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Dimensions and Issues

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CHAPTER 9

Environmental Issues in California Agriculture

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Many human activities have had a significant effect on the environments in which they take place, and agriculture is no exception. California's natural waterways have been greatly modified to enable conveyance of water to its farmlands as well as its cities, and to provide facilities for flood control, navigation, and hydroelectric power generation. Most of the natural wetlands in the state have been drained and transformed into fertile, highly productive agricultural land. Farmers have introduced many new species of plants and animals to California and in the process changed many of its ecosystems.

While modifications of California's environment have generated immense good, they have also increasingly become a cause of concern. Over the last half-century many policies and regulations have been introduced to control some of the effects that California agriculture has had on its environment.

Two main types of policy intervention have been made. First, numerous policies have sought to control agricultural externalities. These center on issues such as reducing groundwater contamination from animal waste; worker safety, environmental contamination, and food safety problems associated with pesticide use; water-logging problems associated with excessive irrigation and lack of drainage; air pollution from agricultural waste burning such as rice, and earth mining activities; and odor pollution associated with livestock. A second set of policies has specifically attempted to preserve ecosystems and species. These policies identify and protect the environmental amenities that may be threatened or damaged by agricultural activities.

Environmental policies affecting California agriculture have continually evolved over the last fifty years. The evolution has been affected by changes in technology as well as by changes in the political environment and public beliefs and preferences. For example, new knowledge about the impact of agricultural chemicals on human health and the environment, the discovery of new methods of pest control, and the introduction of new monitoring or pollution-detecting strategies have led to changes in environmental laws and regulations affecting agriculture. Similarly, changes in the relative political power of environmental groups or various farm groups and/or changes in public perception and concern about certain environmental issues have led to changes in regulations.

Farming in California is subject to policy-making and regulation by a wide variety of agencies. In addition to traditional agencies in the U.S. Department of Agriculture, they include other federal agencies such as the U.S. Environmental Protection Agency and the U.S. Fish and Wildlife Service; state agencies such as the California Environmental Protection Agency, California Department of Food and Agriculture, California Department of Public Health, State Air Quality Control Board, and State Water Quality Control Board; and county and municipal agencies. These many agencies that control various aspects of California's environment have operated under a complex set of policies that are not necessarily consistent and are subject to modification.

The complexity and the changing nature of environmental policies in California have provided an ample background for research in agricultural and environmental economics. Agricultural economists have assessed the impacts of various policy proposals, attempted to provide an economic rationale for proposed policies, and introduced proposals for policy reform and modification. Some of this research may have affected the existing policies and regulations in California; some has provided general background knowledge for the body of literature in agricultural and environmental economics.

A survey of the environmental policies affecting California agriculture identifies some of the difficulties that policy makers are faced with in their attempts to establish environmental regulations. Problems with detecting and monitoring agricultural pollutants (for example, difficulties in monitoring the process of groundwater contamination by animal waste runoff) have sometimes led to overly strict policing of agricultural activities that are likely to cause environmental side effects. For example, a chemical may be banned or its use restricted even though policy makers may be concerned only with the environmental side effects of some of its residue. Similarly, animal production in a certain area may be restricted or limited even though the only local concern may be with the waste that the animals are producing. The evolution of new technologies will likely help to develop policy measures that will relate more to specific environmental side effects (e.g., contamination of groundwater) rather than to the general related activities (e.g., dairying as a whole).

Establishment of straightforward and efficient policies is influenced by difficulties in measuring the impacts of externalities. The assessment of health risk effects and environmental side effects associated with pesticide use, for instance, is subject to much uncertainty. These uncertainties have contributed to the constant debates and controversies regarding environmental regulation affecting agriculture. One of the challenges facing the scientific community is to provide data to reduce such uncertainties. As Baumol and Oates (1975) have suggested, uncertainty regarding outcomes has led to policies that aim to reach a target level of environmental quality based mainly on biological or ecological criteria, even in instances where balancing marginal benefits with marginal costs might be more appropriate.

Another practical difficulty in determining environmental quality is its multi-dimensionality. The same chemical can cause several types of environmental problems—worker safety, food safety, groundwater contamination, or damage to wildlife. The benefits of chemicals, as well as the magnitude of their environmental side effects, can vary significantly according to crop and location. The way a chemical is applied can alter its impact on the environment; a chemical sprayed from an airplane is likely to generate more environmental side effects than one applied by low-pressure, precise-application techniques. Thus the social costs associated with the use of certain chemicals may vary significantly across locations and applications, and policies such as uniform taxation or direct regulation of agricultural chemical use may be economically inefficient in many situations. Efficient regulation of the environmental side effects of agriculture may call for policies that vary by location and agricultural activity, and the need for flexibility may also provide a challenge in terms of design and implementation.

Much of the economic research on the environmental regulation of agriculture has simply estimated the economic impacts of proposed regulation. However, some research has also suggested improvements in policy design and demonstrated how changes in policy instruments might result in attaining environmental objectives at much lower economic costs. This chapter discusses some of the major environmental issues arising from California agriculture, and describes the conclusions of recent economic research that has analyzed the efficacy of various approaches to handling these issues. The diversity of problems and policy issues is illustrated here through discussion of control of animal wastes, pest control and the regulation of pesticides, endangered species protection, climate change, and the growing role of agricultural land as a source of recreational amenities.

DAIRY PRODUCTION AND THE ENVIRONMENT

California is the United States' major dairy producer, and is home to approximately one-sixth of the nation's dairy cow population. These 1.64 million cows account for over one-fifth of all milk produced in the United States (California Department of Food and Agriculture, 2002). Although the United States milk cow inventory decreased by approximately 130,000 head between 1997 and 2001, the number of milk cows in California increased by 14 percent during this time. Milk production per cow has also increased by approximately five percent during the same period (National Agricultural Statistics Service, 2002). In short, California dairy production has been increasing both in scale and efficiency in recent years.

Until recently, the dairy industry in California had been closely concentrated near the larger population centers in Los Angeles and Northern California. The largest dairy-producing region in the state had been the Chino region near Riverside, not far from Los Angeles. These patterns were in accordance with the models of agricultural land use first developed by Johann von Thünen almost 200 years ago. Von Thünen modeled the allocation of land uses around a city as a function of the economic return, or "rent" to the land, which in turn is a function of transportation costs. In the city's core, urban uses such as residences and industry will determine the highest value of the land. Von Thünen hypothesized that dairying and other intensive farming industries would be located immediately outside of the urban core, because they had the highest transportation costs, both in absolute terms and in terms of the losses that would be suffered by any delays in getting easily spoiled products to market. Less intensive industries such as forestry, extensive field crops, and ranching would be located further outside of the central city.

The allocation of land predicted by von Thünen's model does not take environmental externalities into account, however. Recent studies suggest that when the cost of environmental quality is taken into account, then the location of various activities have to balance transportation and pollution costs (Goetz and Zilberman). Thus, pollution-intensive industries either have to reduce their pollution or relocate farther away from the city. The new modeling suggests that incentives (taxes on waste or subsidies to remove waste) or zoning may be introduced to induce industries to modify their behavior. Furthermore, in some cases optimal resource allocation, which takes into account both pollution and transportation costs, may lead to establishment of green zones separating animal production from urban areas.

The disposal of animal manure in the Chino area has historically caused severe groundwater contamination problems. Dairies in this region designated certain lands as disposal areas where all liquid and solid animal wastes are disposed. In many cases, one acre of land is needed for disposing of the wastes from more than 30 or 40 cows, and most of the salt content in this waste percolates into the groundwater.

The Clean Water Act was introduced in the early 1970s. One of its most important purposes was to reduce groundwater contamination and especially salinization by animal waste. The standard regulation proposed by the State Water Quality Control Board restricted the ratio of cows' disposal acres—the tons of manure disposal compared to the animal waste produced by one cow—to be no greater than 1.5. Studies performed at the time to assess the economic impacts of this standard suggested that it would reduce the dairy cow population drastically and reduce the economic surplus that this industry generates by about 80 percent (Moffitt, Just and Zilberman; Hochman, Zilberman and Just). Not surprisingly, the proposal encountered strong objections by dairy farmers and resulted in heavy litigation. An alternative proposal was to treat solid and liquid wastes separately; the solid waste was to be hauled to safe disposal areas outside the Valley, and restrictions were to be imposed on the disposal of liquid waste so that the original target of salt reduction could be met. On analysis this policy proposal was found to meet regional water quality targets at less than 50 percent of the cost of the original proposal. This policy was adopted, and enabled the industry to survive for another two decades. The use of disposal areas for animal waste is not optimal and is not sustainable in the long run, however. A major challenge for the California dairy industry is to find better solutions for disposal of animal wastes.

Accommodating the animal waste regulation requires investment in waste disposal facilities. Some farmers may have significant credit constraints and not be able to obtain the resources from private lenders to invest in the waste disposal facilities. Government credit provision may alleviate this problem and reduce the difficulty of adjusting to the waste disposal regulation. Macdougall *et al.* (1992) show that credit support policies can significantly reduce the cost of adjustment to water quality regulation in the Chino area. They also show that the ability of the dairy industry to withstand animal waste regulation is much higher in periods of low interest rate and economic prosperity and thus that regulation should be introduced in such periods.

The concern with the environmental side effects has resulted in a wide variety of constraints and regulation that resulted in outcomes that are consistent with the theory presented above. Many dairies have moved from the Chino area to the San Joaquin Valley, where growers could find both larger disposal areas and better opportunities to market their manure as fertilizer. Four of the five leading dairy counties in California are now in the San Joaquin Valley: Tulare, Merced, Stanislaus, and Kings (California Department of Food and Agriculture, 2002). Part of this move is certainly a shift away from the high land values brought by residential development, but much of it is also due to decreasing the environmental costs.

California has not yet found the balance between transportation costs and environmental concern in locating its animal facility and managing its land resources. The design of optimal policies to control the side effects of animal agriculture will be one of the major challenges to policymakers and agricultural economists in the coming years.

EXOTIC PESTS

Agriculture is about managing living systems, and these systems evolve over time. One of the biggest challenges to California agriculture is the control of pests, and these pests have evolved genetically and migrated from other locations. With growing trade and tourism, California has been exposed to infiltration of exotic pests originated elsewhere. Two of them are especially expensive and difficult to control. The Mediterranean fruit fly has coexisted with agriculture for some time now, whereas various sharpshooters, carrying Pierce's disease, have recently posed a potentially huge threat to California's vineyards.

The Mediterranean Fruit Fly

The Mediterranean fruit fly, Ceratitis capitata (Wied.), or the Medfly, is an imported pest, infestations of which have serious consequences for California agriculture. The 1980-81 infestation was ultimately eliminated at a great expense—reported at over

$100 million—to the State of California and the federal government. A significant amount of public funds has been spent on eradication efforts for subsequent infestations. In 1989-90 there was another Medfly infestation (similar to the one in 1980-81), and findings of the Medfly have continued since.

Because of aggressive eradication efforts, the impact on the California agricultural industry has been minimal compared to potential damage. However, the eradication efforts have not been without controversy. In addition, infestations to date have been in urban areas. The protocol for eradication involves a system of traps, aerial application of Malathion-treated bait, and the use of sterile male Medflies. The most controversial part of the protocol has been the aerial application of bait. This technique has raised fears and concerns among urban residents, and, coupled with diminished availability of public funds, has caused local officials, public interest groups, environmental groups, and health and safety groups to raise questions about the necessity of eradicating the Medfly.

The outbreak of the Medfly in 1993-94 raised the specter of a possible embargo of California products by Japan, and probably Korea, Taiwan, and Hong Kong (which usually follow Japan's lead). This concern increased with the discovery that the Medfly had spread eastward into Riverside County near commercial citrus orchards. Japan has indicated that if a fertile female Medfly is found in a commercial orchard, it will consider placing an embargo on shipments of fresh fruit and vegetables from California. (While the question could be raised regarding why the embargo should affect the entire state when only a small part of its production area is affected, it should be noted that the issue of trade sanctions is a political one, not necessarily based on science or economics.)

The list of crops that serve as hosts to the Medfly is quite extensive. In a 1991 production-cost study, 22 different commodities were included: apples, apricots, avocados, bell peppers, cherries, dates, figs, grapes, grapefruit, kiwis, limes, mandarin oranges, nectarines, olives, peaches, pears, persimmons, plums, prunes, and tomatoes (both processed and fresh). In 1992, these commodities represented nearly 1.6 million acres of irrigated cropland and over $4.2 billion in value of farm production. The farm value of exports amounted to $559 million, with a substantial amount shipped to Japan and other Asian countries.

The assumption made in the production-cost study was that through periodic and regular applications of Malathion-treated bait, a marketable product would be produced. Increased costs would come from the application of bait and, for those crops shipped from California in a fresh state, there would be a post-harvest treatment using methyl bromide or a cold treatment to meet U.S. Department of Agriculture quarantine restrictions. The annual increased costs were estimated to range from a low of $349.6 million to a high of $731.9 million. The reason for this range is that the effective application of pesticides is dependent on weather factors and the length of the season. The estimated cost for post-harvest quarantine treatments was $135.3 million, which includes the cost of the treatment and the loss of fruit due to treatment damage. An additional $8.1 million in transportation costs for movement to and from treatment facilities was also estimated. Hence, total annual costs of controlling the Medfly were estimated to range from a low of $493 million to a high of $875.3 million. Compared to the 1992 value of the total value of production for the crops affected, these costs are substantial.

The economic impacts from a trade embargo would include effects on fresh shipments of apples, apricots, avocados, bell peppers, sweet cherries, dates, figs, table grapes, grapefruit, kiwis, lemons, limes, tangerines, oranges, nectarines, peaches, pears, persimmons, plums, and tomatoes. These commodities do not necessarily match those of the production study, because an embargo would likely include all exported commodities to the countries in question. For example, in the production-cost study, lemons were excluded; however, in the embargo study, they are considered. Also, the embargo would likely take place even though the commodities could be treated for shipment.

The 1992 farm value of these products was $2.1 billion, and the farm value of total exports was $354.8 million. These crops were grown on 655,000 acres (8.5 percent of the total 1992 harvested acres in California). The 1992 total f.o.b. value of shipments of these products, including both domestic and export (excluding tomatoes for which there was no available data), was $2.9 billion. The total f.o.b. export value was $605.5 million, and the f.o.b. value of shipments to Japan, Korea, Taiwan, and Hong Kong was $376.3 million, amounting to 62.1 percent of total exports for this product.

Estimates of the changes in revenue from 1992 due to an export embargo vary by crop as to their significance. In most cases, the estimated change in price was small and not very significant as reflected in the lost revenue figure. However, for the citrus crops—grapefruit, lemons, navel oranges, and Valencia oranges—which were the most impacted, the estimated revenue loss was highly significant. For grapefruit, the loss in revenue is estimated to be 51 percent of the 1992 levels; for lemons, 38 percent; for navel oranges, 15 percent; and for Valencia oranges, 55 percent. The loss in revenue for all of the commodities considered was $564.2 million or 20 percent of the 1992 value of shipments.

This loss represents a decrease in income to growers, packers, and shippers of the commodities involved. At the levels indicated, it is highly unlikely that any profits would result to those commodities most heavily impacted. The costs of growing, packing, and shipping the commodities would still occur. The question that remains is how long the industries involved would continue to produce at the levels that existed before an embargo.

The total impact of a Medfly infestation on the industries involved should also take into account the costs of controlling the pest. When these costs are added to the embargo estimates, they indicate even higher losses to the industry. The total impact on the commodities would range from a low of $1.057 billion to a high of $1.44 billion. These figures represent losses to all segments of the industries involved—from pesticide applications to control the Medfly, to losses in revenues due to losses in export markets and price decreases in domestic markets.

In the short run, the domestic consumer would benefit from an embargo, particularly from citrus. Estimated price decreases range from no change in the case of apricots, to over 60 percent for grapefruit. How long the consumer would benefit from these price decreases would depend on how long it took for the industry to readjust its production or to find new markets. Price decreases of the magnitude estimated for the citrus industry would be expected to last no longer than two years before production adjustments would be made. In the long run, the consumer might be worse off. Producers would eventually decrease production in order to raise prices enough to regain lost revenues and adequately cover capital investments.

In addition to a loss in income to the commodities affected, the California state economy would also be impacted. It is estimated that there would be a $1.2 billion decrease in gross state product and a loss of 14,200 jobs. Hence policies to eliminate pest invasions have a significant impact on both the industries affected and the general economy.

Pierce's Disease

The presence of Pierce's Disease (PD) makes it almost impossible to grow European-type (Vinifera) grapes for wine in the southeastern United States (Purcell). PD requires two components to spread. One is the bacterium Xylella fastidiosa; the second is a vector of transmission. Two vectors appear in California. One is the xylem-feeding sharpshooter leafhoppers (Cicadellinae), and the other, the glassy-winged sharpshooter (Homalodisca coagulata), is native to the southeastern states, from Florida through Texas.

The sharpshooter leafhoppers

The sharpshooter transfers the bacteria from an infected host plant to other plants. Once infected, yield decreases, and often the vine will die. The leafhoppers breed over winter in riparian vegetation, ornamentals, and/or pastures, picking up the Xylella bacteria from host plants. The insects then migrate in the spring to feed on succulent vegetation, such as grape vines, infecting the vines as they spread. An infectious blue-green sharpshooter has more than a 90 percent chance of transmitting the bacteria. Recent PD outbreaks in California's Napa Valley wine grapes, one of the premier wine-producing regions of the United States, are estimated to have cost vineyard owners $46 million in 1999 (Johnson, 2000).

Insecticides have limited effectiveness on PD in vineyards where the sharpshooters enter each spring from riverbank vegetation. Applying insecticide to the riparian area where the insects are concentrated might control the spread of PD, but applications are constrained due to wildlife and water quality concerns. Removal of the bacterial and sharpshooter host plants at their riparian sources might reduce incidences of the disease, but the riparian vegetation may be protected by legislation. Brown et al. considered the economic impact of planting crops between the source area and the grape vines. These crops act as a barrier to transmission in order to slow or prevent the sharpshooter migration, but this strategy requires taking land out of grape production.

The optimal barrier crop strategy depends on the profitability of the barrier crop relative to wine grapes and the effectiveness of the barrier crop, measured by percentage reduction in pest penetration per unit of barrier length. Growers in the Napa Valley considered the use of Christmas trees as a barrier crop. Brown et al. (2002) estimated the optimal length of a barrier for an 800-feet long row of grapes originated at a riparian zone. They found the length of the barrier declined with the effectiveness of the barrier crop and the profits of grapes relative to the barrier crop.

The average profits per acre of grapes without PD were $5,230, and the baseline return from Christmas trees was $1,764 per acre. A barrier characterized by an effectiveness parameter of .05, .25, and 1.0, respectively, requires the grower to plant barriers only 69, 21, and 12-feet wide while reducing profit per acre on average from $5,230 to $4,856, $5,127, and $5,175, respectively. Without any barrier, the average profit per acre will decline to $3,054, as most of the rows near the riparian zone will be decimated. Thus, a barrier crop with a .25 effectiveness allows the grower to earn 98 percent of the profit earned in the case of no PD, while effectiveness of .05 leads to a loss of about 9 percent of the profits and, without a barrier, close to 40 percent of the average profits are lost to PD.

Brown et al. also considered a mixed strategy that allows removal of the riparian zone in addition to riparian buffers. Their analysis assumed the price of $1,489 per ton of grapes as a baseline. Removal of riparian vegetation to control PD is being hotly debated in California. The U.S. Fish and Wildlife Service, which has jurisdiction over riparian areas, opposes clearing vegetation. The results of the simulations suggest that partially removing the host vegetation is suboptimal regardless of society's willingness to pay for riparian habitat. As the price of grapes rises, the breakeven social value of riparian vegetation increases linearly. With the bench price of $1,489 per ton, the removal of a 6 foot by 100 foot strip of riparian vegetation would be socially optimal if it provided less than $5,481 in environmental benefits. Alternatively, the value of the riparian zone strip is implicitly above $5,481 if the riparian zone is maintained. Recent research focuses on modification of the riparian zone, which will replace plants that are hosts to the bacterium and vector, while maintaining a riparian zone.

The glassy-winged sharpshooter

This insect, and the PD it carries, is not just a threat to raisins and table and wine grapes, but it also has the potential to spread the disease to other important agricultural commodities. A joint state-federal plan has dedicated a total of $36 million to eradicate and prevent the spread of the glassy-winged sharpshooter (GWS), a new arrival in California. The federal government will allocate $22 million to augment state and private agricultural industry efforts to control the spread of the GWS and support research to find methods to cure PD.

The GWS is active in warmer climates. It has already decimated most of the grapevines in Temecula in Southern California, and it is a problem in Los Angeles and Kern counties. Purcell's (1999) simulations predicted that the GWS will spread to 15 grape-growing counties including Fresno and Tulare, which produced over $500 million worth of grapes in 2000. The damage potential of PD spread through GWS can reach billions of dollars over time (Lynch, Brown and Zilberman, 1999). GWS transmitted PD from oleanders and other host crops, especially citrus, and it is now being controlled by spraying pesticides in host citrus orchards adjacent to grape vines. The bacterium Xylella fastidiosa affects other crops besides grapes including almonds, peaches, and oleander. Brown et al. suggests that the net present value of potential damage is greater than $2 billion. Ongoing research aims to find biological control and biotechnology solutions to these pests, but for now the solution is through application of chemical pesticides.

THE REGULATION OF PESTICIDES

A driving factor behind pesticide regulation in the United States is the desire to protect consumers from harmful residues on food. The Food Quality Protection Act (FQPA) was unanimously passed by the U.S. Congress in 1996 and hailed as a landmark piece of pesticide legislation. It amended the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), and the Federal Food, Drug, and Cosmetic Act (FFDCA), and focused on new ways to determine and mitigate the adverse health effects of pesticides. FQPA is different from past legislation; it is based on the understanding that pesticides can have cumulative effects on people, and that policy should be designed to protect the most vulnerable segments of the population. Recent research described below has investigated some of the impacts that FQPA's provisions—many of which have yet to be fully implemented—may have on California growers and consumers.

Pesticides are also regulated to mitigate the impact on worker health or the greater environment. Of particular interest to many Californian growers is the pending ban on Methyl bromide, an extremely effective soil fumigant that is being phased out because of its impact on the ozone layer.

The Food Quality Protection Act

The publication of the National Research Council report *Pesticides in the Diets of Infants and Children* (1993) showed that pesticide residues have disproportionate effects on children. Children eat and drink more as a percentage of their body weight than adults; they also consume fewer types of food. These dietary differences account for a large part of the exposure differences between adults and children. The committee also found that pesticides have qualitatively different impacts on children because children are growing at such a rapid pace. This concern for the differential impact pesticides have on children is reflected in regulatory changes required by the FQPA. For instance, the "10X" provision of the FQPA requires an extra ten-fold safety margin for pesticides that are shown to have harmful effects to children and women during pregnancy.

The FQPA has also resolved the "Delaney Paradox" created by the Delaney Clause of FFDCA. Prior to FQPA, the Delaney clause prohibited the use of any carcinogenic pesticide that became more concentrated in processed foods than the tolerance for the fresh form. This was supposed to protect consumer health, yet it had the paradoxical effect of promoting other non-carcinogenic pesticides that created other (possibly more serious) health risks for consumers. FQPA standardizes the tolerances for pesticide residues in all types of food, and looks at all types of health risks.

The federal Environmental Protection Agency (EPA) must now ensure that all tolerances are "safe," defined as "a reasonable certainty that no harm will result from aggregate exposure to the pesticide" (EPA, Office of Pesticide Programs, 1999). Historically, pesticide exposure was regulated through single pathways, either through food, or water, or dermal exposure. Now the EPA must consider all pathways of pesticide exposure, including cumulative exposure to multiple pesticides through a common mechanism of toxicity. This means that even though pesticides may be sufficiently differentiated that they are used on different crops to control different pests, they can have similar health effects on people. The result is that in some instances, pesticide tolerances for seemingly different insecticides must be regulated together based on their cumulative effects.

The Costs of Banning Organophospates

When FQPA was first signed into law, 49 Organophosphate (OP) pesticides were registered for use in pest control throughout the United States, and accounted for approximately one third of all pesticide sales (Casida and Quistad, 1998). OP insecticides are highly effective insect control agents because of their ability to depress the levels of cholinesterase enzymes in the blood and nervous system of insects. It has been suggested that while dietary exposure to a particular OP may be low, the cumulative effects of simultaneous exposure to multiple OP insecticides could cause some segments of the U.S. population to exceed acceptable daily allowances (Byrd, 1997). Reducing the risk from these aggregate effects is specifically addressed in the FQPA and is one of the reasons the EPA has chosen OP pesticides for the first cumulative risk assessment.

Due to their popularity and widespread use, many in the agricultural community are worried about FQPA implementation resulting in increased restrictions on OP pesticides. By the time EPA released the Revised OP Cumulative Risk Assessment in 2002, 14 pesticides had already been canceled or proposed for cancellation, and 28 others have had considerable risk mitigation measures taken (U.S. Environmental Protection Agency 2002). Risk mitigation may include: Limiting the amount, frequency, or timing of pesticide applications; changes in personal protective equipment requirements (for applicators); ground/surface water safeguards; specific use cancellations; and voluntary cancellations by the registrant.

Economic theory suggests that these increased restrictions and cancellations from the eventual implementation of FQPA will result in a reduced supply of commodities currently relying on OP pesticides for pest control. This will result in higher prices for consumers and a lower quantity sold. In order to estimate the possible welfare effects on the state of California, University of California researchers conducted a study on the effects of a total OP pesticide ban on 15 crops. The estimated price and quantity changes are presented in Table 1.

Results of the economic analysis suggest that the total loss to producers and consumers in California from banning all OP use will be approximately $200 million. There is significant uncertainty as to the final level of OP restrictions; this is only an order or magnitude estimate of the effects. However, these effects only represent about 2 percent of the total revenue generated by the 15 crops studied in California. While the overall effects seem small, they may be more intense in some segments than others. The researchers found that the degree of impact rests on the effectiveness of alternative pest control strategies producers have to choose from when faced with an OP ban. In some cases, OP pesticides have no close substitute, and cancellation will have larger effects. For instance, the losses in broccoli, one of the crops most sensitive to an OP ban, are driven by the lack of an alternative insecticide to treat cabbage maggot.

Table 1. Price and Production Changes from Organophosphate Ban

Crop	Change in Price	--------Change in Production[a]-------	
	(percentage)	*California*	*Rest of US*
Alfalfa	0.93	-184,845	48,743
Almond	0.48	-1,356	n/a
Broccoli	16.00	-111,285	2,083
Carrots	>0.01	-5	-3
Cotton	1.69	-1,148	-19,214
Grapes	0.05	-999	-265
Lettuce, Head	0.36	-12,778	3,864
Lettuce, Leaf	0.46	-1,510	-148
Oranges	0.32	-40,517	-28,137
Peaches & Nectarines	0.32	-1,561	-2,016
Strawberries	0.26	-508	-743
Tomatoes, Fresh	0.03	-388	-223
Tomatoes, Processed	0.16	-10,849	114
Walnuts	0.58	-1,091	n/a

a) Change in tons

Source: Metcalfe, et al. The Economic Importance of Organophosphates in California Agriculture, 2002.

Trading One Disease for Another?

As illustrated above, it is generally true that removing a pesticide from the production process will result in an increase of the price of the treated commodity. If consumers respond to the increased prices by reducing consumption of the affected fruits and vegetables (and perhaps shifting consumption to less nutritious foods), they may suffer a loss of health benefits associated with the change in consumption. Scientific evidence is accumulating which shows a protective effect from fruits and vegetables in the prevention of cancer, coronary heart disease, ischemic stroke, hypertension, diabetes mellitus, diverticulosis, and other common diseases. The level of protection suggested by these studies is often quite dramatic. A recent review of several studies found that "the quarter of the population with the lowest dietary intake of fruits and vegetables compared to the quarter with the highest intake has roughly twice the cancer rate for most types of cancer" (Ames, Gold and Willett, 1995).

Negative health outcomes from a change in dietary behavior may offset the direct health benefits of a pesticide ban, such as reduced exposure to carcinogenic residues on produce. A recent study by Cash (2003) investigates the possible magnitude of such offsetting health effects. Using data on what over 18,000 people eat and previous findings on how people respond to changes in the price of fruits and vegetables, the author simulated some of the health effects of a small increase in produce prices. Specifically, Cash examined the effects of a one-percent increase in the price of broad categories of fruits and vegetables on coronary heart disease and ischemic stroke, two of the most common causes of death in the United States. The results are reported in Table 2.

Table 2. Cases of Coronary Heart Disease and Ischemic Stroke Induced in the U.S. Population by a one percent Increase in the Price of All Fruits, All Vegetables, or All Fruits and Vegetables

Disease	All Fruits	All Vegetables	All Fruits and Vegetables
Coronary Heart Disease	1,442	2,951	6,903
Ischemic Stroke	744	1,482	3,022
Total	2,186	4,433	9,925

Source: Cash, *Essays on the Economics of Protecting Health and the Environment*, 2002.
Results reported are the simulation means from a series of Monte Carlo trials (n=100,000).

For a one percent increase in the average price of all fruits and vegetables, the simulations indicate an increase of 6,903 cases of coronary heart disease and 3,022 ischemic strokes. In order to offset these 9,925 cases in a population of 253.9 million people, a pesticide action would have to prevent 1 in 25,580 cancers. This is almost four times as protective as the mean risk of pesticide uses that were banned between 1975 and 1989 (Van Houtven and Cropper, 1996). Although these results can not be applied directly to most individual pesticide bans—which typically only affect the price of a few crops—the study shows that pesticide regulations that reduce relatively small risks at high cost may actually have a negative impact on overall consumer health. Furthermore, the research also suggests that low-income consumers may be the hardest hit by the negative health impacts of price-induced dietary changes, whereas high-income consumers tend to reap the greatest direct benefits from reduced residue exposures.

Economic theory tells us that regulatory intervention is justified in the presence of market failures. In the case of pesticide residues on food, the two most salient sources of failure are externality and incomplete information. The externality arises because the costs faced by dietary exposure to pesticide residues are not borne by the producers who make the application decisions. The incomplete information problem arises because a consumer can not easily determine the level of pesticide residue on produce. Even if this were readily apparent, the risks posed by these residues are not well understood.

The problem illustrated in the previous section is that regulatory decisions that are based on narrow criteria may give rise to other undesirable outcomes. When the target risk is small and the costs of reducing it are relatively large, there is a strong possibility that the net effect of a regulatory effort may be negative. Although consideration of such tradeoffs may be repulsive when the metric is in "body counts," the reality is that it is impossible for government to eliminate all risks to our health and well-being. A standard of discretion must be applied, whether it be benefit-cost analysis, established levels of acceptable risk, or some other measure.

The Food Quality Protection Act is a wide-reaching law that will have a large impact on California agriculture in the coming years. While an increased awareness of the effects of agricultural chemicals on vulnerable groups—especially infants—is a welcome addition to the nation's pesticide laws, regulators need to take into account the potentially high costs of additional pesticide bans on both producers and consumers. These costs can be measured not just in dollars, but also in dietary changes that may have negative health consequences. In implementing the regulations required by the FQPA, EPA should keep in mind that this most recent overhaul of the pesticide laws specifically grants the agency discretion in setting standards when use of the pesticides prevents other risks to consumers or avoids "significant disruption in domestic production of an adequate, wholesome, and economical food supply" (U.S. House of Representatives, 1996). Too narrow of a regulatory focus that ignores economic responses and countervailing health risks is misguided, as the net effect on public health could be negative.

Banning Methyl Bromide

Pesticides often come under the regulatory microscope for reasons other than the health effects of chemical residues on food. Methyl bromide (Mbr), a commonly used soil and commodity fumigant, is both highly volatile and extremely toxic to non-target organisms, including humans. Although its use has been regulated to protect worker health for several years, it is now facing a complete ban because of its potential global impact. When Mbr was found to contribute to the continuing degradation of the ozone layer, procedures were initiated under the Montreal Protocol to lead to a complete national or worldwide ban on its use, currently scheduled in the United States for the year 2005.[1]

Mbr is particularly important in California for strawberries, nursery crops, and trees and vines. It is also used for post-harvest commodity fumigation, especially for walnuts and cherries, which accounts for just 5 percent of total agricultural use. While this application accounts for relatively little use overall, it is important to those crops relying on it for export shipments.

Mbr use for soil fumigation rose significantly from 1985 to 1990 as progressively fewer alternatives remained available. Crops affected by the cancellation of Mbr are strawberries ($431 million total farm value in 1990), tomatoes ($875 million), almonds ($592 million), grapes ($1.5 billion), peaches ($198 million), nectarines ($100 million), walnuts ($229 million), and nursery crops ($1.9 billion). Each of these crops has significant export value, which would be decreased by inability to fumigate as required by the importing country. Estimates of the cost of a contract for pre-plant soil fumigation with Mbr range from $225 per acre for strip fumigation of vegetable fields to $1,000 per acre for strawberries, with most orchards and vineyards falling in between.

[1] As of the writing of this chapter, a United Nations panel had recommended that critical use exemptions for several agricultural uses be approved, including strawberries, tomatoes, cut flowers, and golf course maintenance (Revkin, 2003). If finalized, this exemption would apply to growers across the United States and in twelve other countries.

The impact of removing Mbr is highly dependent on available alternatives. There is no single alternative capable of targeting the wide range of pests and diseases that Mbr is capable of controlling, but there are several alternatives available for specific crops and pests. One of the major problems facing the agricultural community is that the move from a broad spectrum to a narrow spectrum pesticide is likely to require greater expenditures on information gathering regarding available pest control strategies, on the monitoring of specific field conditions, and, most likely, on the pesticides themselves. The alternatives identified, which have varying efficiencies and efficacies compared to Mbr, are Metam-sodium, Telone, Nemacure, urea or other nitrogen fertilizers, crop rotation, fallowing, soil sterilization, and replanting without treatment. The latter strategy has yielded poor results and is not likely to be pursued by a commercial agricultural enterprise.

Economic analysis of the alternatives to Mbr shows that Vapam is the highest profit alternative for all annuals and a number of perennials. In some cases, crop rotation would be the highest profit alternative. These instances are typically characterized by relatively low per acre profits compared with Mbr, however.

Total lost profits in agricultural crops as measured by producer surplus are estimated to be $68.1 million annually, while lost consumer welfare is estimated to be $131.6 million annually. Consumer welfare change is significant only in the case of strawberries, due to California's high market share. Lost producer profits are also highest for strawberries, at $45.5 million annually. Distribution of these impacts varies significantly by region in California. They are highest in the central and southern coast areas, which have high strawberry production, and in the San Joaquin Valley, which has a high concentration of trees and vines. In addition, lost profits for the nursery industry are also estimated at $67.7 million annually, making it a severely impacted industry.

Table 3. Incremental Value for Methyl Bromide Fumigation, $ per lb

Crop	Sacramento Valley	San Joaquin Valley	Northern Coast	Central Coast	Southern Coasts	Southern Valleys	Statewide
Almonds	1.7	1.8	--	--	--	--	1.8
Grapes	3.8	5.3	4.5	7	--	8.8	5.4
Nectarines	--	10.7	--	--	--	--	10.7
Peaches	4.7	7.1	--	--	2.5	--	6.4
Strawberries	--	11.1	--	26.4	30.5	19.4	27.5
Fresh Tomatoes	8.6	8.3	--	7.4	14.8	7.4	8.9
Walnuts	4.9	8.2	--	1.4	--	7.6	6.3
Rose Plants	--	--	--	--	--	--	28.7
Cut Flowers	--	--	--	--	--	--	40.5
Fruits, Vines, Nuts	--	--	--	--	--	--	41.7
Strawberry Plants	--	--	--	--	--	--	11.6

An interesting analysis is an evaluation of the net income effects of banning Mbr in terms of profits generated per pound of Mbr applied. This information is presented in Table 3. There is a wide variability in the profitability of Mbr fumigation, reflecting the wide range of environmental conditions in California agriculture. Mbr fumigation on almonds in the Sacramento Valley, for example, is barely profitable, as it generates incremental profits that just cover application costs. In high value crops such as nurseries and strawberries, however, Mbr fumigation generates large incremental benefits. In the case of cut flowers and nursery-grown fruit, nut, and vine seedlings, Mbr benefits exceed $40 per pound applied.

As demonstrated by Table 3, the variation in impacts by crop and region is significant. This variation is consistent with other analyses of environmental regulations of California agriculture. More than most states, California possesses a wide range of soil and climatic conditions, and the profitability of agriculture varies widely as a result. Thus, pesticide bans and other agricultural input regulations have variable impacts that depend on crop and region.

ENDANGERED SPECIES

Federal and state legislation relating to endangered species has resulted in increased regulation and litigation affecting the business environment in California. The implementation of the federal Endangered Species Act (ESA) has had impacts that have included adverse effects on California agriculture and the state economy. In 2003, there were 149 animals listed as endangered or threatened under state or federal law, or both (California Department of Fish and Game, 2003a). There were also over 200 species of plants listed as endangered, threatened, or rare (California Department of Fish and Game, 2003b).

An overall estimate of economic impact for California agriculture is highly difficult, because effects and recovery plans vary by species. Economic impacts take many forms, but usually they are based on the effects on costs of production and yields. These may come through restrictions on production inputs such as pesticides or on land use, cultural practices, and water. Another set of impacts arises because of inability to plant crops or use land for agricultural purposes, usually through the reduction of water allotments or restrictions on the conversion of land for agricultural purposes. A third set of impacts comes from a shift in agricultural production from a higher value use to a lower value use. Examples of this may be a shift from cropland to rangeland or a shift from irrigated to non-irrigated crops. These first three sets of economic impacts center on the generation of gross and net revenues. A fourth set centers on the value of an asset, usually land or the agricultural enterprise itself, when there is a restriction on its highest use. These economic impacts are not exclusive of each other and can occur in combination.

At least two policy issues are related to endangered species. The first is the issue of "takings," a thorny and complex question. Unlike other takings, where a private asset may be appropriated for public use (e.g., land condemnation for a public project), takings under the ESA are not as clear and have been treated as a private cost of doing business. Property owners contend that any restriction imposed by ESA is, in fact, a taking of private property by restricting its ability to generate its highest value or cash flow, and that compensation should be made. Legal interpretation of this claim is being developed, and legislative attempts have been made to deal with this issue.

The second issue is how the ESA is applied with respect to species. One approach is to administer recovery plans on a species-by-species basis, which can lead to duplication of efforts and resource use. An alternative is to manage on an ecosystem or habitat approach. This approach looks at the management of an ecosystem that will support many species, some of which will serve as natural predators to the species in question. Either approach will have economic consequences for the property owner in question; preference may depend on the relative costs of each approach.

Forest, rangeland, and abandoned farmland might be most affected by endangered species legislation, since many species have habitat on these lands. Land under active cultivation might not be affected unless it is located in a buffer zone with certain practices excluded under the recovery plan. In the case of water reallocations, the method of reallocation will constitute the greatest factor in the size of the economic impact. In the case of pesticide restrictions, the impact will vary according to whether the regulations are selective or broad in their application. Hence, the selection of appropriate public policy alternatives is critical to mitigating economic impacts.

Case Studies

Despite the far-reaching scope of the ESA, no estimates of the total impact of the Act on California Agriculture exist. Economic impacts of the ESA vary significantly by farmer, crop, and geographic location. Some farmers and sectors of agriculture might be totally unaffected, while others might experience significant consequences. The total impact on agriculture could be small compared to its gross value, but individual farmers and crops might be seriously affected. Recent studies have looked at the potential California impacts of individual protection plans for vernal pools, the California gnatcatcher, and the kit fox.

Vernal pools are seasonal wetlands that fill sporadically during the rainy season. They occur in shallow depressions on flat land, and provide important habitat to plant and animal species that are specifically adapted to the extreme cycle of wet and dry that characterizes large parts of California. Because at least 11 federally protected endangered species depend on vernal pools, the United States Fish and Wildlife Service (USFWS) has designated 1.6 million acres of land in California and southern Oregon as critical habitat for vernal pool species. A draft study commissioned by the Fish and Wildlife Service estimated that the total costs of this designation over 20 years would be between \$128 and \$135 million (Economic and Planning Systems, 2002).

A study conducted by Sunding, Swoboda, and Zilberman (2003) takes specific issue with both these estimates and the methodology employed by USFWS in conducting such analyses. Sunding and his colleagues argue that a total cost estimate includes the impact of the restrictions on housing and agricultural prices; losses borne by parties other than the affected landowners, such as consumers and developers; the costs imposed by regulatory delays; and the effects that designation plans may have on congestion, sprawl, and regional economic activities. Their analysis suggests that the USFWS study underestimates the actual economic impacts of the proposed vernal pool designation by 7 to 14 times, implying that the actual damages may exceed $1 billion. Furthermore, Sunding *et al*. find that consumers are likely to face the largest portion of these costs, contradicting the USFWS study's implicit assumption that landowners bear all of the costs of critical habitat designation.

In a related study, Sunding (2003) examined the potential costs of critical habitat designation for protection of the coastal California gnatcatcher, or *Polioptila californica*. The California gnatcatcher is a non-migratory bird that primarily inhabits coastal sage scrub. Its habitat is centered on highly populated areas of southern California. Rapid urban and agricultural development in the region contributed to the decline of the gnatcatcher population, and it was listed as a federally threatened species in 1993. In April 2003, USFWS designated almost 500,000 acres of critical habitat for the gnatcatcher in Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties.

Sunding's analysis suggests extremely high economic impacts for this designation—between $4.6 and $5.1 billion for the period from 2003 to 2020. This implies costs of approximately $10,000 per designated acre, and of $150,000 per developed acre. In this case, the costs are primarily borne by consumers in the form of higher housing prices, as the designation will impose serious restrictions on the development of new housing. According to Sunding, these costs are largely imposed in three ways: the increase in out-of-pocket costs to developers, the delay of completion of housing projects, and the reduced scale of these projects.

Agricultural activity can sometimes be restricted by ESA designation in very specific ways. For example, in the 1990s the USFWS proposed to ban the use of two non-restricted anticoagulant pesticides, chlorophacinone and diphacinone, because their use to control ground squirrels and jackrabbits on cropland were impacting the endangered San Joaquin kit fox. Although the kit fox does not generally consume the treated crops, it is a predator that often feeds on the affected target species. Since these pesticides accumulate in the liver of the dead pest, the kit fox could be poisoned through biological magnification of the anticoagulants. Zilberman, Siebert and Zivin (1997) estimated that the direct costs of the proposed restrictions to growers in Kern County would be in excess of $70 million per year. They termed these costs as short-run, because they hypothesized that suitable alternatives to the restricted pesticides may be developed, although there would likely be some delay before their implementation.

CLIMATE CHANGE

Climate change, caused by increased stock of greenhouse gases (GHGs), is potentially one of the most serious environmental problems facing mankind. Clouds and GHGs allow the sun's heat to pass through to the earth, but they form a barrier to the outgoing infrared heat, thus acting as a greenhouse. A greater concentration of GHGs increases this, leading to the possibility of climatic change and global warming. The atmospheric concentration of carbon dioxide (CO2), the major GHG, has increased by approximately 30 percent since the Industrial Revolution.

The Intergovernmental Panel on Climate Change (IPCC), a United Nations-sponsored research group, identifies a number of recent climate changes that are attributable in part to human activity. The estimated global mean temperature has increased by 0.6° plus or minus 0.2° C over the last 50 years. Continental precipitation has increased by 5-10 percent in the Northern Hemisphere, and decreased in some regions.

In the absence of policy intervention, CO2 concentrations are projected to increase by 75 to 350 percent above pre-specified levels during the next century (Gitay *et al.*, 2001). Temperature is projected to increase by .14-5.8°C, a change approximately two to 10 times larger than the estimated increase during the last century.

There is a growing body of literature on the impact of climate change on agriculture. Many of these studies are based on the ecosystem movement paradigm, which assumes that "ecosystems will migrate relatively intact to new locations that are close analogs to their climate and environment" (Gitay et al., 2001). The estimated levels of global warming are likely to cause 100-to-200-mile movement of climate and ecosystems away from the Equator and towards the Poles. With that, the Sacramento Valley may have the climate conditions of Bakersfield, and the San Francisco Bay will have the weather of Los Angeles. Under these assumptions, some regions close to the Equator will be deserted, and currently uncultivated lands close to the Poles will enter production. Some lands will switch from "cold climate" crops to "warm climate" crops, and current use patterns will continue on much of the agricultural lands with some modifications. Since the area of arable landmass declines as one moves away from the Equator, the "ecosystem movement" may result in reduction of supplies of food products. The higher carbon sequestration levels associated with climate change will also result in a "fertilization effect" that will increase yields per acre. Climate change will increase food supplies if the "fertilization effect" dominates the "ecosystem movement" effect, and it will decrease if the "ecosystem movement" effect is dominant.

Studies reviewed by Gitay *et al.* (2001) suggest that climate change does not pose a serious threat to the U.S. and global food capacity. The estimated annual impacts of climate change on U.S. agriculture range in most studies between a net loss of $10 billion to a net gain of $10 billion. On the other hand, the empirical simulations mentioned above suggest that the distributional effects of climate change are likely to be substantial. Adams, Hurd, and Reilly (1999) found that northern regions in the United States are likely to gain from climate change while southern regions are likely to lose. In particular, northern regions in California and Oregon may gain from climate change, while southern California regions may lose.

Most of the analysis on the impact of climate change was based on regions with rainfed agriculture. California agriculture is unique in its reliance on irrigation, which requires heavy investment in fixed infrastructure. Furthermore, perennial crops that are prominent in California are also investment incentives. Thus, the adjustment to climate change may require high cost of fixed investment of relocation. Most of the water infrastructure in California has been subsidized by the public sector and, thus, historical private costs of production are not good indicators of cost after adjustment to climate change (Fisher, 2002). Without the subsidies, the cost of water is likely to increase, and that will reduce the profitability of agriculture and restrict the extent to which agricultural production capacity is relocating.

Climate change will change the precipitation pattern of California, and that will add extra cost in addition to the relocation effect. Increase in temperature will increase the amount of rain relative to snow during the winter. Less water will be stored in snow packs, and larger volumes of runoff will be released earlier in the season, exacerbating the risk of flooding and reducing the availability of water for agriculture in the late spring and summer when demand is at its peak (Fisher, 2002). Adjusting to these changes will require extra investment in dams and infrastructure.

Most of the impact assessments of climate change treat it as a transition occurring at a given moment in time. However they tend to underestimate the cost and complexity of adjusting to climate change, since it is a continuous process that at present is subject to much uncertainty. Thus, several modifications of infrastructure and production patterns may occur as climate change progresses, and the lack of certainty may increase the adjustment cost (Zilberman, Liu, Roland-Holst, and Sunding, 2003).

While much of the literature suggests that the impacts of climate change on U.S. agriculture are likely to be modest, the analyses in the case for California suggest that the cost of adjustment to climate change may be quite substantial.

AGRICULTURAL LAND AS A SOURCE OF ENVIRONMENTAL AND RECREATIONAL AMENITIES

Much of the preceding discussion has illustrated how regulation seeks to mitigate the negative environmental externalities that arise from agriculture in California. Yet there is also recognition by both the public and the government of the role that agriculture plays in land stewardship. There are major government programs that reward participating farmers for conservation activities. Furthermore, agriculture provides valuable recreational amenities to consumers, both indirectly and directly.

The U.S. Department of Agriculture, through the Farm Service Agency and the National Resource Conservation Service, offers programs such as the Conservation Reserve Program (CRP), Wetland Reserve Program, Grasslands Reserve Program, and the Environmental Quality Incentives Program (EQIP) to encourage farmers to engage in conservation activities. In the same way that taxes can be used to discourage activities that have negative side effects, governments may choose to subsidize those activities with "positive externalities"—that is, activities that carry benefits that are enjoyed by parties other than those who have direct control over the resource. The economic justification for such subsidies is that in their absence, private decision-making will result in too few of these conservation activities. By subsidizing the desirable activities, governments can increase the private benefits to the farmers, and thus encourage a move toward a more optimal level of provision.

The Conservation Reserve Program is the largest of these programs. Under the CRP, farmers are paid to retire environmentally sensitive cropland from production. Agricultural land may be eligible if it is highly prone to erosion, contributes to a serious water quality problem, provides important wildlife habitat, or can provide other substantial environmental benefits. Farmers can also receive additional reimbursement for conservation expenses, such as planting cover crops to reduce erosion on retired land.

Although the CRP was established in its current form in the 1985 Farm Bill, it has its origins in the 1950s, when Congress established similar programs in the Soil Bank

Act. These programs were explicitly touted as a way of avoiding a repeat of the 1930s Dust Bowl. The renewed interest in such programs in the 1980s was in large part a response to the depressed agricultural commodity prices of the time. The CRP was not only seen as a way of achieving environmental protection, but it also allowed for another channel of payments to distressed farmers and helped to ease overproduction by retiring land from active use.

The CRP has been reauthorized in every subsequent farm bill, and has been growing at a moderate pace in recent years. USDA will pay out $1.6 billion to American farmers under the CRP between October 2003 and September 2004; these payments cover over 34 million acres in all fifty states. Participation in California is fairly modest, with 383 farms receiving $4.4 million in payments for just under 143,000 acres of set-aside land in 2003-2004. In contrast, Texas farmers will receive over $142 million for conservation of over 4 million acres of land. At the same time, the average payments received by participating farms in California ($11,380) are well over the national average of $4,354 per participating farm (United States Department of Agriculture, 2003).

The EQIP program is of much greater importance to California farmers. EQIP was first enacted in the 1996 Farm Bill, and its reauthorization in the 2002 Farm Bill provides $11.6 billion in assistance over ten years. EQIP grants farmers payments for specific environmental improvements on their land. Participating farmers can receive cost share assistance for up to 75 percent of the cost of environmental projects that fit in to the priority areas chosen for each state. In California alone, $38.6 million was allocated for the fiscal year 2003. About half of this money was designated for special programs such as water conservation in the Klamath basin, replacement of diesel engines, and statewide surface and groundwater conservation projects. The other half goes to "regular appropriations," which are distributed on a per-county basis. For 2003, Fresno, Merced, Riverside, Stanislaus, and Tulare counties were each slated to receive over one million dollars in EQIP funds (United States Department of Agriculture, 2003b).

Such "green payment" programs are likely to become more important in the future, as the liberalization of international trade makes it increasingly more difficult for governments to continue traditional agricultural price support programs. Under current WTO regulations, agricultural conservation programs are considered more acceptable than price supports, because they support farmers in ways that have less of an impact on agricultural markets. This trend, if it continues, may be of particular benefit to many California farmers, who receive relatively less benefit from price support programs than farmers in other parts of the country.

It is interesting to note that agricultural support programs have traditionally received strong support from urban, as well as rural, residents. This is probably due in large part to the role that agriculture plays in maintaining the rural qualities enjoyed both by Californians and the state's many visitors. Visitors to the countryside enjoy the scenery, connection to the nation's history, and perceived lifestyle offered by agricultural activities. Even those individuals who rarely visit rural areas may benefit from simply knowing that these areas are being maintained in a certain way, a phenomenon that economists refer to as "existence value." For these reasons, society's interest in providing public support to agricultural activities extends beyond an altruistic concern for the welfare of farmers or arguments of domestic food security. Society may seek to provide assistance to the farmer both for protecting the environment and for maintaining the rural way of life.

This desire to maintain the scenic and recreational amenities of agricultural areas can also translate to private incentives for conservation of agricultural activities and the environment. For example, vineyards in northern California's wine country are sources of tourist revenue as well as income from wine production. The wineries benefit directly from the crowds of visitors who crowd the tasting rooms every weekend, and the region is home to numerous bed and breakfasts to house these guests. Such examples of "agri-tourism" can be pursued anywhere that farm activities are scenic, rather than noxious, from the point of view of the potential visitor. In California, agri-tourism activities also include dude ranches, self-pick berry and apple farms, corn mazes, and farm-animal petting zoos (Warnert, 1999). The potential economic impact of these activities is unknown, but it may be informative to note that golf courses, a quasi-agricultural land use, resulted in a total sales impact in California of $7.8 billion in 2000, directly supporting over 62,000 jobs (Templeton *et al*., 2002).

In the preceding discussion of dairy production, we noted that the negative externalities involved in dairy production counteract the other benefits of having these facilities located close to population centers. In contrast, the positive externalities associated with the recreational and environmental amenities of some farming activities are magnified when these operations are located closer to urban areas. Although Napa Valley wine would still taste as sweet if it were located 200 miles further from San Francisco, there would be far fewer people enjoying a drive through wine country on any given Sunday. Everything being equal, farmers who are closer to population centers will be able to reap greater private benefit from provision of new agri-tourism opportunities.

CONCLUSIONS

Agricultural activities affect the environment both directly, through the transformation of wildlands into farmlands, and indirectly, through a spillover of residues that may cause pollution and other negative side effects. A large body of legislation has been established to control the impact of agriculture on the environment. This legislation may restrict the availability of resources, both land and water, for agriculture.

This chapter shows that compliance to various regulations of control of animal waste and other pollutants is costly. The selection of the right policy tool to control pollution is essential as the use of incentives and targeted policies may reduce the cost of compliance drastically and will enable obtaining higher levels of environmental quality with much lower cost. We also found that the intensive farm systems of California have to deal constantly with pest problems, and the environmental regulation may increase the cost of pest control and present a challenge to the university and farming community to develop technologies to control pests in an environmentally friendly and cost-effective manner. At the same time, excessive control of pesticide use, while improving environmental quality, may result in undesirable human health and nutrition problems, and the regulation of pesticides involve trade-offs among the economic cost, the environment, and human health.

The growth of California agriculture and its costs of operation are also restricted by limited access to land and water resources, resulting from the Endangered Species legislation. To reduce the cost of complying with this regulation, it is important to better understand the behavior of wildlife and fish and the resources they need to survive. Thus, to some extent effective regulation and management of the future of agriculture require ecological understanding and knowledge of the value and function of land and water resources that are outside agriculture. Moreover, California agriculture by itself is a source of valuable environmental amenities and, as society's concern for environmental issues and willingness to pay for environmental amenities increase, there is a growing emphasis on improving stewardship of natural resources and maintaining and improving environmental quality in farming.

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