Pesticide Regulation in California: A Preliminary Assessment of Current Costs and Benefits, and Implications for Future Policy Reform and Research

Rachael E. Goodhue and Kelly Wiersma
University of California, Davis

Prepared for the American Agricultural Economics Association Annual Meeting
August, 2001
Chicago, Illinois

Abstract:
A necessary condition for socially desirable regulation is that total social benefits outweigh total social costs. We report available information regarding the costs of pesticide regulation in California, and evaluate the likelihood that the generated benefits outweigh these costs. We conclude with a discussion of the implications for future policy research and reforms.

Author Affiliations:
Rachael Goodhue is an assistant professor and Kelly Wiersma is a 2001 B.S. graduate, both affiliated with the Department of Agricultural and Resource Economics, University of California, Davis. Goodhue is a member of the Giannini Foundation of Agricultural Economics.

Contact Information:
Email: goodhue@primal.ucdavis.edu.
Phone: 530 754 7812
Fax: 530 753 5614

Pesticide use regulations facing Californian producers are increasing in number and complexity, relative to even a decade ago. In order to apply his chosen chemical, a producer may need to become or hire a licensed pesticide applicator, notify local authorities of his intended use (and perhaps obtain their formal approval), abide by buffer zone and application rate restrictions, comply with state worker safety requirements, and report his use to the state, in addition to complying with federal regulations. For some chemicals a permit is required prior to application in California. In short, we are approaching a system of prescription pesticides, where only licensed individuals may apply a pesticide under use restrictions when an application is deemed necessary by regulators or experts.

The evolution of our pesticide regulation system toward ever-greater complexity presents some striking policy questions. In this paper, we seek to address two such questions: How large must the environmental and health benefits of pesticide regulations be in order to justify compliance costs borne by the private sector and enforcement costs borne by regulators? Based on available information regarding such benefits, does the current California pesticide regulation system generate enough benefits to justify its costs?

Economic theory regarding regulation of externalities focuses on optimal regulatory design. The optimal level of an activity generating a negative externality occurs where the marginal social benefit and the marginal social cost of the activity are equal, if an interior optimum exists. Under perfect information and costless implementation, the optimal regulation will use quantity restrictions or taxes to implement this solution. Another possibility is that a privately profitable activity is so socially costly that the optimal regulatory solution is a ban. In this case, the marginal social cost of the activity is everywhere above its marginal social benefit.

In reality, information is not perfect or complete, nor are the consequences of actions known with certainty. Economists have used mechanism design and other asymmetric information approaches to model the possible consequences of this imperfection. Risk analysis is used to analyze the implications of exogenous uncertainty. Implementation is not costless. Constructing and maintaining a regulatory system requires the use of real resources, as does monitoring of regulated agents. In turn, these economic agents must expend real resources on compliance activities. Some of these costs are one-time fixed costs, and some of them may be repeated, but independent of the marginal cost of private agents' economic choices. From a social viewpoint, implementation costs reduce the net benefit of mitigating a negative externality. In fact, depending on their structure, implementation costs may lead to negative net benefits for policies that equate the marginal social costs and social benefits of the regulated activity.

Information and implementation costs are important considerations when designing or reforming a regulatory system. As California's regulatory system increases in complexity and costliness, the question of whether the current system is the most desirable approach becomes more pressing. Fully answering this question is beyond the scope of this paper. Instead, we provide some measures that provide insight into the likelt degree of cost-effectiveness of California's existing regulatory regime. If the current system's total costs outweigh its benefits, then the need for reform is pressing. If current benefits outweigh its costs, then determining the efficiency of the system requires marginal analysis. We conclude the paper with a discussion of the correct approaches for doing so.

We begin by reviewing the existing system of pesticide regulation in California, and documenting direct regulatory costs. We then identify some indirect regulatory costs, and provide rough estimates of their possible magnitudes. We estimate a state-level production function, and are unable to reject the hypothesis that there is no producer surplus generated from pesticide use that can be used to offset the costs of regulation. We use our cost calculations to generate a lower bound on the health and environmental benefits that must be generated in order to justify the costs of the current regulatory system, and discuss the likelihood that the generated benefits are indeed of the necessary magnitude using available measures of the valuation of such benefits. Finally, we discuss the considerations necessary for conducting a true marginal analysis, and the factors that are likely to determine whether the current California pesticide regulatory approach should be reformed.

Pesticide Regulation in California: Direct Costs and Functions

The California Department of Pesticide Regulation (DPR) is the primary state-level government agency responsible for pesticide regulation. According to its mission description in its 1997 strategic plan, "DPR regulates all aspects of pesticide isales and use, recognizing the need to control pests, while protecting public health and the environment and fostering reduced-risk pest management strategies."[1] In pursuit of this mission, it manages the most comprehensive statewide pesticide enforcement program in the nation. It is assisted in this by the County Agricultural Commissioners. The DPR's main policy mandate is to implement and enforce pesticide use regulations. It is responsible for registering pesticides for use in California. It licenses pesticide applicators. It tracks pesticide use in California and publishes aggregated results. Finally, it conducts research and supports outside research regarding pesticide efficacy, environmental effects, and health effects.

The DPR budget was $52.2 million for the 1999-2000 fiscal year.[2] The DPR budget allocates funds to seven branches. Ranked in order of decreasing funding, the branches are local Assistance, enforcement, environmental monitoring/pest management, pesticide registration, worker health and safety, medical toxicology, and information technology.

$12.8 M (25%) of the budget funds the Local Assistance Branch. As a complement to the Enforcement Branch, Local Assistance provides field enforcement carried out by county agricultural commissioners and their staffs. The funds allocated to Local Assistance provide training, coordination, supervision, and technical support by the Enforcement

[1] http://www.cdpr.ca.gov/docs/planning/mission.htm Accessed 5/13/01.

[2] www.cdpr.ca.gov/docs/pressrls/balancesheet.pdf, DPR Balance Sheet, May 9, 2001.

Branch to each of the county commissioners enabling comprehensive enforcement by the DPR.

$12.4 M (24%) of the budget is allocated to the Enforcement Branch, which enforces pesticide laws and regulations, certifies and licenses pesticide users and applicators (including brokers, dealers, agricultural pest control advisors, and pest control businesses). The Branch conducts outreach and compliance programs and administers the nations largest produce residue-monitoring program. As mentioned previously, the Enforcement Branch also provides training and supervision to Local Assistance.

$11.8 M (23%) of the budget goes to the Environmental Monitoring/pest management Branch, which monitors the environment and the effects of pesticide use on the environment. The Branch analyzes the hazards of specific pesticides and develops preventive strategies to reduce the negative impacts on the environment. Pesticide users that comply with the environmentally sound and effective practices are given grants by the Branch as an incentive to continue such practices.

$6.5 M (12%) of the budget is given to the Pesticide Registration Branch. Before a pesticide can be used or sold it must be registered (licensed) under the DPR. The Registration Branch coordinates the evaluation processes necessary to make registration decisions. The Branch maintains product label files and a pesticide data library gathered by Branch scientists as well as scientists in other Branches.

Both the Worker Health/Safety Branch and the Medical Toxicology Branch receive funds of $3.2M (6%). The Worker Health/Safety Branch evaluates, assesses and characterizes human exposure to pesticides and develops risk reduction procedures. The Branch investigates alleged pesticide related illnesses and investigates work conditions. The Medical Toxicology Branch reviews toxicology studies and reports scientific estimates on the likelihood of adverse health effects resulting from exposure to specific pesticides and the dose of pesticide exposure that would cause the adverse effect.

$2.3M (4%) of the budget is allocated to the Information Technology Branch, which is responsible for the overall coordination of data processing activities. The Branch provides support services to the Department including implementation and evaluation of information technology needs.

The DPR's revenues FY1999-2000 totaled $52.2 M, balancing the expenses listed above. The DPR is supported through four funds: the state General Fund, minor funds (such as reimbursements), federal funds, and the DPR fund. The DPR fund constituted $34.4 M (66%) of total revenues.[1] There are four components to the DPR Fund: mill assessment revenues (fees collected for pesticide sales), registration of products and pesticide-related business licenses, transfers from reserves, and interest income.

The 1997 Census of Agriculture reports that there were 41,639 farms in California with a market value of agricultural products sold greater than $10,000.[2] Dividing the DPR budget by the number of farms, the pesticide regulation enforcement cost per farm is $1,254. Because part of the funds obtained to pay for enforcement are obtained through assessments and licensing fees, the full cost is not born solely by California taxpayers. In fact, mill assessment fees totaling $27 million account for 52% of the revenues received by the DPR. When you add registration and licensing fees totaling $4.1 million to the mill assessment fees, farmers and others certified to buy, use, and sell pesticides provide 60% of the DPR's revenues.

There are three types of licenses or certifications issued in California to agricultural producers and others who buy, sell, and/or use pesticides. First, a person may obtain their Agricultural Pest Control Adviser License (PCA license). A PCA license is required when a person offers a recommendation on agricultural use of pesticides, or holds him or herself as an authority on any agricultural use. A person who sells or solicits pesticides for agricultural use must also possess a PCA license.[3] Obtaining a PCA license requires the most extensive education and training program of the three types of certification that are available. There is a licensing exam that costs $50, and a license renewal fee of $40 per year (payable every second year as an $80 lump sum) as well as 20 hours per year of continuing education.[3]

The second type of license is the Qualified Applicator License, which is needed by persons who supervise the application of restricted and / or general use pesticides, and are responsible for the safe and legal operation of the pest control business. This license also has an annual education requirement of 10 hours. The initial licensing exam costs $40, and the renewal fee is $30 per year (paid every 2 years).[3]

The last form of certification is a Qualified Applicator Certificate. Of the three, this has the lowest requirements and costs. Any person that uses or supervises the use of federally restricted pesticides or State restricted materials for any purpose must be certified as a Qualified Applicator. This certificate is also required for anyone in the business of landscape maintenance who performs pest control that is incidental to such a business. This certificate requires an initial exam with a fee of $15, a $15 renewal fee per year (paid every two years) and 10 hours of continued education per year.[3]

Indirect costs

The indirect costs of California's pesticide regulation system are those that are not incurred as direct budgetary costs. The most important indirect cost is time spent on compliance activities by private entities, although there are other costs. For example, if

---

[2] www.nass.usda.gov/census/census97/congdist2/states/california/ca.htm, California Farm Count by Congressional District, May 7, 2001

[3] www. cdpr.ca.gov/docs/license/apcainfo.htm, Licensing and Certification Program, February 6, 2001

county agricultural commissioners are not fully compensated by the DPR for staff time spent on processing pesticide application permits and other activities, then this time is an additional cost. We have no evidence regarding whether this cost exists, or its significance if it does.

Some compliance activities are undertaken by agricultural producers. Producers must file applications for pesticide use permits, and maintain records related to their use of pesticides. Producers must keep records regarding their use of pesticides, worker education regarding pesticide use, and worker pesticide exposure. Producers must ensure that workers have had the necessary instruction in pesticide use application. For some pesticides, producers must notify neighboring property owners before application. Producers with fields near houses, schools, and other places where people live or spend a substantial amount of time face limitations on the types of pesticides they use, the manner of application, and even the timing of application. Producers may alter their production practices in order to comply with regulations, which may be costly. We do not consider these production costs in this analysis.

Carter et al. (1996) provide information on one specific component of such costs: the paperwork required to comply with regulations. The sample of 263 California producers spent an average of 21.8 hours per month on regulation-related paperwork. This total included other types of regulation, such as worker safety and air quality. Sixty-eight percent of respondents listed pesticides specifically as among the three most time-consuming types of regulation. Many of the other regulatory categories are at least partially related to pesticide use; for example, respondent comments regarding worker safety and training regulations suggest that in some cases they were commenting on pesticide application training requirements. Based on these two observations, we assume that half of the time spent by respondents on regulation paperwork was related to pesticide use: 10.9 hours per month, or 130.8 hours per year. Again using our estimated wage of $10 per hour, annual record keeping costs are $1,308 per producer. On a per-farm basis, these costs are roughly as large as the direct budgetary costs of $1,254 per farm. Multiplying by the 41,639 California farms with over $10,000 in sales, the total statewide cost is $54,463,812.

Some compliance expenses are borne by pesticide applicators, including some producers. Each other year, licensed pesticide applicators pay a fee to the DPR. These fees are included in the direct budget costs discussed above. Training costs, however, are not. All licensed applicators must complete additional training every year. Some training options are free of charge, others require payment of an additional fee. The amount of training differs across licenses. PCA's must complete 20 hours of training per year, while the other two categories must complete 10 hours of training. Given the required training hours and the number of applicators, roughly 750,000 man-hours each year are expended. At a wage of $10, the cost of the time spent on this compliance activity is $7.5 million. This cost excludes any fees paid for continuing education classes.

Still other expenses are incurred by agricultural processors. Some firms monitor pesticide use very closely, including compliance with federal and state requirements. In order to do so, they must hire staff to monitor growers and maintain records regarding pesticide use. No systematic data has been collected on such practices, so we do not provide an estimate of the costs involved. We recognize that not accounting for these costs biases our estimate of total cost downward.

The DPR pesticide regulation process is another source of indirect costs. This process is similar in many respects to the U.S. EPA pesticide regulation process, but it is completely independent. EPA registration does not eliminate the need for a chemical company to obtain California-specific registration. This increases the costs of marketing pesticides in California. Further, California requires separate registration processes for each use for each crop. Since many specialty crops account for a limited number of acres in California, in many cases a chemical company will choose to not pursue registration for these uses. Total demand is limited, which makes it more difficult to recover the costs of registration. Consequently, efficiency-improving pesticides may not be marketed. Of course, it may also sometimes be the case that the costs of registration prevent the introduction of pesticides that would negatively impact social welfare, due to the large health and environmental externalities. We have no estimate of these potential costs and benefits. The net effect on our analysis of omitting these considerations is indeterminate.

Finally, pesticide regulations may have dynamic indirect consequences. Rather than focusing on increasing agricultural productivity, at least some agricultural research and innovation activities may be oriented toward aiding farmers and other industry members comply with regulations. To the extent that this redirection increases social surplus by reducing compliance costs, mitigating negative externalities of agricultural production, or other means, regulation will have a dynamic benefit. However, the actual degree of redirection may not have been the social surplus-maximizing choice.

Measuring the Benefits of Pesticides: Econometric Production Model

In order to assess how large the reduction in negative externalities must be, we first examine whether pesticide use generates producer surplus in agricultural production. We model agricultural output as a Cobb-Douglas function of pesticides, other material inputs, capital costs, and a constant term, as in Teague and Brorsen (1995). This allows us to estimate a log-linear production function. One drawback of this model specification is that it imposes a constant marginal revenue product of an input for a given output price and output level. Our null hypothesis is that the marginal revenue product of the last dollar spent on pesticides will equal its marginal cost of one dollar. If accepted, our null hypothesis, considered in conjunction with our data and specified functional form suggests that there is no producer surplus generated by pesticide use available to offset the costs of regulation. If we have misspecified the production function, we may underestimate the producer surplus generated by pesticide use. More generally, if we reject our null hypothesis and need to integrate the marginal revenue product function in order to estimate producer surplus our estimates will be potentially quite sensitive to the functional form we specify for production.

Our time series data for California, described below, fails the Durbin-Watson test for autocorrelation, so we perform an autoregressive estimation procedure with a one-period lag. Higher order lags did not have statistically significant coefficients. Since the data is in dollars, we estimate dollars of agricultural output produced as a function of dollars expended on inputs.

Our estimated equation is of the form

(1) $\ln(PQ) = B_0+B_1 \ln(WPest)+ B_2 \ln(OthMat) + B_3 \ln(Capital)$

where PQ is the value of crop production, WPest is expenditures on pesticides, OthMat is other material inputs, and Capital is capital expenditures.

Data

We used data on the value of crop production and the cost of agricultural inputs for California, 1949-1999, available from the Economic Research Service, USDA.[3] We deflated the current values using an index of prices paid by producers with a base period of 1910-1914 (Strickland, 2001). We assign other inputs as either other material inputs, or non-land capital inputs. We aggregate seed, fertilizer and lime, and hired labor as other material inputs (OthMat), and aggregate other intermediate inputs, electricity, fuel and oil, and interest as non-land capital inputs (Capital).

One drawback of our data aggregation is that we can not separate inputs used in livestock production from inputs used in crop production. This may bias our parameters. In particular, this is likely to understate the importance of pesticides in crop production. A second drawback is that we can not separate real estate and non-real estate interest, so our non-land capital inputs variable is biased downward by real estate interest expenses.

Results

Our econometric estimation results are reported in Table One. Based on these results, we can not reject the hypothesis that producers indeed equate the marginal revenue product of a dollar spent on pesticides to its cost. Our estimated production elasticity for pesticides is not significant at the 5% level. Accordingly, we calculate estimates of the marginal revenue product for our point estimate of the elasticity, and for values one standard deviation above and below the point estimate. Our estimated elasticity results in marginal products that are not significantly different from 1, using two different measures of the ratio of the value of agricultural output to the cost of pesticides used. One is the sample average for our entire 1949-1999 sample, 24.75. The second is the average of the last five years in our sample, 1995-1999, 17.51. We include marginal product estimates based on the latter in order to reflect the relatively larger share of pesticides in agricultural production costs in more recent years.[4]

---

[3] http://www.ers.usda.gov/data/FarmIncome/finfidmu.htm For California, 1949-1999.

[4] Of course, it would be preferable to estimate elasticities based only on this recent time period. The data set used here does not permit this.

Table One: Agricultural Production Function

Variable	Coefficient Estimate	Standard Error
Intercept	3.912	0.740**
Pesticides	0.084	0.062
Other Material Inputs	0.232	0.110*
Capital Expenses	0.346	0.085**

*Significant at the 5% level. ** Significant at the 1% level.

We can not reject that the marginal revenue product is equal to one, the cost of an additional dollar of pesticide. Further, our data combined with our model specification dictates that the estimated marginal product is constant for all values of total pesticide expenditure. Thus, there is no producer surplus to offset the costs of pesticide regulation. All offsetting benefits must be accounted for though the mitigation of negative health and environmental consequences.

Comparing Benefits and Costs

We have obtained an estimate of some of the direct and indirect costs of pesticide regulation, summarized in Table 2. In order for the current regulatory system to be socially efficient, the external benefits of pesticide regulations must be at least as large as the costs. These regulations are intended to protect worker health and safety, consumer health and safety, and the environment. Such benefits are difficult to quantify. In addition to the difficulty of valuing these outcomes, it is difficult to project what marginal and total externalities would be sustained in the absence of regulation.

Table Two: Costs of Pesticide Regulation

Cost	Dollars per year
Direct DPR budget	$52,200,000
Indirect: producer record keeping	$54,463,812
Indirect: licensing education	$7,500,000
Total direct and indirect costs	$114,163,812

Realizing these difficulties, we offer some rudimentary approximations using existing willingness-to-pay estimates and other available information. While these measurements are crude at best, they do provide us with an idea of the relative magnitudes of the valuations that are necessary to justify the existing pesticide regulation system. We consider three specific objectives of specific DPR regulations: protection of groundwater from pesticide contamination, protection of workers and non-workers from negative health and safety effects of acute pesticide exposure, and protection of workers from negative health and safety impacts of chronic pesticide exposure. For each objective, we compare the **total** costs of pesticide regulation to measures of the benefits obtained. Clearly, these examples do not include all DPR objectives or regulations. Equally clearly, it is difficult if not impossible to separate the impact of DPR pesticide regulation from federal regulation. We offer simple calculations regarding the importance of this problem for our findings.

Protecting groundwater from pesticide contamination

The economics literature contains a number of estimates of the value of the protection of water from pesticides and other agricultural contaminants. We use estimates of household willingness to pay to calculate the social benefit of DPR regulations. These valuations range from $34 –69 per (urban) household annually (Caudill and Hoehn, 1992), to a mean of $641 per household annually, with a range of $165-$1,452 per household (Sun, Bergstrom and Dorfman). Groundwater accounts for 30% of California's water supply in a normal year, so we calculate the value of protecting the water supply of 30% of California's 11,445,800 households from contamination. This calculation assumes that groundwater supplies the same share of urban and rural households as it does total water supplies. Given these assumptions, the total willingness to pay for this activity always outweighs or equals the total costs of state-level regulation. (Of course, this assumes that the valuation can be used for the existing level of actual contamination, relative to its level in the absence of regulation.) These calculations also ignore the impact of federal regulations regarding pesticide use and water pollution.

To evaluate the importance of the allocation of the benefit to state and federal regulations, we calculate the share of the benefits that would have to be attributable to the state regulation to cover regulatory costs. Under the lowest willingness to pay scenario, state regulations would have to account for virtually all groundwater protection (98%). This share declines to 2% for the higher valuations. Given the range of valuations, it appears that the benefits of groundwater protection likely offset a significant portion of pesticide regulation costs. In addition, if households' valuation of the prevention of groundwater contamination is independent of the share of their water supply obtained from groundwater, our estimate of the benefits of groundwater contamination may be biased substantially downward.

Acute pesticide exposure

In order to assess the benefits of regulation in terms of reducing negative effects of acute pesticide exposure for workers and non-workers, we calculate the costs of the cases of pesticide exposure reported to the DPR for 1999 that resulted in hospitalization or disability, and were determined to be definitely or probably linked to pesticide exposure. We then calculate how large the reduction in these health and safety costs due to DPR regulation must have been in order to offset all costs of pesticide regulation. That is, we ask: if the current level of costs due to acute pesticide exposure is (100%-x%) of the level of costs that would have been incurred in the absence of regulation, how large must x be to cover the costs of pesticide regulation? We examine this question for a variety of shares of regulation due to DPR regulation, rather than other state and federal regulators.

We include only costs related to time lost from work, evaluated at $10/hour, for disabilities with a definite time reported. In 1999, there were six individuals who were disabled indefinitely. For their disability cost, we use the lower bound for the value of a life range for a worker in a standard blue collar job cited by Viscusi, Vernon and Harrington (2000): $3 million. For hospitalizations, we included the costs of time lost from work and a nominal per day cost of hospital treatments: $200. This likely understates the true costs of hospitalizations. This bias will result in a larger percentage reduction in the costs of acute pesticides exposures being necessary to offset the costs of regulation.

Examining the findings reported in Table 4, it appears unlikely that the mitigation of negative externalities associated with acute pesticide exposure offsets a large share of the costs of pesticide regulation, given the approach and data we use. Many observers believe that pesticide exposure cases are underreported; doctors may not associate the observed symptoms with pesticide exposure, and many farmworkers are thought to be reluctant to seek medical attention due to lack of insurance, language barriers, and, in some cases, the risk of deportation. DPR has implemented procedures to help it address the former problem. In 1999, roughly half of the investigated cases were found through these procedures, rather than being originally reported as pesticide exposure (DPR website, 2001). We are investigating means of addressing the latter difficulty. If we simply adjust occupational acute exposure costs by 1.33, roughly the ratio of total workers employed as estimated by agricultural labor experts to the official State of California estimate, our primary conclusion remains unchanged. The benefits of pesticide regulation due to reduced acute pesticide exposure could offset a large share of the costs of pesticide regulation. A 50% reduction in acute exposure costs due to state regulation would cover 48% of the costs of state pesticide regulation. Provided that the state's share of the total reduction is at least 25%, even a 25% reduction in exposure costs due to regulation will result in the state's share of the benefits offsetting at least 8% of its budgetary costs.

Table Three. Share of Pesticide Regulation Costs Offset by Reduced Acute Exposure Cases as a Function of the Reduction in Exposure Costs and the Share of Reduction due to State Regulations

Reduction in	*state share*			
exposure costs	0.05	0.25	0.5	1
0.25	0.02	0.08	0.16	0.32
0.50	0.02	0.12	0.24	0.48
0.75	0.05	0.24	0.48	0.96
0.95	0.24	1.20	2.40	4.81

One factor that suggests that the benefit of state regulation may be larger in this area that is others is that the California DPR is recognized nationwide as a leader in research and policy development regarding the chronic and acute health and safety risks faced by workers and others during pesticide application. Anecdotally, the EPA sometimes uses this work to aid in developing its own policies. Any such influence of DPR actions on national regulations will increase the relative benefits of DPR regulations.

<u>Chronic pesticide exposure</u>

It is difficult to obtain data regarding realized costs of chronic pesticide exposure, although it is possible to obtain projections from medical experts and others. Rather than attempting to pursue this approach and evaluate the validity of medical studies, we calculate the necessary changes in various outcomes of exposure to offset the total costs of pesticide regulation. We use two estimates of the measure of the value of life, $3 million and $6 million, cited as the lower and upper ends of the most commonly found range in Viscusi, Vernon and Harrington (2000). Using these values, a reduction of 19-38 deaths annually due to chronic ailments resulting from pesticide exposure will offset the annual costs of pesticide regulation.

Alternatively, a reduction in the risk of a chronic pesticide exposure fatality per worker *per annum* due to regulation of 0.23 cases per 10,000 workers to 0.45 cases per 10,000 workers justifies annual pesticide regulation expenditures, given the number of agricultural workers in California.[5] For purposes of comparison, the EPA's negligible risk standard for exposure to pesticides *through the food supply* requires that a person's maximum *lifetime risk* of contracting cancer be one in a million or less. For a different perspective, under the Superfund Program the EPA is mandated to require cleanup of a toxic waste site if the lifetime cancer risk from exposure is at least 1/10,000, while cleanup may be required at the EPA's discretion if the lifetime cancer risk is at least one in a million (Viscusi, Vernon and Harrington, 2000). Assuming a 75-year lifespan, and assuming that individual lives may be treated in term of individual-years of exposure, the one in a million requirement translates into 0.13 cases per 10,000 exposed individual-years, or fewer. In other words, the necessary reduction due to state regulation must be roughly 2-3.5 times as large as the EPA standard for negligible exposure through food consumption. On the other hand, the necessary reduction to cover the costs of regulation is orders of magnitudes smaller than the risk standard for mandatory toxic waste site cleanup, which converts to 13 fatalities per 10,000 exposed individual-years. Thus, the likelihood that the net benefit of regulation covers a substantial share of state pesticide regulation costs depends on the exposure risk that would occur in the absence of regulation, and the marginal change in exposure due to state, rather than federal, regulation.

Given the relative magnitude of the EPA food standard compared to the necessary change in fatalities for state regulation to be cost effective and given the EPA's consideration of worker exposure in their broader risk assessment component of their pesticide regulation process, it seems unlikely that savings from the identified costs of mitigated chronic illnesses will offset all of the costs of the California pesticide regulatory system, although it may offset a non-negligible share. As mentioned earlier, DPR research and policies may be used by the EPA in its own decision making process, which would increase the benefits due to state activities. Table 5 reports the share of DPR expenses offset by the benefits of reduced chronic illnesses due to pesticide exposure as a function of the annual risk reduction per 10,000 individuals due to pesticide regulation, and the share of this reduction due to state regulation. If the impact of regulation is near the lower end of the range of EPA risk standards, perhaps a change of 0.50 or 1 per 10,000 individual years, then even a small state share of this reduction, such as 5%, will offset 8-17% of our identified state pesticide regulation costs. The same holds true for smaller regulatory risk reductions when a larger share of the reduction is due to state regulation. In order to cover 8% of costs, state regulation must reduce the risk of chronic illness by 0.025 instances per 10,000 individual-years of exposure. To cover 17% of costs, it must reduce

[5] For the total number of agricultural workers, we use the approximate sum of the total number of farms as a proxy for farm operators (from the Agricultural Census, 1997) and the total number of farmworkers (from Martin and Perloff, 1996) estimated for the state of California: 841,000 in total.

the risk by 0.05 instances per 10,000 individual-years of exposure. Given that negligible exposure translates to 0.13 instances per individual-years of exposure, a net contribution in the 8-17% of total costs seems plausible, given our assumptions.

Table Four. Share of Pesticide Regulation Costs Offset by Reduced Chronic Exposure Risks as a Function of the Reduction in Exposure Risk and the Share of Reduction due to State Regulations

Change in risk of	*state share*			
chronic illness per 10,000 individual-years	0.05	0.25	0.50	1.00
0.05	0.01	0.04	0.08	0.17
0.10	0.02	0.08	0.17	0.33
0.15	0.02	0.12	0.25	0.50
0.50	0.08	0.41	0.83	1.66
1	0.17	0.83	1.66	3.31
5	0.83	4.14	8.29	16.57
10	1.66	8.29	16.57	33.15

Implications for policy analysis and policy reform

Since it appears likely that the California pesticide regulatory system can be plausibly considered cost effective in terms of total costs and total benefits, marginal analysis must be used to determine the degree of efficiency of the current system, and whether or not the current system should be reformed. The question then arises of the correct approach to an analysis of the marginal benefits of a regulatory system. One approach is to evaluate the effects of small changes in the levels of regulated activities. This approach is difficult to implement when evaluating an aggregated regulatory system that addresses multiple activities and goals, such as the California pesticide regulation system. It is further complicated by the simultaneous existence of the federal regulatory system.

A second approach is to evaluate "marginal" activities, such as newly introduced regulations. Another category of marginal activities would be ones that provide for more restrictive limitations on pesticide use than national regulations, or that add an additional type of restriction on pesticide use relative to national regulations. Methyl bromide use restrictions implemented by the DPR in January, 2001, are an example of a new regulation that adds an additional type of restriction relative to national regulations.

While the EPA restricts the total amount of methyl bromide that may be used in the U.S., the DPR regulations specify permissible combinations of acres and application rates that may be applied at any given time, and include buffer zone restrictions for fumigated areas. The EPA regulations are intended to combat global warming (methyl bromide is slated to be banned completely in 2005). In contrast, the DPR regulations are intended to restrict worker and public exposure to methyl bromide during the application process. Evaluating such instances has the additional advantage of separating the social benefits due to EPA regulations and social benefits due to DPR regulations.

If marginal activities appear to not be cost-effective, then alternative approaches to pesticide regulation should be considered. Any such evaluation of potential policies should consider implementation costs explicitly. Further, in a regulatory system that addresses multiple goals and activities, the most desirable regulatory approach may differ by activity.

Many factors determine the relative performance of different systems. The more heterogeneous producers are in terms of the effects of their use of a specific pesticide or application procedure on profit and social welfare, the less likely it is that a use restriction-based system, such as the current system, will dominate a prescription-based system, where individuals will need to meet specified requirements to apply the pesticide. For example, regulations intended to protect worker health and safety are likely to have homogeneous benefits and costs across producers. In this event, a use restriction system may be preferable. In contrast, regulations intended to protect public health and safety with regard to pesticide application are likely to have highly heterogeneous benefits across producers, as well as potentially heterogeneous costs. This suggests that a prescription approach may be preferable to a use restriction approach for such policies.

Discussion

In this paper, we have developed a lower bound for the externalities that must be mitigated by the current pesticide regulatory system in order for these benefits to outweigh direct and indirect regulatory costs. Using information regarding the value of health and environmental benefits to perform rough calculations, it appears that the current regulatory system is cost-effective. However, this statement assumes that the benefits of the California-specific regulatory system can be separated from the effects of the federal regulatory system, and that we have not dramatically over-estimated the share of benefits due to the state system. Further, based on our econometric analysis, we assume that there is no producer surplus generated by pesticide use that may offset regulatory costs. Our choice of functional form may bias our evaluation of producer surplus. Given that studies exist that show pesticides are overused, while other studies demonstrate they are underused based on the same marginal theoretical criterion, we cannot predict the direction of any bias with confidence. Finally, there were many costs that we could not estimate, many benefits we did not evaluate, and our measures of benefits and costs alike were crude. We did not include any allowances for uncertainty regarding costs or benefits, or the impact of such uncertainty on expected social surplus. Nonetheless, it appears that the California pesticide regulation system provides benefits greater than its costs. Refinements of these estimates *for the system as a whole* are unlikely to reverse this conclusion, unless the state-level contribution to externality mitigation is infinitesimal relative to federal regulation, and/or the unmeasured costs are orders of magnitude larger than the estimated costs

Based on our analysis, we can not draw conclusions regarding the cost-effectiveness of any specific regulatory activity, nor regarding any measure of the "marginal" benefit of the regulatory system. Our findings do allow us to conclude that any efficiency justification for reform of the pesticide regulatory system must be based on an analysis of specific regulatory activities, an explicit and detailed evaluation of the marginal benefits of state regulation given federal regulation, or on the dynamic consequences for agricultural productivity.

Sources

California Department of Pesticide Regulation website. Specific pages used: http://www.cdpr.ca.gov/docs/dprdocs/pisp/1999pisp.htm Information regarding acute pesticide exposures.http://www.cdpr.ca.gov/docs/planning/mission.htm DPR mission statement. Accessed 5/13/01 www.cdpr.ca.gov/docs/pressrls/balancesheet.pdf, DPR Balance Sheet, May 9, 2001. http://www.cdpr.ca.gov/docs/license/apcainfo.htm Licensing and Certification Program. Accessed February 6, 2001

Carter, Harold O. et al. *Voices of California Farmers: Effects of Regulation.* University of California Agricultural Issues Center. August, 1996. 150 pages.

Caudill, James D. and John P. Hoehn. "The Economic Valuation of Groundwater Pollution Policies: The Role of Subjective Risk Perceptions." Michigan State University. Department of Agricultural Economics. East Lansing Staff Paper 92-11. 14 pages.

http://www.dismal.com/cgi/sql_state_test.asp?State=California&View=Demographics. Number of households in California. Accessed May 7, 2001.

Economic Research Service, United States Department of Agriculture website. Specific page used: http://www.ers.usda.gov/data/FarmIncome/finfidmu.htm "Value Added to the U.S. Economy via the Production of Goods and Services." Data for California, 1949-1999.

Martin, Phillip and Jeffrey Perloff. "Hired Farm Labor." Chapter 6 in *California Agriculture: Issues and Challenges.* Jerome Siebert, editor. Giannini Foundation, University of California, Division of Agriculture and Natural Resources. August, 1997.

http://www.nass.usda.gov/census/census97/congdist2/states/california/ca.htm California Farm Count by Congressional District. Accessed May 7, 2001. Number of farms in California with annual sales over $10,000.

Strickland, Roger. "Index of Prices Paid by Farmers: Base Period 1910-1914." Personal communication via email. 2001.

Sun, J., John C. Bergstrom, and Jeffrey Dorfman. "Estimating the Benefits of Groundwater Contamination Control." *Southern Journal of Agricultural Economics*. 24(2):63-17. December, 1992.

Teague, Mark L. and B. Wade Brorsen. "Pesticide Productivity: What are the Trends?" *Journal of Agricultural and Applied Economics*. 27(1): 276-282t. July, 1995.

Viscusi, W. Kip, John M. Vernon and Joseph E. Harrington, Jr. *Economics of Regulation and Antitrust.* MIT Press, Cambridge. 2000.

http://watersupplyconditions.water.ca.gov/dwr_drought_rept.html Share of state water supply from groundwater. Accessed May 13, 2001.