fecal coliform. Levels of cadmium decrease as education increases until 63.5% of graduating high school seniors are eligible for UC and CSU schools (Figure 3). The maximum percent eligible in the sample is 65.3%. While our model suggests a quadratic relationship, the turning point is at the upper bound of our range, so the upward turn at high levels of educational attainment might not actually occur. For low levels of educational attainment, copper declines as education increases. At 45.82%, levels of copper begin to increase again. Only about 8% of the observations include eligibility rates above 45.82%, so like cadmium, the relationship at high levels of education may be imprecisely estimated.

Figure 3. The Relationship between Median Concentrations of Cadmium and Education Using Model 2.a.



Fecal coliform exhibits the opposite relationship. Levels of fecal coliform increase as education increases until eligibility rates of 45.17%, at which point, coliform levels decrease as education increases. The same caveat that applied to copper and cadmium applies to fecal coliform; the downward turn at high levels of education may not be observed in reality. The log-log specification best fit the data for arsenic, and this model predicts that a 1% increase in UC-CSU eligibility rates corresponds to a 2.73% decrease in median arsenic concentrations.

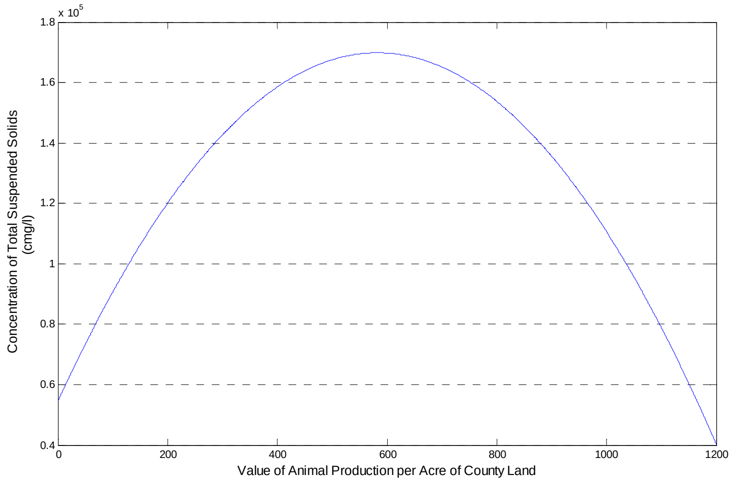
It appears that for arsenic, cadmium, and copper, increasing education increases the demand for water quality, while for fecal coliform, increasing education does not increase the demand for lower coliform levels. These discrepancies could be in part due to common knowledge about the effects, and presence, of bacteria while the effects and presence of pollutants like arsenic, cadmium, and copper may be less widely known. Consequently, increased education will not increase the already high awareness about fecal coliform, but may increase awareness and understanding of arsenic, cadmium, and copper.

The Effects of Agriculture

Interestingly, a $1 increase in the value of crop production per acre of county land is associated with a 0.02 ug/l *decrease* in cadmium concentrations. The mean crop production value is $194. A 10% increase at the median value, $19.40, would lead to about a 0.4 μg/l decrease in cadmium, which is about 21% of the current median cadmium concentration. Cadmium comes from industrial sources, so it is likely that the negative and economically significant correlation between crop production and cadmium occurs because areas with a predominance of agricultural production have less industrial production. Nickel is also *negatively* correlated with the value of crop production per acre of county land, but, unlike cadmium, it is a common agricultural pollutant. Nickel can be found in fertilizer runoff, so one would expect no correlation or a positive correlation. It is possible that lower valued crops tend to use more nickel-containing fertilizer, in which case, our measure of crop production intensity is inadequate to estimate the effects of crop production on nickel concentrations.

As the value of animal production per acre of county land increases, the concentration of total suspended solids increases but at a decreasing rate (Figure 4). The model implies a turning point at $494.34 per acre of county land. This amount is within the range of values in the dataset, but only less than 1% of samples exceed this value. It is likely that total suspended solids concentrations will level off instead of turning down at this turning point. The increase in TSS is likely due to the erosion caused by animal grazing and animal movement. Since there are spatial limits to the number of animals that can be produced in a given area, there are likely limits to the effects of animal production on total suspended solids.

Figure 4. The Relationship between Median Concentrations of Total Suspended Solids and the Value of Animal Production per Acre of County Land Using Model 2.a.



The Effects of Ethnic Composition

Our results show that the common belief that minorities are more often subject to lower environmental quality than Caucasians may not always hold true. Higher percentages of Hispanic people are associated with higher levels of total suspended solids and nickel, but *lower* levels of manganese. The correlation between the Hispanic population and nickel suggests that nickel is associated with fertilizer runoff used on lower valued farms. Hispanic people are disproportionately employed at higher rates in agriculture in California, so areas with a higher percentage of Hispanic people are likely to have more agricultural activity as well.

Higher percentages of African American people are associated with increased levels of arsenic and magnesium, but lower levels of copper and cadmium. Similarly, Native Americans are associated with higher levels of phosphorus, sulfate, and magnesium, but lower levels of copper, and cadmium.

Part of the discrepancy between the relationship between minorities and water quality found in this study and the relationship found in other studies is likely due to the difference in the spatial scale of observations. Studies like Pearce et al. (2006) and Saha and Mohai (2005) find evidence of poorer environmental quality in areas with higher concentrations of minorities but find these relationships at the New Zealand census area unit level or American census block unit, respectively. At the much larger county level, there does not appear to be a general trend between minority populations and water quality that holds across all pollutants. However, at a more localized level, these trends may exist in California, and our coarse scale cannot detect them.

To determine if the effect of income on water quality varies by ethnic group, we run a set of regressions that interact race and income. Interestingly, in the models for nitrates, total suspended solids, and selenium, the coefficient on the percent of a county's population that is black is positive and statistically significant and the coefficient on the interaction between that variable and income is statistically significantly negative. These relationships suggest that black people are more likely to experience lower water quality but as their income increases water quality improves.

The Effects of Age Composition

Although one might suspect populations containing individuals who are more susceptible to pollution, such as the very young or the elderly, to demand better water quality, our results only support this hypothesis for copper and arsenic. For manganese and total suspended solids, higher percentages of children 4 years old and younger are associated with increased levels of these pollutants. Possible explanations could be the greater toxicity of copper and arsenic particularly for very young children and/or the public's awareness of, and sensitivity to, the consequences of these pollutants.

The Effects of Gender

Contrary to popular opinion that women tend to be more environmentally-minded, our results show that a one percentage point increase in the males' share of the population is correlated with a 15.66% *increase* in dissolved oxygen and a 17.25% *decrease* in arsenic concentrations. Only for magnesium do we find a positive correlation between the males' share and the pollutant. This is likely due to a higher percentage of males being employed by industries that are the sources of magnesium discharge into water bodies.[2]

Time Trends

This set of models finds time trends for two water quality indicators. In model 2.a, chromium exhibits an inverted U-shaped relationship with time, with the turning point well before the start of our dataset. Consequently, it appears that concentrations of chromium are decreasing, at an increasing rate over time. In model 2.b, pH is positively correlated with time. This suggests that surface water in California is getting less acidic over time. Models 2.a and 2.b were also run using time fixed effects instead of a time trend. This did not substantially alter the results.[3]

4.3. Spatial Correlation

Our analysis of spatial correlation suggests that such correlation is, indeed, present (Tables 9 and 10). We find statistically significant coefficients on the lagged variables as well as a change in significance of other related variables. First, when the spillover variables are included, the relationship between income and median levels of ammonia and copper are no longer statistically significant. Since median income is likely correlated across neighboring counties, income may actually be picking up the effect of other neighboring counties' pollution.

We find a positive relationship between phosphorus and the two year lagged value of neighboring counties' crops; a one percent increase in the value of neighboring counties' crop production per acre of neighboring county land is associated with an 8.81% increase in phosphorus concentration. A one percent increase in the two year lagged intensity of neighboring animal production is associated with a 14.07% increase in phosphorus concentration. For both neighboring crop and animal production, agricultural production occurring further back in time has a negative impact on phosphorus concentration, but these impacts are smaller in magnitude than the above-mentioned impacts. These negative relationships are likely picking up ecological phenomena such as algal cycles in response to phosphorus additions.

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[2] Our gender variable captures the number of males living in a given county, while the effect we believe we are picking up comes from the number of males working in a given county. In 2004, the median commute time in California was 20 minutes (Barbour, 2006). From this commute time, we infer that the majority of workers live and work within the same county.

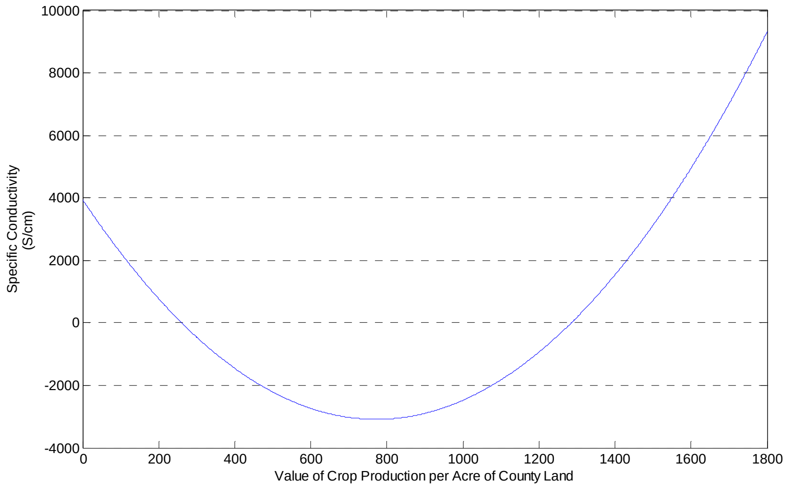
[3] The results of these models are available upon request from the authors.

Once accounting for neighboring counties' agricultural production, the coefficient on the county's value of animal production becomes statistically significantly positive, predicting a 2.14% increase in phosphorus concentrations for a 1% increase in the value of animal production per acre of county land. When accounting for spatial correlation, the coefficient on the value of crop production becomes negative. Phosphorus can come from both fertilizer and manure runoff, but based on these results, animal production seems to be a greater contributor to phosphorus in California surface water than crop production. This could be due to better methods of preventing fertilizer runoff as compared to methods of preventing animal waste runoff.

The relationship between total suspended solids and neighboring crop production is less clear. The value of crop production lagged one year is positively correlated with total suspended solids, but the value of crop production lagged three years is negatively correlated. This latter phenomenon could in part be due to delayed clean-up efforts that bring water bodies with high total suspended solids down to much lower levels, but only after levels have been elevated for a few years. When the spillover variables are included, the positive relationship seen between total suspended solids and animal production is no longer statistically significant and the value of crop production becomes positively related to total suspended solids. Based on these results, it seems that crop production has an immediate and more localized effect on levels of total suspended solids than it does on phosphorus. Interestingly, with the inclusion of spatial controls, a u-shaped relationship between time and total suspended solids emerges, with the turning point occurring in 2003. This suggests that total suspended solid concentrations are currently increasing over time, and this trend could be due, partly, to increased construction and development across the state of California.

Specific conductivity is becoming an increasingly important problem in agricultural areas of California. When we do not control for spatial correlation, there is no relationship between specific conductivity and either measure of agricultural production. However, once we control for neighboring crop production, a quadratic u-shaped relationship between the value of crop production and specific conductivity appears, with the turning point occurring at $772.94 (Figure 5). Only 6% of observations lie above this value, and like models discussed previously, it is possible that this turning point is better described as a leveling off point. Specific conductivity can impede the production of crops, so highly valued crops cannot always be grown in areas with high specific conductivity. While agriculture is a main contributor to specific conductivity in many parts of the state, our indicator of agricultural production picks up the effects of specific conductivity on crop choice and production possibilities instead of the effect of crop production on specific conductivity.

Figure 5. The Relationship between Specific Conductivity and the Value of Crop Production per Acre of County Land



An interesting relationship exists between pH and bordering counties' value of animal production. Animal waste contains ammonia, and this ammonia can bubble up into the air and contribute to acid rain (Reddi, 2003). When controlling for spillover effects, the coefficient on the value of neighboring counties' animal production lagged one year implies that a one percent increase in neighboring counties' animal production decreases pH by 0.5%, implying more acidic water is positively correlated with neighboring animal production. The coefficient on own-county animal production is insignificant. Given the mechanism through which animal production contributes to water pH, it appears that animal production has a greater impact on surrounding areas than the immediate area of production. Additionally, the time trend found in model 2.b for pH is robust to the addition of the spatial controls.

The inclusion of spatial controls leads to time trends in the models for nitrate and nickel. The relationship between nitrate and time is very similar to the relationship discussed for chromium above; nitrate concentrations are decreasing over time at an increasing rate. Model 3.b estimates that nickel concentrations are also decreasing over time.

5. Conclusion

This study has found that contrary to what one might expect, the per capita income is not a significant factor in explaining the variability in water quality indicators across the counties in California. Rather, many factors both on the supply side (for example, agricultural and industrial activities, and spatial characteristics where these activities take place) and the demand side (for example, socioeconomic-demographic factors influencing preferences and the demand for environmental quality) affect concentrations of water pollutants in California. Our econometric estimations show that while for some specifications, the environmental Kuznets curve hypothesis is supported, these finding are not robust to the inclusion of socioeconomic variables or controls for spatial correlation. The study area is likely driving this result. Previous work that finds significant relationships between income and environmental quality (Grossman and Krueger, 1995; Cole, 2004; Khanna and Plausman, 2004) often uses observations from a wide range of income levels and finds turning points that occur at income levels below the minimum level of income contained in our dataset. Our data may support their findings but the California per capita income levels in our dataset are at levels that exceed the income ranges of their studies. Additionally, if pollution tends to level off at high ends of income, this may explain why we find very few statistically significant relationships between income and water quality; all of our observations fall on this flat portion of the relationship. Furthermore, some studies suggest an Nshaped relationship between income and environmental quality. It is possible that our data are concentrated around the second turning point, and consequently, the relationship appears to be flat.

Our estimation of the relationships between education and water quality suggest that a continued emphasis on education in California may create a population that is more aware of, and concerned about, water quality. The estimated relationships between measures of agricultural activity and water pollution levels suggest the importance of understanding which sectors of agriculture (livestock production or crop production) has a stronger impact on water quality and in what specific ways. The evidence of spillover effects of phosphorus and pH suggest that policies designed to control these types of pollutants must consider a broader spatial scale than those pollutants for which the source and impact occur in the same area. The lack of a statistical relationship between agricultural activity and many pollutants commonly associated with agriculture suggests that other sources contribute to these pollutants, and policies designed to control these pollutants should consider *all* sources in order to be effective. The statistically significant time trends found in this study suggest that for chromium, nitrates, and nickel, programs and policies designed to reduce concentrations have been successful. However, while the concentration of total suspended solids was decreasing up until 2003, it is now increasing over time, holding all other variables constant. This time trend suggests that policies put in place to control TSS may be inadequate.

Similarly, the relationships we found between monitoring intensity and median concentrations suggest that for some pollutants such as arsenic, fecal coliform, magnesium, and nitrate, sampling is efficiently targeted at sites with poor water quality. On the other hand, for pollutants such as phosphorus and total suspended solids, water bodies with low pollutant concentrations are sampled too frequently.

Future work can improve the estimations presented in this paper by including a randomized, balanced panel dataset of water quality in California to ensure that results are representative of the entire state and not just the counties who sample frequently. Also, since many of the turning points occur at the ends of variable ranges, repeating the estimation procedures as ranges shift can shed light on whether or not turning points actually occur. Finally, while this study has focused mainly on socioeconomic factors, future research need to explicitly and in more detail incorporate natural processes and factors such as cite characteristics, variability in soil properties and climate patterns, hydrological connectivity and pollutant transport and discharge, and rural (agricultural runoff) versus urban (construction and industrial) sources of water pollution in California.

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Appendix

Table 1: Sources of Water Pollution

Pollutant	Natural Sources	Industrial Sources	Agricultural Sources	Household Sources
Ammonia		coke plant emissions and effluent, ceramic production, mining	fertilizer runoff, animal waste runoff	septic systems, cleaning products, sewage treatment plants
Arsenic[1]	erosion of natural deposits	glass and electronics production runoff	orchard runoff	
Cadmium	erosion of natural deposits	Galvanized pipe corrosion, metal refinery discharge		galvanized pipe corrosion, waste batteries and paint runoff
Chromium	erosion of natural deposits	steel and pulp mill discharge		
Copper	erosion of natural deposits		insecticide runoff	plumbing system erosion
Dissolved Oxygen[a]	warm weather, runoff from forests	thermal pollution	runoff from pastures, cropland	waste water treatment plants
Fecal Coliform	animal waste		animal waste	human and animal waste
Iron[2]	naturally occurring		Fertilizer and insecticide runoff	corroding pipes
Lead	erosion of natural deposits			plumbing system corrosion
Magnesium	erosion of natural deposits	construction and electronic industry runoff	fertilizer runoff	
Manganese[3]	naturally occurring	industrial discharge		landfill runoff
Mercury[4]	erosion of natural deposits	refinery and factory discharge	cropland runoff	landfill runoff
Nickel[5]	erosion of natural deposits	power plant and metal industry emissions	fertilizer runoff	waste incinerator emissions
Nitrate[6]	erosion of natural deposits		fertilizer runoff	fertilizer runoff, septic tank leaching, sewage
Nitrite[7]	erosion of natural deposits		fertilizer runoff	fertilizer runoff, septic tank leaching, sewage
pH[H]	erosion of bicarbonates and carbonates	industrial pollutant dumping		
pH[L]	rain	coal burning industry emissions, mining	manure storage	automobile emissions
Phosphorus	erosion of natural deposits	industrial effluent	fertilizer and manure runoff	sewage effluent
Selenium	erosion of natural deposits	petroleum refinery discharge, mine discharge		
Specific Conductivity	erosion of natural deposits	Industrial inputs	agricultural runoff	road salt
Sulfate	erosion of gypsum, volcanoes	mining runoff, fossil fuel combustion	fertilizer runoff	
Total Coliform	naturally present, animal fecal matter	None	animal waste	human and animal waste

Total Suspended Solids	natural soil erosion	industrial wastewater	Soil erosion	soil erosion from construction sites, sanitary wastewater
Zinc	erosion of natural deposits	alloys, paints, batteries, car parts, electrical wiring	insecticide runoff	sewage sludge

a: Sources refer to sources that reduce the dissolved oxygen content

L: sources refer to causes of low pH, H: sources refer to causes of high pH

Source unless otherwise noted: EPA. 2008. *Drinking Water Contaminants*. Available: http://www.epa.gov/safewater/contaminants/index.html
1: Texas Cooperative Extension. 2008. *Dissolved Oxygen*. Available: http://aquaplant.tamu.edu/contents/dissolved_oxygen.htm.
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6: Michigan Department of Environmental Quality. *Total Suspended Solids*. Available: http://www.deq.state.mi.us/documents/deq-swq-npdes-TotalSuspendedSolids.pdf.
7: Central New York's New Real-Time Surface Water Quality Network. 2008. *Specific Conductivity*. Available: http://www.ourlake.org/html/specific_conductivity.html.

Table 4: Random or Fixed Effects Regression Results for Models 1.a-c. (Statistically Insignificant Models Not Shown)

Pollutant		(1.a)	(1.b)	(1.c)	Pollutant		(1.a)	(1.b)	(1.c)
Ammonia	income	-1.28e-4**	-1.18e-4*	-1.12e-4*	pH	income	5.13E-04	-7.95e-4*	-8.20e-4*
	income^2	2.41e-9**	2.27e-9**	2.23e-9*		income^2	1.09E-08	1.52e-8*	1.58e-8*
	income^3	-1.45e-14**	-1.38e-14**	-1.35e-14**		income^3	-7.02E-14	-9.29e-14*	-9.63e-14*
	time		-2.41E-03	0.51		time		0.05	-10.98
	time^2			-1.28E-04		time^2			2.76E-03
	RE/FE	FE	FE	FE		RE/FE	FE	FE	FE
Arsenic	income	-0.02*	-0.01	-9.28E-03	Phosphorus	income	-4.68e-4**	-5.79e-4**	-5.30e-4*
	income^2	3.00E-07	1.89E-07	1.51E-07		income^2	8.56e-9**	1.02e-8**	9.46e-9**
	income^3	-1.74E-07	-1.06E-12	-8.23E-13		income^3	-5.00e-14**	-5.90e-14**	-5.48e-14*
	time		4.21	2.05E+02		time		0.02	10.09
	time^2			-5.00E-02		time^2			-2.52E-03
	RE/FE	FE	FE	FE		RE/FE	FE	FE	FE
Copper	income	86.14**	88.61*	127.72**	Specific Conductivity	income	-4.25**	-3.33	-3.23
	income^2	-1.51e-3*	-1.55E-03	-2.33e-3**		income^2	1.04**	8.94e-5*	8.78e-5*
	income^3	8.55E-09	8.78E-09	1.36e-8**		income^3	-6.77e-10**	-6.10e-10*	-6.01e-10*
	time		-276.77	5427649***		time		-180.43	57979.15
	time^2			-1358.44***		time^2			-14.55
	RE/FE	FE	FE	FE		RE/FE	FE	FE	FE

Fecal Coliform	income	0.04	0.57***	0.57***	Total Coliform	income	0.42	0.37	0.37
	income^2	-8.35E-07	-1.29e-5***	-1.28e-5***		income^2	-9.96E-06	-8.61E-06	-8.64E-06
	income^3	6.24E-12	9.36e-11***	9.35e-11***		income^3	7.52e-11*	6.29E-11	6.31E-11
	time		-56.27***	48.46***		time		54.91*	-57.83*
	time^2			-0.03***		time^2			0.03*
	RE/FE	RE	RE	RE		RE/FE	RE	RE	RE
Nickel	income	-1.77e-3*	-1.87e-3*	-1.87e-3*	Zinc	income	566.18*	2202.06	218.57
	income^2	3.93e-8*	4.16e-8*	3.16e-8*		income^2	-0.01*	-0.06	-5.83E-03
	income^3	-2.63e-13*	-2.79e-13*	-2.79e-13*		income^3	1.26e-7*	5.16E-07	5.02E-08
	time		0.05	-0.03		time		17419.7*	-20060.34**
	time^2			2.01E-05		time^2			9.37**
	RE/FE	RE	RE	RE		RE/FE	RE	RE	RE
Nitrate	income	1.18E-03	2.32e-3*	3.08e-3**					
	income^2	-2.07E-08	-3.68E-08	-4.96e-8**					
	income^3	1.16E-13	1.98E-13	2.68e-13*					
	time		-0.32*	240.48***					
	time^2			-0.06***					
	RE/FE	FE	FE	FE					

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively. FE and RE indicate the fixed effect or random effect specification, respectively.

Table 6: Regression Results for Model 2.a. (Site Type Effects Excluded from Table)

	Variable	Ammonia	Cadmium	Chromium
Income	Income	-5.23E-5**	2.35E-03	1.27E-03
	Income Squared	1.13E-9**	-4.59E-08	-2.10E-08
	Income Cubed	-7.53E-15**	2.66E-13	1.03E-13
Time	Time	-0.01	0.53	1.22*
	Time Squared	3.23E-06	-2.66E-04	-6.23E-4*
Water Acres	Water Acres	2.00E-07	4.34E-05	4.92E-06
	Water Acres Squared	-3.41E-13	-7.76E-11	-1.51E-11
Monitoring Intensity	Moderate Low Monitoring	-0.04*	1.92	-0.10
	Moderate High Monitoring	-0.02	1.44	-0.23
	High Monitoring	-0.01	-2.55	-1.77
Population Density	Population Density	0.01	-0.49	0.47
	Population Density Squared	-1.29E-04	0.01	-0.04
Education	Education	-0.01	-1.27***	0.39
	Education Squared	1.21E-04	0.01***	-0.01
Intensity of Agricultural Production	Value of Crop	-5.54E-05	-0.02*	-0.02
	Value of Crop Squared	6.37E-08	9.62E-06	1.86E-05
	Value of Animal	1.24E-04	-0.02	0.08
	Value of Animal Squared	-7.14E-07	3.60E-05	-3.89E-04

Immigrants	Percent Immigrants	0.45	110.37	248.97
Ethnic Composition	Percent Black	0.17	-96.99***	-18.90
	Percent Asian or PI	-0.32	47.50*	13.09
	Percent Native American	-1.24	-189.69***	45.69
	Percent Hispanic	-0.33	-7.81	14.43
	Percent Other	0.32	126.21	169.34
Gender	Percent Males	0.36	7.63	44.64
Age Composition	Percent 0 to 4	1.37	-10.63	-45.22
	Percent 5 to 17	0.44	88.44	-13.17
	Percent 18 to 40	0.29	-51.86*	5.62
	Percent 65 or Older	0.08	30.78	52.11
	Constant			
	Observations	94	80	67
	Groups	29	25	25
	R-Squared	0.5477	0.7668	0.9862
	RE / FE	RE	RE	RE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Table 6: Regression Results for Model 2.a. (Site Type Effects Excluded from Table), Continued

	Variable	Copper	Fecal Coliform	Nitrate
Income	Income	29.42*	-0.49**	0.000493
	Income Squared	-5.10E-04	1.06E-5**	-1E-08
	Income Cubed	2.79E-09	-7.30E-11**	6.81E-14
Time	Time	6514.85	28.88	0.17
	Time Squared	-3.42	-0.01	-8.5E-05
Water Acres	Water Acres	0.54	-1.67E-03	3.95E-06
	Water Acres Squared	-9.04E-07	5.23E-9***	-8.1E-12
Monitoring Intensity	Moderate Low Monitoring	9027.94	1032.15***	0.84
	Moderate High Monitoring	23354.31	880.94***	0.41
	High Monitoring	17873.12	871.68***	2.46***
Population Density	Population Density	-3510.71	64.74	-0.10
	Population Density Squared	16.55	-2.27	0.01
Education	Education	-11120.83**	60.54**	0.08
	Education Squared	121.36**	-0.67**	-0.00072
Intensity of Agricultural Production	Value of Crop	-160.23	1.42*	-0.0016
	Value of Crop Squared	0.06	-6.53E-04	6.26E-07
	Value of Animal	-515.63	0.29	-0.01

	Value of Animal Squared	2.80	-1.36E-03	0.000034
Immigrants	Percent Immigrants	-2628089.00	9307.24	-302.69**
Ethnic Composition	Percent Black	-635174.8**	3728.12	13.49
	Percent Asian or PI	470949.70*	-1382.47	-2.85
	Percent Native American	-1835387.00***	5108.70	-0.34
	Percent Hispanic	16201.06	243.05	7.90
	Percent Other	1573866.00	21047.49*	20.11
Gender	Percent Males	669737.10	9379.49	-13.62
Age Composition	Percent 0 to 4	-3350633.00*	1085.13	1.02
	Percent 5 to 17	1769918.00***	-4021.42	-9.80
	Percent 18 to 40	-251732.50	-2896.95	9.70
	Percent 65 or Older	16282.22	6897.26	-3.31
	Constant			
	Observations	95	55	116
	Groups	25	16	32
	R-Squared	0.5875	0.9959	0.4477
	RE / FE	RE	RE	RE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Table 6: Regression Results for Model 2.a. (Site Type Effects Excluded from Table), Continued

	Variable	Selenium	Specific Conductivity	Total Suspended Solids
Income	Income	1.02E-04	1.12	1.67
	Income Squared	4.21E-09	-1.98E-05	-4.01E-05
	Income Cubed	-5.77E-14	1.43E-10	3.13E-10
Time	Time	0.45	-364.40	-575448.40
	Time Squared	-2.27E-04	0.18	143.45
Water Acres	Water Acres	1.43E-06	-0.01	
	Water Acres Squared	-5.92E-12	4.61E-09	
Monitoring Intensity	Moderate Low Monitoring	-1.41	2606.35	4038.30**
	Moderate High Monitoring	2.82	4766.49**	6362.90**
	High Monitoring	1.01	2868.93	3721.22
Population Density	Population Density	-0.42	-1295.34	231726.30***
	Population Density Squared	0.02	46.05	-22100.29***
Education	Education	-0.25	-191.67	752.17
	Education Squared	2.27E-03	2.20	-10.37
Intensity of Agricultural Production	Value of Crop	-0.01	-9.72	17.78
	Value of Crop Squared	5.85E-06	0.01	-0.02

	Value of Animal	-0.01	-13.00	336.15***
	Value of Animal Squared	-7.13E-07	0.02	-0.34***
Immigrants	Percent Immigrants	-656.83	-364298.40	-15925.32
Ethnic Composition	Percent Black	-18.52	-14339.53	454307.70
	Percent Asian or PI	2.81	33070.79	-47516.99
	Percent Native American	-103.09	-33484.28	-547528.20
	Percent Hispanic	26.75	-3341.65	299331.10**
	Percent Other	411.25**	-243095.20**	-65230.89
Gender	Percent Males	17.86	-187.61	40725.85
Age Composition	Percent 0 to 4	159.78	13294.02	808379.10*
	Percent 5 to 17	-63.66	5522.83	-365171.30**
	Percent 18 to 40	-7.01	15193.82	39501.35
	Percent 65 or Older	-9.90	6062.48	-11512.96
	Constant			5.77E+08
	Observations	125	442	145
	Groups	42	52	45
	R-Squared	0.3617	0.3030	0.0004
	RE / FE	RE	RE	FE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Table 7: Regression Results for Model 2.b. (Site Type Effects Excluded from Table)

		Arsenic	Dissolved Oxygen	Magnesium
Income	Ln(Income)	0.56	-5.21	12.47
Time	Time	-0.10	-0.34	-0.22
Water Acres	Ln(Water Acres)	0.37		-4.75*
Monitoring Intensity	Moderately Low Monitoring	1.15*	-0.73**	2.75
	Moderately High Monitoring	1.42**	-0.77**	2.68
	High Monitoring	5.07***	-1.28***	3.63**
Population Density	Ln(Population Density)	0.63*	9.22	4.81**
Education	Ln(Education)	-2.73**	0.44	1.78
Intensity of Agricultural Production	Ln(Crop Value)	0.46	0.04	-2.12
	Ln(Animal Value)	0.00	0.16	2.76
Immigrants	Ln(Percent Immigrant)	-0.67	0.36	0.24
Ethnic Composition	Ln(Percent Black)	1.34*	-1.87	7.23***
	Ln(Percent Asian or PI)	-2.11	-1.21	-8.85
	Ln(Percent Native American)	-1.62	0.93	9.74***
	Ln(Percent Hispanic)	-1.57	1.75	-4.34
	Ln(Percent Other)	-1.11	-0.07	2.76**
Gender	Ln(Percent Males)	-17.25*	15.66*	250.70***

Age Composition	Ln(Percent 0 to 4)	-5.29	0.13	-7.69
	Ln(Percent 5 to 17)	3.61	-1.36	34.15
	Ln(Percent 18 to 40)	6.42	-13.43***	46.39*
	Ln(Percent 65 or Older)	-2.25	-1.08	32.19
	Constant	153.30	733.62	737.54
	Observations	50	203	46
	Groups	21	47	11
	R-Squared	0.9239	0.0389	0.9948
	RE/FE	RE	FE	RE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Table 7: Regression Results for Model 2.b. (Site Type Effects Excluded from Table), Continued

		pH	Phosphorus	Sulfate
Income	Ln(Income)	0.14	-5.83	3.13
Time	Time	0.11**	-0.58	0.56
Water Acres	Ln(Water Acres)		0.81	
Monitoring Intensity	Moderately Low Monitoring	0.07	-1.46	1.17
	Moderately High Monitoring	-0.03	-2.57**	2.90**
	High Monitoring	0.27**	-1.74	2.28
Population Density	Ln(Population Density)	-2.91	1.11	-15.69
Education	Ln(Education)	0.07	5.31	1.83
Intensity of Agricultural Production	Ln(Crop Value)	0.07	-0.03	-1.23
	Ln(Animal Value)	-0.02	0.52	1.42
Immigrants	Ln(Percent Immigrant)	0.02	1.97	1.17
Ethnic Composition	Ln(Percent Black)	1.15**	-1.46	-8.09
	Ln(Percent Asian or PI)	0.56	-2.16	-13.03
	Ln(Percent Native American)	-0.17	3.80**	8.94*
	Ln(Percent Hispanic)	-1.19	2.80	-4.04
	Ln(Percent Other)	0.03	2.45*	-1.19
Gender	Ln(Percent Males)	0.76	-39.39	155.82
Age Composition	Ln(Percent 0 to 4)	1.08*	7.65	13.49
	Ln(Percent 5 to 17)	-0.61	-22.83***	-18.95
	Ln(Percent 18 to 40)	0.13	-39.42**	0.79
	Ln(Percent 65 or Older)	-1.35**	-15.31**	-3.32
	Constant	-214.55**	1098.67	-1117.47
	Observations	240	42	93

	Groups	49	17	28
	R-Squared	0.0087	0.9201	0.0781
	RE/FE	FE	RE	FE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Table 8: Regression Results for Model 2.b. with Ethnic Composition and Income Interaction Terms (Site Type Effects Excluded from Table)

	Variable	Nitrates	Selenium	Specific Conductivity
Income	Income	1.23E-04	-1.70E-03	1.51
	Income Squared	5.26E-10	5.96E-08	-3.98E-05
	Income Cubed	-2.22E-14	-4.43E-13	3.42E-10
Time	Time	0.23**	0.53	-348.14
	Time Squared	-1.19E-04**	-2.63E-04	0.17
Water Acres	Water Acres	7.89E-06	1.21E-05	1.04E+03
	Water Acres Squared	-1.24E-11	-1.30E-11	-3.71E-09
Monitoring Intensity	Moderate Low Monitoring	0.93	-0.49	1796.49
	Moderate High Monitoring	0.99	4.05*	3613.57*
	High Monitoring	3.01***	-0.05	1733.79
Population Density	Population Density	0.31	-0.50	-2302.46
	Population Density Squared	-1.68E-03	4.76E-03	76.69*
Education	Education	0.10	-0.27	-266.83
	Education Squared	-3.40E-04	4.30E-03	2.77
Intensity of Agricultural Production	Value of Crop	-2.08E-03	2.98E-03	-5.18
	Value of Crop Squared	1.36E-06	-5.39E-06	3.11E-03
	Value of Animal	-0.02	-0.06*	-3.22
	Value of Animal Squared	6.24E-05	8.02E-05	0.01
Immigrants	Percent Immigrants	-396.82	-3435.35	1755861.00
Ethnic Composition	Percent Black	113.15**	200.07	-186306.00**
	Percent Asian or PI	-20.72	277.28	-56437.36
	Percent Native American	11.32	-445.74	-40229.79
	Percent Hispanic	12.48	119.49*	-41764.89
	Percent Other	-167.98	483.67	120181.40
Income Interaction	Percent Immigrants*Income	3.84E-03	0.07	-59.29
	Percent Black*Income	-2.57E-03**	-0.01*	6.60***
	Percent Asian or PI*Income	1.22E+04	-0.01	2.55
	Percent Native American*Income	-4.6E-05	0.01	0.10
	Percent Hispanic*Income	-2.33E-04	-3.28E-03	1.19
	Percent Other*Income	0.01	9.89E-04	-14.09

Gender	Percent Males	-4.89	-9.77	82.81
	Constant			
	Observations	116	125	442
	Groups	32	42	52
	R-Squared	0.4895	0.4177	0.3240
	RE/FE	RE	RE	RE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Table 9: Regression Results for Model 3.a. (Site Type, Age and Composition, and Water Acres Effects Excluded from Table)

	Variable	Ammonia	Chromium	Copper
Income	Income	-2.46E-05	-1.03E-03	26.75
	Income Squared	4.88E-10	2.25E-08	-4.39E-04
	Income Cubed	-2.84E-15	-1.70E-13	2.16E-09
Time	Time	-3.35E-03	0.26	6923.70
	Time Squared	161.00*	-1.26E-04	-3.61
Spillover Effects	Crop_1	-71054.97***	2426.77	-7914567.00
	Crop_1 Squared	18.55	-3366271.00*	6.38E+09
	Crop_2	-1672.34	11348.34*	4.65E+07
	Crop_2 Squared	-291.90	-2900024.00***	-3.47E+09
	Crop_3	84450.58***	-22238.68*	-1.06E+08
	Crop_3 Squared	2011.26	1.23E+7**	4.39E+08
	Animal_1	-1898076.00	-254694.40*8	-3.31E+08
	Animal_1 Squared	1782.63	2.35E+8**	6.06E+11
	Animal_2	-2566277.00	14026.55	4.07E+08
	Animal_2 Squared	-3650.83	1.73E+08	-1.39E+12
	Animal_3	4534974.00	266603.70**	4.28E+08
	Animal_3 Squared	3.14E-08	-4.53E+8**	2.75E+10
Monitoring Intensity	Moderate Low Monitoring	-0.01	0.08	6278.37
	Moderate High Monitoring	-0.01	-0.99	18954.08
	High Monitoring	0.01	-2.01	14811.54
Population Density	Population Density	-4.39E-04	3.41**	-17655.90
	Population Density Squared	2.75E-04	-0.56**	1016.03
Education	Education	-2.70E-05	-0.36	-12823.49**
	Education Squared	2.35E-05	0.01	150.11
Agricultural Intensity	Value of Crop	9.82E-09	-0.02	-174.83
	Value of Crop Squared	-2.61E-05	2.10E-5*	0.06

	Value of Animal	-6.35E-07	0.05	-544.05
	Value of Animal Squared	-3.42	-2.17E-04	2.82
	Constant			
	Observations	94	67	95
	Groups	29	25	25
	R-Squared	0.7059	0.9974	0.6005
	RE/FE	RE	RE	RE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Table 9: Regression Results for Model 3.a. (Site Type, Age and Composition, and Water Acres Effects Excluded from Table), Continued

	Variable	Fecal Coliform	Nitrate	Specific Conductivity	Total Suspended Solids
Income	Income	-1.48	3.20E-04	1.70	4.87
	Income Squared	3.62E-05	-6.12E-09	-3.35E-05	0.00
	Income Cubed	-2.88E-10	4.32E-14	2.40E-10	0.00
Time	Time	53.25	0.37*	-175.43	-1306277.00**
	Time Squared	-0.03	-1.82e-4*	0.08	326.02**
Spillover Effects	Crop_1	3332767.00	990.55	-2210413.00	-6.22E+7**
	Crop_1 Squared	-3.08E+08	53314.97	-8.39E+08	4.09E+10**
	Crop_2	1170947.00	781.18	-2556546.00	-2.68E+07
	Crop_2 Squared	-1.64E+08	924.91	2.82E+07	2.12E+10
	Crop_3	-5858282.00	-2917.65	1.04E+07	9.76E+7**
	Crop_3 Squared	8.43E+08	133818.40	-4.95E+08	-9.92E+10**
	Animal_1	-9737963.00	-36363.43	4.84E+07	6.18E+07
	Animal_1 Squared	7.91E+10	7.54E+07	-6.56E+10	1.32E+11
	Animal_2	-1.35E+07	-54835.84	-5386712.00	5.30E+8*
	Animal_2 Squared	3.44E+10	7.32E+07	-8.90E+09	-1.11E+12**
	Animal_3	3.48E+07	69785.83	-4.80E+07	-1.99E+08
	Animal_3 Squared	-1.28E+11	-1.00E+08	6.46E+10	3.49E+11
Monitoring Intensity	Moderate Low Monitoring	1112.81***	0.70	2147.68	1486.70
	Moderate High Monitoring	964.08***	0.32	3940.19**	2815.69
	High Monitoring	687.60	2.25***	2456.05	3964.39
Population Density	Population Density	-264.50	0.30	-505.85	-80383.80

	Population Density Squared	-9.96	-0.01	33.99	4592.51
Education	Education	3.29	0.17	23.33	-42.67
	Education Squared	0.20	-1.97E-03	-1.47	1.17
Agricultural Intensity	Value of Crop	0.55	1.81E-03	-18.18**	90.54**
	Value of Crop Squared	-1.86E-04	-7.32E-07	0.01*	-0.0461126***
	Value of Animal	8.85	-0.03	-2.61	-26.84
	Value of Animal Squared	-0.03	8.96E-05	9.53E-03	-0.04
	Constant				1.31E+9**
	Observations	55	116	442	145
	Groups	16	32	52	45
	R-Squared	0.9981	0.5037	0.3239	0.0092
	RE/FE	RE	RE	RE	FE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Table 10: Regression Results for Model 3.b. (Site Type, Age and Composition, and Water Acres Effects Excluded from Table)

		Arsenic	Dissolved Oxygen	Magnesium
Income	Ln(Income)	0.75	-4.03	-5.82
Time	Time	0.03	-0.28	0.40
Spillover Effects	Ln(Crop_1)	-0.90	0.17	-0.43
	Ln(Crop_2)	-0.70	-0.59	11.97**
	Ln(Crop_3)	1.13	-0.16	0.40
	Ln(Animal_1)	-2.31	0.80	-1.65
	Ln(Animal_2)	-3.20	1.36	-11.33***
	Ln(Animal_3)	5.99**	-2.28	4.04
Monitoring Intensity	Moderately Low Monitoring	1.24*	-0.73**	2.68**
	Moderately High Monitoring	1.53**	-0.77**	2.19*
	High Monitoring	6.71***	-1.24**	4.00***
Population Density	Ln(Population Density)	0.01	10.72	4.94**
Education	Ln(Education)	-3.33**	0.48	2.15
Intensity of Agricultural Production	Ln(Crop Value)	0.91	0.00	-2.83
	Ln(Animal Value)	0.02	0.32	4.50
Gender	Ln(Percent Males)	-16.19	14.72	311.38***
	Constant	-132.11	604.72	-84.40
	Observations	50	203	46
	Groups	21	47	11
	R-Squared	0.9460	0.0346	0.9637
	RE/FE	RE	FE	RE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

Table 10: Regression Results for Model 3.b. (Site Type, Age and Composition, and Water Acres Effects Excluded from Table), Continued

		Nickel	pH	Phosphorus	Sulfate
Income	Ln(Income)	0.17	-0.18	-9.29	2.05
Time	Time	-0.50**	0.12**	0.60	1.64
Spillover Effects	Ln(Crop_1)	-0.16	0.05	0.37	-1.08
	Ln(Crop_2)	-1.17	0.28	8.81***	1.58
	Ln(Crop_3)	0.88	0.20	-6.09***	-1.15
	Ln(Animal_1)	2.23	-0.64*	-2.07	0.40
	Ln(Animal_2)	0.42	0.01	14.07**	-1.93
	Ln(Animal_3)	-2.11	-0.27	-13.75***	-0.07
Monitoring Intensity	Moderately Low Monitoring	0.82**	0.04	1.59	0.95
	Moderately High Monitoring	1.18**	-0.02	0.42	2.63**
	High Monitoring	0.12	0.29***	-3.47**	1.76
Population Density	Ln(Population Density)	-0.35	-3.14*	2.14	-37.66
Education	Ln(Education)	1.63	0.16	14.64*	1.95
Intensity of Agricultural Production	Ln(Crop Value)	-0.50*	0.12	-1.74**	-2.03
	Ln(Animal Value)	0.31	0.03	2.14***	2.29
Gender	Ln(Percent Males)	7.08	0.73	-101.79	264.78
	Constant	992.09**	-244.10**	-1149.64	-3268.17
	Observations	45	240	42	93
	Groups	21	49	17	28
	R-Squared	0.8785	0.0143	0.9697	0.0821
	RE/FE	RE	FE	RE	FE

*, **, and *** indicate significances at the 10%, 5%, and 1% confidence levels, respectively.
FE and RE indicate the fixed effect or random effect specification, respectively.

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