Evaluating Regulation and Conservation Policy for California's Agri-environmental Externalities*

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1. Introduction

The production of food and fiber by commercial agriculture has both positive and negative effects on the surrounding environment. Farms can provide wildlife habitat and scenic views for their urban neighbors, while the carbon sequestered by vegetation grown on that land can help to mitigate global warming. At the same time, noise, dust, and odors produced by normal farming operations can annoy urban residents, and runoff of pesticides, fertilizer, and animal waste can lead to water pollution downstream. The economic values that society places on these byproducts of agricultural production are rarely captured fully by private markets for farmland and commodities. When market prices fail to reflect the impact of farming on the surrounding environment, farmers are left with little incentive to incorporate the value of off-farm environmental quality into their land management decisions. This type of market failure is often a rationale for government action such as regulation, taxes, subsidies, and the redefinition of property rights.

For the past two decades, federal government intervention related to the environmental impacts of agriculture has primarily consisted of voluntary conservation payment programs funded by farm bill legislation. These programs pay farmers to manage their land in ways that reduce erosion and runoff, while increasing the provision of wildlife habitat and other environmental benefits. In addition to voluntary conservation programs, the overall effort to address the off-farm environmental impacts of farming also includes compliance provisions of the farm bill and regulations on chemical use, emissions of air and water pollutants, and the private use of endangered species habitat. The burden that these environmental laws can place on farms has been highlighted by recent debates on amending endangered species legislation and expanding the federal regulation of confined animal feeding operations.

This paper reviews and evaluates the combination of regulations and voluntary conservation programs that seek to preserve environmental quality. Section 2 begins by discussing why markets may not address the full impact of farming on the surrounding environment. While missing or incomplete markets can provide a rationale for government action, it can be difficult to develop appropriate policy responses due to the difficulty in measuring the relationships between crop production, environmental quality, and

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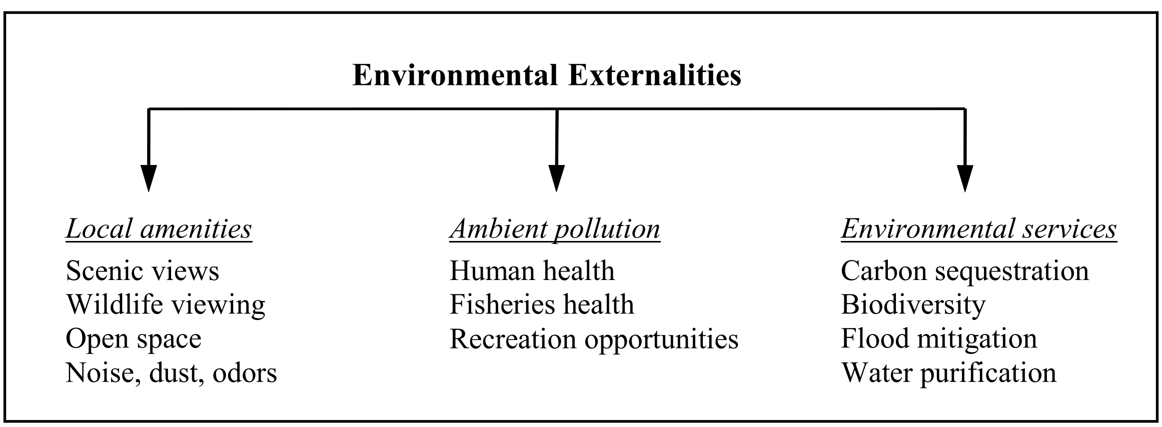
the public's willingness-to-pay for each. Despite the lack of quantitative grounding, policymakers have enacted a variety of regulations and voluntary conservation programs. Section 3 describes the impact on farms from U.S. environmental laws and regulations. A review of the regulatory framework shows that agriculture faces less environmental regulation than other sectors of the economy. This underscores the role of farm bill conservation programs in addressing environmental issues. Section 4 describes the incentives provided by these programs and the distribution of funding. While the current programs appear to generate benefits that exceed their implementation costs, they do not align farmers' financial incentives with public environmental goals. Section 5 suggests that in order to increase the efficiency of the current conservation programs or to design new policies for ecosystem services, the key challenge will be to find ways to link farmers' financial incentives to measurable environmental outcomes.

2. Externalities as a Rationale for Government Intervention

Market prices guide farmers' management choices. Farmland values provide most farmers with the incentive to manage farmland in a way that will maintain its long-term agricultural productivity.[1,2] This often requires preserving on-farm environmental quality. For example, if a farmer uses a pesticide that inadvertently kills native populations of beneficial insects, the farm's pollination and/or pest management costs may rise in the future. The decrease in future profitability stemming from this increase in production costs will also decrease the resale value of the land. Similarly, tillage methods that lead to high rates of soil erosion may increase short-term profits but may also decrease the farm's future productivity and its resale value. In these two examples, private market prices provide an incentive for the farmer to make land management choices that preserve on-farm environmental quality. However, the farmer's choices can also influence environmental quality off the farm.

When farmers are not compensated for the impacts that their land management choices have on the welfare of people living off the farm, these impacts are termed externalities. The environmental externalities from farming can be divided into three categories—local amenities, ambient pollution, and environmental services. Figure 1 illustrates this taxonomy with commonly cited examples from each category.

Figure 1. Environmental Externalities from Agricultural Production



[1] This is less true in areas where farmland values mainly reflect the potential for urban development. If farmers plan to sell their land for development in the near future, they have little incentive to worry about its long-term agricultural productivity. However, only a small share of farmland is likely to be converted in the foreseeable future. Plantinga, Lubowski, and Stavins (2002) find that only 9 percent of the total agricultural land value in the United States reflects the capitalized value of the land's potential for future urban development.

[2] Of course, some farms are owned and managed by different people. Since this distinction does not affect the results suggested in this paper, it is ignored; the farmer and the owner of the farmland are treated as the same person.

The externalities in figure 1 are among the many “ecosystem services” recognized by ecologists. For example, Daily (1997, page 3) defines ecosystem services as “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life. They maintain biodiversity and the production of ecosystem goods such as seafood, forage, timber, biomass fuels, natural fiber, and many pharmaceuticals, industrial products, and their precursors.” The environmental externalities which are the focus of this paper can be viewed as the subset of ecosystem services which are affected by agricultural production but are not directly bought and sold in private markets. The reason for further distinguishing between local amenities, ambient pollution, and environmental services is that they each differ in their geographic dispersion which affects the appropriate policy response.

Local amenities tend to be concentrated within a small geographic area around the farm where they originate. Since these amenities mainly affect people who live at the ag-urban fringe, the economic values that urban residents assign to them can be expected to be at least partly capitalized into residential property values. Some of the commonly cited positive amenities include scenic views, wildlife habitat, and access to open space. Farmland that provides these amenities has been found to increase property values in nearby residential neighborhoods. For example, Irwin (2002) examines how different types of farmland influence property values in suburban and exurban counties in central Maryland. Her results suggest that converting one acre of privately owned pasture to low-density urban development would decrease residential property values by 0.89 percent within a 0.25 mile radius of the converted acre. Meanwhile, farms that produce negative amenities such as noise, dust, and odors have been found to decrease housing prices nearby. Using data on housing transactions in Berks County, Pennsylvania, Ready and Abadalla (2005) analyze the impact of confined animal feeding operations. Their results imply that, on average, removing a confined animal feeding operation would increase housing prices by 6.4 percent within a 0.3 mile radius of the operation.

Farmers contribute to ambient air and water pollution through their use of management practices that lead to soil erosion and emissions of fertilizer, pesticides, and animal waste. Compared to local amenities, the impacts of ambient pollution tend to be more diffuse and are therefore less likely to be reflected in residential property values near the farm. Instead, they contribute to pollution problems at distant locations, decreasing recreation opportunities and negatively affecting human and ecosystem health. For example, nitrogen runoff from farms in the Mississippi-Atchafalaya River Basin is a major contributor to the “dead zone” in the Gulf of Mexico, where a combination of high nitrogen concentrations and upwelling have led to algal blooms that decrease the water’s oxygen content, ultimately leading to fish kills and other problems. Overall, runoff from agriculture in the Mississippi Basin has been estimated to contribute 65 percent of the nitrogen flowing into the Gulf of Mexico, with 50 percent from fertilizer and 15 percent from animal waste (Goolsby et al. 1999). While economists can estimate the ensuing revenue losses to fisheries and the resulting value of diminished recreation opportunities, it is difficult to identify how individual farms contribute to these losses. More precisely, it is difficult to monitor and track emissions from individual farms and to determine how those emissions contribute to measures of ambient water pollution.

The way that farmers manage their land also influences the performance of environmental services that are valued by local, regional, and global populations. Specific services that are often associated with commercial agriculture include carbon sequestration, biodiversity, flood mitigation, and water filtration. New York City’s watershed in the Catskill Mountains is a classic example of the link between farmland management and the provision of environmental services that convey economic value. The Catskill watershed historically provided natural filtration of the city’s drinking water. However, by the mid 1990s, increasing runoff of pesticides and nutrients in the watershed were making it increasingly difficult for the city to satisfy the requirements of the Safe Water Drinking Act. The city of New York was faced with the prospect of building and operating a water filtration plant that would have cost $6 to $8 billion. Instead, they were able to satisfy EPA by promising to invest $1 to $1.5 billion in reducing emissions into the watershed in order to improve its natural capacity for filtration. The money was used to purchase land in sensitive areas and to pay other landowners to change their management practices in ways that would reduce runoff. This included paying farmers to plant native grasses and to install fences and pumps that would reduce nutrient emissions from animal feeding operations (Salzman 2005; National Research Council 2005).

While farmers can adopt management practices that reduce negative externalities and increase positive externalities, market prices rarely provide incentives for them to do so. Coase (1960) observed that as long as property rights to an externality are clearly defined, the producers and consumers of that externality have an incentive to negotiate a solution without additional government intervention. However, as the number of producers and consumers increases, it can become increasingly expensive to organize the negotiation process. With a large number of disparate stakeholders, the incentive to negotiate may be dwarfed by the costs of negotiating. This situation can provide an economic rationale for government involvement.[3] In this case, the government's role is to provide farms with incentives to simultaneously produce the socially efficient quantities of the crop and the externality associated with its production.

As one moves from left to right in figure 1, it becomes increasingly difficult to link environmental outcomes back to management choices made on an individual farm. The increasing difficulty in establishing these linkages increases the cost of organizing negotiations between farms and the people affected by externalities—which, in turn, increases the rationale for government intervention. Unfortunately, as one moves from left to right in the figure, it also becomes increasingly difficult to evaluate the relative efficiency of alternative public policy responses to an externality.

Crafting a socially optimal response to an agricultural externality requires understanding the system of supply and demand relationships that characterize production of the crop, production of the externality, and consumers' willingness-to-pay for each. This requirement poses three difficulties. First, estimates of consumers' willingness-to-pay for externalities are imprecise. As the externalities or the people affected by them become more geographically dispersed (moving from left to right in figure 1) it becomes increasing difficult to recover the demand from market data. Economists generally agree that consumers' valuation of a small change in a local amenity can be inferred from housing price differentials. There is less agreement about how to determine the value that society places on reducing ambient pollution or enhancing environmental services. For example, recent estimates for the economic cost of failing to mitigate global climate change have varied by more than an order-of-magnitude (Stern and Taylor 2007; Nordhaus 2007). These studies use similar scenarios for future climate change. The large difference in their estimates stems from different opinions about the appropriate way to address intergenerational equity and the extent to which society discounts the possibility of catastrophic outcomes in the distant future.

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[3] Coase noted this in his original 1960 article. On page 18, he says "…there is no reason why, on occasion, such governmental administrative regulation should not lead to an improvement in economic efficiency. This would seem particularly likely when, as is normally the case with the smoke nuisance, a larger number of people is involved and when therefore the costs of handling the problem through the market or the firm may be high."

[4] The study used an index of benthic macroinvertebrate health as a measure of overall water quality. Macroinvetebrate populations (aquatic insects, crustaceans, worms, and mollusks, among others) are believed to be a key indicator of ecosystem health. Within each of 9 eco-regions, EPA defined "poor" stream miles as those with index values below 95 percent of the least-disturbed stream miles.

[5]The term "impaired" in EPA's study means that, because of pollution, the relevant water body fails to adequately support one or more of its designated uses such as fish consumption, drinking water, swimming, and boating.

The second difficulty is learning the relationship between agricultural land management and the production of air pollution, water pollution, and environmental services. The cumulative effect of farm externalities is widely believed to make a significant contribution to some environmental problems, particularly water quality (see, for example, Ruhl, 2000). However, data do not exist to consistently quantify most of the externalities from figure 1 on a national scale. The U.S. Department of Agriculture (USDA) tracks changes over time in the use of certain farm chemicals and growing practices, while the U.S. Environmental Protection Agency (EPA) tracks changes over time in measures for ambient air and water quality. What is generally missing is the link between the two sets of changes. EPA recently completed its first nationally consistent statistically based study of water quality in the nation's wadeable streams (U.S. EPA 2006). It concludes that 42 percent of U.S. stream miles are in poor condition compared to the least-disturbed streams that remain.[4] Excess sedimentation, phosphorus, and nitrogen were found to be the three most significant stressors to water quality in poor stream miles. While the sources of these pollutants were not identified by the study, EPA's 2000 National Water Quality Inventory (2002) cites production agriculture as the leading source of impaired river and stream miles.[5] Unfortunately, comparable efforts have not been made to characterize the link between farming and most other externalities.

The final difficulty in understanding the system of supply and demand relationships is that many of the externalities may be interrelated. A single management practice may produce multiple externalities. For example, removing intensively farmed land from production and replacing it with native grasses may simultaneously increase carbon sequestration, enhance scenic views, and reduce runoff of agricultural chemicals. Alternatively, an action taken to reduce one negative externality may create or exacerbate another negative externality. EPA is currently concerned about waterborne discharges of animal waste from confined feeding operations because they can lead to fish kills, diminished water clarity, and reduced aquatic biodiversity. These negative externalities can be mitigated by storing the manure in pits and lagoons or spreading it on fields, all of which reduce the chance of waterborne emissions. However, pits, lagoons, and land application of manure all create annoying odors for urban neighbors and increase the airborne emissions of ammonia, hydrogen sulfide, and other chemicals.

Without knowing the system of supply and demand relationships for the crop and each environmental externality, one cannot guarantee that any particular public policy will be socially efficient. Nevertheless, given the information available, policymakers have developed a variety of tools to address externalities from farming. At the federal level, these consist of environmental regulations and incentive payments.

3. Environmental Regulation

Environmental regulation in the United States is often described as following a "polluter pays" principle. That is, individual firms have to pay in order to legally emit pollutants into the air and water by purchasing a permit from the government or by installing pollution abatement equipment that satisfies minimum

[6] A limited number of non-major sources must also obtain permits.

[7] Emissions thresholds vary by chemical. The lowest threshold is 10 tons/year for hazardous air pollutants, although thresholds may be lower in air basins that fail to meet national ambient air quality standards. The Title V permit database can be accessed at: http://www.epa.gov/region09/air/permit/title-v-permits.html.

[8] This figure refers to the number of facilities in SIC category 02 (livestock) holding active NPDES permits according to EPA's Permit Compliance System database on 12/6/2007: http://www.epa.gov/enviro/html/pcs/pcs_query.html.

[9] EPA defines a CAFO as any facility that meets all three of the following criteria: (1) Animals are confined or maintained for at least 45 days during any 12-month period; (2) Crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility; or (3) The facility has: (a) More than 1000 animal units, or (b) More than 300 animal units & discharges directly into U.S. waters, or (c) Less than 300 animal units & discharges directly into U.S. waters & has been identified by the regulatory authority as a significant polluter.

technology standards. Firms that are caught emitting illegally are punished through fines, injunctions, and, occasionally, jail time. In 2005, EPA's compliance and enforcement programs cost firms more than $11 billion in compensation for past damages to the environment, criminal fines, and the cost of court-ordered actions to comply with current regulations (EPA, Office of Enforcement and Compliance Assurance 2005). While the agricultural sector of the economy has no general exception to the polluter pays principle, farms receive preferential treatment.

Table 1 summarizes the major environmental regulations and exemptions for farms. Current laws regulating air pollution, water pollution, and the use of toxic chemicals implicitly or explicitly exempt virtually all but the largest feedlots from direct federal regulation. The Clean Air Act sets national ambient air quality standards for a variety of chemicals, and Title V of the Act requires major industrial sources of emissions to purchase permits specifying what must be done to satisfy technology-based abatement standards, with the price of the permit varying with the level of emissions.[6] "Major" sources are those which emit more than threshold quantities of regulated chemicals, and thresholds are set at levels well above what would be expected from an individual farm. As a result, there are no California farms with Title V permits, as of December 2007.[7]

Wastewater emissions from confined animal feeding operations (CAFOs) have been the primary focus of federal environmental regulations on farming. This is especially relevant in California given the state's water quality issues and the role of CAFOs in the agricultural economy. Dairy products are the state's top agricultural commodity in terms of cash receipts, and CAFOs account for most of the dairy production. Two hundred and ninety of these operations have had to obtain federal wastewater permits in order to discharge pollutants into rivers and streams.[8] These National Pollutant Discharge Elimination System (NPDES) permits are required under the federal Clean Water Act for the largest CAFOs as well as for firms in other sectors of the economy.[9] Each permit certifies that the holder satisfies industry-specific abatement standards and that the affected water body satisfies water quality standards.

While production agriculture clearly faces less environmental regulation than other sectors of the economy, it would be incorrect to claim that farms are unaffected. Compared to developing countries, the United States tends to place more emphasis on using the pesticide registration process to protect food safety, the health of pesticide applicators, and wildlife populations, which may put domestic growers at a competitive disadvantage in international markets. For example, the Monterey Protocol allows Mexico and other developing countries to implement a slower phaseout of methyl bromide. Meanwhile, China has not committed to reduce its use of the fumigant. If continued gradual reductions in the domestic use of methyl bromide increase the price of U.S. strawberries and tomatoes, domestic growers may lose some of their share in international export markets to their competitors in Mexico and China (Carter et al., 2005). Furthermore, farms may be affected by environmental regulations on upstream and downstream firms. For example, firms that manufacture pesticides or process farm products do not enjoy the same regulatory exemptions as farms. Wineries and dairy processing facilities in California have had to purchase Title V air pollution permits, for example. Part of the burden from these regulations may get passed on to farms through higher pesticide prices and lower farm gate prices. Likewise, farms do not currently have any explicit exemption from endangered species legislation.

[10] This figure includes direct costs such as the registration fee, and water quality monitoring, analysis, and reporting, as well as indirect costs like the value of time spent attending water quality management training, and implementing best management practices. The exact costs will differ across growers and across the three regions, due to differences in waiver requirements. The costs also reflect the ability of growers to form "coalitions" that can apply for group waivers and coordinate water quality monitoring efforts.

[11] As of January 1, 2006, there were approximately 88,000 active National Pollution Discharge Elimination System wastewater permits in the country.

Table 1. Summary of Federal Environmental Regulations and Key Exemptions for Farms

Area	Statute[a]	Regulation	Key Exemptions/Limitations	Outcome
Water pollution	CWA, Sec 402	Point source wastewater permits *Point sources* must satisfy technology and water quality standards to obtain a permit to legally discharge pollutants into U.S. waters.	*Point sources* include confined animal feeding operations (CAFOs) in general, but exempt "agricultural stormwater discharges and return flows from irrigated agriculture."	Approximately 4,100 CAFOs have permits. All other farms may legally discharge soil, animal waste, fertilizer, and pesticides into U.S. waters without an individual permit.
	CWA, Sec 404	Dredge or fill permits Permits are required to fill wetlands.	Excludes "normal farming" activities with incidental discharges of dredged or fill material.	In some cases, farmers can convert wetlands to crop production without a permit.
	CWA, Sec 208 CWA, Sec 303 CWA, Sec 319 CZMA	Nonpoint source pollution States must develop plans to address pollution from *nonpoint sources* in waters failing to meet ambient quality standards.	1) Federal funding & enforcement is limited. 2) States determine which *nonpoint sources* to Regulate.	Some states exempt farmers, while other states promote voluntary adoption of best management practices. Direct regulation by state or local officials is rare. The Central Coast, San Joaquin, and Los Angeles water boards are among the few exceptions.
Air pollution	CAA, Sec 110	State Implementation Plans Each state must develop an enforceable plan to meet national ambient air quality standards, or be regulated by EPA.	Permitting regulations emphasize "major sources" that emit threshold levels of pollutants. Thresholds implicitly or explicitly exclude farmers.	Very few individual farms are required to obtain permits for air emissions.
Chemical use	FIFRA TSCA	Pesticide/fertilizer registration Registration, determination of approved uses, and limitations on who can apply them	Subject to EPA approval, states may register additional pesticide uses or temporarily use an unregistered pesticide to address pest emergencies	EPA determines which pesticides and fertilizers farmers can use, but special exemptions have been allowed for methyl bromide and others.
	CERCLA EPCRA RCRA	Monitoring, reporting, and liability for storage/disposal of toxic chemicals	Exempts FIFRA registered pesticides and agricultural use of fertilizer	EPA does not regulate, track, or report farmers' use of registered pesticides and fertilizer.
Wildlife habitat	ESA FMBTA	Prohibit "takings" of threatened and endangered species, and migratory birds	Unclear whether intent must be present in the case of poisoning of migratory birds	Legal actions have been taken against farmers and ranchers who "take" T&E species
Farm bill	Swampbuster and Sodbuster	Farmers who convert wetlands or fail to apply conservation systems on highly erodible land cannot collect payments.	Provisions apply only to a small share of current recipients of farm program benefits. Moreover, enforcement is questionable.	Farmers receiving payments have an incentive to comply. Other farmers do not.

CAA=Clean Air Act; CERCLA=Comprehensive Environmental Response, Compensation, and Liability Act; CWA=Clean Water Act; CZMA=Coastal Zone Management Act; EPCRA=Emergency Planning and Community Right to Know Act; ESA=Endangered Species Act; FIFRA=Federal Insecticide, Fungicide, and Rodenticide Act; MBTA=Migratory Bird Treaty Act; RCRA=Resource Conservation and Recovery Act; TSCA=Toxic Substances Control Act.

California is one of few states where some regional authorities have also imposed mandatory restrictions on agricultural practices that contribute to ambient air and water pollution. In the Sacramento Valley Air Basin—a nonattainment area for ozone and particulate matter—mandatory restrictions on rice straw burning have been established. These restrictions limit each farmer to burn no more than 25% of their total acreage each year, while simultaneously limiting the total acreage that can be burned to 125,000 acres, and placing additional restrictions on the days when burning is allowed. While there are no explicit restrictions on waterborne emissions from individual farms, farmers in the Central Coast, Central Valley, and Los Angeles regions must obtain "conditional waivers" for waterborne emissions. The waivers exempt farms from waste discharge requirements if they submit land management plans and agree to do some water quality monitoring. The Los Angeles Water Board estimates that, for the average farm, the total cost of obtaining a waiver is $416 per year.[10] However, these costs may be partly offset by Proposition 84, which allocates $15 million in grants to projects that reduce discharges from agricultural operations. The restrictions on rice straw burning have also been coupled with incentive payments to farms for developing alternative uses for rice straw (California Air Resource Board [2003]).

Overall, most farms in California and elsewhere in the United States face less environmental regulation than most firms in other industries, including manufacturers of farm inputs and processors of farm products. Why treat farms differently? Some have suggested that this special treatment stems from public belief in the Jeffersonian ideal that farmers are stewards of the land (see Ruhl 2000). Perhaps even more important is the logistical challenge of regulating more than 2 million farms, as EPA noted when it fought to exempt farms from the Clean Water Act in 1977. Today, it would take more than a tenfold expansion of EPA's wastewater permit program to attain universal coverage of farms.[11] Rather than regulate, the United States has developed voluntary incentive-based programs to address the environmental impacts of agricultural production.

4. Voluntary Conservation Programs

The farm bill provides the authority and the funding for USDA to operate a variety of voluntary conservation programs. Given the lack of federal regulation, these programs represent the primary set of instruments that policymakers can use to target agricultural externalities. The major conservation programs can be divided into three categories according to how they address externalities. Land retirement programs protect environmentally sensitive land by paying farmers to remove that land from active agricultural production. Working land programs pay farmers to continue farming, but to do so in a way that increases production of positive externalities and decreases production of negative externalities. Farmland protection programs purchase easements on farmland in order to ensure that it does not get converted to urban or other intensive uses.

The Conservation Reserve Program (CRP) and the Wetlands Reserve Program (WRP) are the two major land retirement programs. The CRP pays farmers to remove environmentally sensitive farmland from production for 10 to 15 year periods. Once removed, this land is planted to trees, grasses, and other forms of vegetative cover that help to reduce soil erosion and provide other positive externalities such as wildlife habitat or a buffer zone between actively farmed land and sensitive wetlands. Traditionally, the CRP has had the largest budget of any conservation program. In 2005, for example, it paid farmers nearly $1.7 billion to idle 35 million acres of farmland. The Wetlands Reserve Program is small by comparison. The goal of the WRP is to enhance the environmental services provided by wetlands. In 2005, farmers were

[12] One reason for increasing EQIP's budget in 2002 was to help owners of concentrated animal feeding operations obtain permits under EPA's revised wastewater permitting guidelines, which take effect in February, 2009.

paid approximately $224 million to restore 142,000 acres of wetlands to a more natural condition, and to remove adjacent land from agricultural production.

Until recently, land retirement accounted for the bulk of USDA's conservation expenditures. This changed when the 2002 farm bill authorized a five-fold increase in the budget for the largest working land program: the Environmental Quality Incentives Program (EQIP), which pays farmers to implement management practices that address resource concerns such as water quality, soil erosion, and wildlife habitat. One of the primary goals is to help farms meet regulatory requirements such as EPA's wastewater permitting guidelines for CAFOs.[12] The 2002 farm bill also created the Conservation Security Program (CSP), which is unique in that farmers can receive payments without developing new projects. Instead, they can be paid for ongoing conservation efforts that would otherwise be considered part of their normal farming operations. Although CSP was originally envisioned as an entitlement program, it has since been limited to selected watersheds. Farms in a participating watershed can enroll in one of three payment tiers, where the size of the payment per/acre varies with the level of conservation. In 2005, CSP paid farmers approximately $456 million. The final major working land program is the Wildlife Habitat Incentives Program (WHIP), which pays farmers up to 75 percent of the cost of undertaking projects that improve habitat for wildlife populations. In 2005, approximately $34 million was obliged to contracts, which can last for up to 15 years.

Finally, two farmland protection programs buy easements from farmers to prevent their land from being converted out of agriculture. The Farm and Ranch Land Protection Program (FRPP) pays up to 50 percent of an easement's cost, matching state and local funds provided by organizations that purchase development rights from farmers. The Grasslands Reserve Program (GRP) provides funding to purchase easements on working grazing lands. The easements pay farmers up to 75 percent of the grazing value of the land during each year of the contract, in addition to cost-sharing of restoration activities. With combined annual expenditures of about $150 million, the funding provided by FRPP and GRP exceeds the combined annual expenditures of state-level easement programs ($123 million) (Nickerson and Barnard 2006). Still,

Figure 2. United States Farm Production Regions

[13] For EQIP, the numbers in the table represent the total value of contracts signed in 2005, even though some of the money will actually be paid over a number of years. For the other six programs, the table indicates the value of payments made to farmers during 2005.

this amount is small compared to the cost of state-level programs, such as California's Williamson Act, that tax farmers based on the agricultural value of their land rather than the total value of that land, which includes the capitalized value of the potential for future urban development. Heimlich and Anderson (2001) estimate that the total annual value of potential tax revenue foregone through preferential taxation in the U.S. is $1.1 billion.

Overall, USDA spent more than $5 billion on conservation in 2005. Nearly $4 billion was spent on the seven programs described above, $0.7 billion was spent on providing technical assistance to farmers on conservation issues, and another $0.5 billion was spent by emergency conservation programs to restore farmland damaged in natural disasters. Table 2 reports the geographic distribution of funding.[13]

Table 2. Conservation Expenditures by Farm Production Region, FY 2005 ($ million)

Farm Production Region	Land Retirement		Working Lands			Farmland Protection		Total, All Programs
	CRP	WRP	EQIP	CSP	WHIP	FRPP	GRP	
Alaska/Hawaii	1	1	26	0	3	2	2	34
Appalachia	53	12	136	10	3	11	4	229
Corn Belt	459	50	113	118	2	7	7	756
Delta	61	42	75	54	3	0	2	236
Lake States	166	28	111	45	1	9	1	362
Mountain	249	6	286	51	4	10	7	613
Northeast	33	8	152	34	9	49	8	293
Northern Plains	349	21	107	28	2	1	13	521
Pacific	103	28	137	89	4	8	4	374
Southeast	45	20	128	19	2	7	3	225
Southern Plains	173	8	123	7	2	2	4	318
California	5	13	84	16	2	6	2	126
United States	1,690	224	1,394	456	34	107	56	3,961

Source: Natural Resources Conservation Service, USDA.
CRP=Conservation Reserve Program; CSP=Conservation Security Program; EQIP=Environmental Quality Incentives Program; FRPP=Farm and Ranch Land Protection Program; GRP=Grassland Reserve Program; WHIP=Wildlife Habitat Incentives Program; WRP=Wetland Reserve Program.

Together, CRP and EQIP account for more than three quarters of the total conservation expenditures. The Corn Belt and Northern Plains regions have the most cropland and account for the largest shares of CRP payments. In contrast, expenditures on EQIP projects are more evenly distributed across the country, partly reflecting the distribution of CAFOs. The geographic distribution of CSP payments is likely to

[14] It is difficult to derive a comparable figure for EQIP since some practices are reported in acres while others are reported in different units (such as feet of pipeline or number of aquaculture ponds). Moreover, multiple conservation practices may be implemented on the same acre of land. If there were no overlap, EQIP would account for an additional 57 million acres. Adding this figure to the subtotal for the other programs would provide an estimate for an upper bound on the geographic scope of conservation programs in 2005.

change from year to year as the program rotates across different watersheds whereas the distribution of WRP payments is largely determined by the locations of impaired wetlands. Payments for farmland protection have been concentrated in the Northeast, which has relatively little farmland remaining and some of the most active state and local easement programs. Finally, notice that payments are not allocated in proportion to the urban population. While more than 12% of the U.S. population lives in California, its farmers receive about 3% of conservation payments.

Four billion dollars may seem like a lot of money for conservation, but it is not enough to enroll more than a small share of farmland. The combined expenditures on CRP, WRP, CSP, WHIP, FRPP, and GRP funded conservation projects on approximately 46 million acres in 2005—at most 10 percent of U.S. cropland.[14] These programs were under-funded in the sense that more farmers wanted to enroll than were able. For example, 22 percent of the WRP applications were funded in 2005, compared to 60 percent for EQIP.

Table 3 displays the combined funding for working land programs (EQIP, CSP, and WHIP) by the primary resource concern addressed. Water quality was the top target in 2005, accounting for 41 percent of payments. Most of this funding was allocated to projects that aim to reduce pollution from sediment, fertilizer, pesticides, and animal waste. Soil erosion accounted for the next largest share of funding, followed by wildlife habitat and water quantity. Considerably less funding was allocated to reduce air and soil pollution. Projects addressing "water quantity" attempt to improve the efficiency of water use in order to assure there are adequate supplies for human populations, wildlife, and farm livestock. For example, in the Pacific region, projects include a special EQIP program to conserve water in the Klamath River Basin.

Table 3. Working Land Conservation Expenditures by Resource Concern, FY 2005 ($ million)

Farm Production Region	Water Quality	Soil Erosion	Wildlife Habitat*	Water Quantity	Other	Air Quality	Soil Quality	Wetland Health	Total
Alaska/Hawaii	6	3	12	6	2	0	0	0	29
Appalachia	51	28	12	15	6	1	2	0	113
Corn Belt	129	59	17	9	13	4	4	0	233
Delta	51	32	15	25	6	1	2	1	131
Lake States	96	32	13	3	2	6	5	1	158
Mountain	82	70	87	88	20	10	10	3	366
Northeast	95	27	24	14	6	5	5	1	168
Northern Plains	68	45	17	28	14	2	3	0	175
Pacific	83	51	34	42	7	9	6	1	230
Southeast	68	29	19	19	10	3	3	1	150
Southern Plains	27	19	45	33	6	2	0	0	131
California	35	15	16	23	3	6	2	1	102
United States	757	397	296	283	94	43	39	10	1884

* "Wildlife Habitat" includes the following NRCS resource concerns: forest health, habitat quality, plant population health, population health, and invasive species concerns on grazing land.

Source: Natural Resources Conservation Service, UDSA.

The coupling of USDA's incentive-based conservation programs with less regulation compared to other sectors of the economy has been dubbed a "pay the polluter" approach to addressing farm externalities, in contrast to the "polluter pays" principle that applies widely to firms elsewhere in the economy (Runge 1991). This preferential treatment is at least partly due to the administrative costs of regulation. While it is feasible to regulate small groups of farms like CAFOs or to require farmers in some water districts to submit land management plans, extending rigorous permitting, monitoring, and enforcement programs to the entire farm sector would require more than a tenfold expansion of EPA's current programs. This underscores the current role of federal conservation programs in addressing farm externalities. Unfortunately, the same monitoring difficulties that make it prohibitively expensive to directly regulate the farm sector also limit the efficiency of current conservation programs and pose a key challenge for any new program that would seek to pay farmers for providing environmental services.

5. Linking Financial Incentives to Measurable Environmental Outcomes

Do the environmental benefits from USDA's conservation programs exceed their implementation costs? Recent analyses suggest that they do. Hemlich (2006) reports net benefits for the Conservation Reserve Program and USDA (2003, 2005) report net benefits for the Environmental Quality Incentives Program and the Conservation Security Program. These studies quantify environmental benefits by multiplying existing estimates for the per/acre value of each externality by the number of acres enrolled in the program. For example, the annual value of improvements to wildlife habitat attributed to EQIP is estimated by calculating: (acres) x ($12.38) x (0.5). The $12.38 figure is an estimate from a previous study by Feather et al. (1999) for the extent to which enrolling one more acre in CRP would increase consumers' willingness-to-pay for nearby wildlife viewing and pheasant hunting opportunities. Multiplying this figure by 0.5 is an ad hoc way of acknowledging that implementing EQIP practices on working land may do less to increase wildlife populations than removing that land from production. This approach to cost-benefit analysis is quite rough. Furthermore, it is important to note that these analyses do not attempt to quantify many of the externalities associated with the conservation programs, including most environmental services. As a result, their measures for net benefits may be systematically underestimated.

The reason why cost-benefit analyses of USDA's conservation programs have relied on ad hoc adjustments like the 0.5 figure is that there has been no systematic attempt to consistently measure how farmers' management practices influence environmental outcomes. Thus, while farmers are paid for implementing management practices that are believed to be environmentally friendly, there is no specific evidence that the cumulative effect of these practices has improved environmental quality (Smith, 2006). Moreover, until we can link management practices to environmental outcomes, it will be difficult to design programs that align farmers' financial incentives with public environmental goals. Farmers currently choose from a menu of programs that pay them to implement management practices regardless of the environmental outcome. This provides an incentive to propose projects that will increase yields or reduce costs, regardless of whether those projects actually succeed in addressing a particular externality.

Ideally, farmers' financial incentives could be aligned with public goals by linking the size of conservation payments to environmental performance. Suppose policymakers want to increase the population of endangered Grey wolves. Under the current working land programs, a farmer could collect payments for implementing a project that is believed to have a beneficial effect on wolf habitat, regardless of whether any wolves actually visit the farm. A performance-based version of the same program might pay farmers

[15] Another strategy that has been suggested for this type of situation is to pay a group of farmers based on their collective contribution to an externality. This type of "group incentive scheme" has been envisioned as a way to control agricultural runoff at the watershed level (e.g. Segerson, 1988). However, the consensus within the literature is that these schemes would work best in watersheds with a small number of homogeneous farms, little non-farm pollution, readily monitored water quality, and short time lags between emissions and measurable changes in pollution. Unfortunately, very few watersheds in the U.S. appear to meet these criteria.

in proportion to the number of wolves that visit the farm (using radio collars) or in proportion to the number of wolf pups born on the farm. In this example, linking payments to the behavior of the wolf population provides a stronger incentive for the farmer to enhance wolf habitat. More generally, linking payments to environmental outcomes rewards farmers for developing new, cost-effective ways of addressing externalities. This incentive for innovation is missing from the current programs.

As we move from local amenities, like opportunities for wildlife viewing, to measures for ambient pollution and environmental services, it becomes increasingly difficult to link environmental externalities back to management choices made at the level of an individual farm. One strategy would be to use calibrated agricultural ecosystem models. These models use chemical and biophysical relationships to explain how environmental outcomes depend on farm characteristics, climate, and management practices. For example, Antle et al. (2003) used the Century model to predict how carbon sequestration rates vary with crop rotations in the Northern Plains region, given data on climate factors and the soil properties of individual farms. Feng et al. (2006) used the Environmental Policy Integrated Climate (EPIC) model to predict how different tillage methods would affect carbon sequestration, soil erosion, nitrogen runoff, and nitrogen leaching in Iowa. While these models contain some prediction error, it seems plausible that they could form the basis for policies that would tie financial incentives to predictions for farm-level carbon sequestration and farm-level nutrient emissions.

Another challenge is accounting for the interactions and threshold effects which tend to characterize the dynamics of wildlife populations and production of some environmental services (Levin, 2005). In particular, externalities that depend on the collective behavior of a group of farms will require policies that address group behavior. The case of threatened smelt (fish) in the Sacramento-San Joaquin Delta provides a timely example. Recent declines in smelt populations have been attributed to agricultural water transfers, runoff of agricultural chemicals, and invasive species (Service, 2007). Voluntary programs that pay farmers to use less water or to implement management practices that reduce agricultural runoff may have no effect on fish populations unless a critical mass of farms participate. One possibility would be to ask farmers throughout a particular watershed to submit bids stating their minimum willingness-to-accept to reduce water use and/or pesticide applications. The bids could then be used to decide whether the expected benefits of achieving target reductions exceed the minimum cost of doing so.[15] This type of bidding scheme, which is similar to the one used by CRP, is actually prohibited under current EQIP rules.

Finally, developing policies that tie financial incentives to environmental performance would require collecting information on the physical characteristics of farmland and farmers' management practices. The California Climate Action Registry provides a model for how this could be done. In addition for forming the basis for policies to address environmental services, these data would provide an important input to the continuing research effort to understand the connections between farmers' management practices and environmental outcomes. Making the information available to the public would also create new opportunities for environmental groups or others who are directly affected by externalities to negotiate directly with farmers without additional government involvement.

6. Conclusions

Within the farming sector of the economy, federal regulation of air pollution, water pollution, and the use of toxic chemicals primarily applies to the largest confined animal feeding operations. Responsibility for regulating emissions from all other farms is mostly delegated to state and local authorities. California is one of few states where regional authorities have imposed mandatory restrictions on agricultural practices due to environmental concerns. However, these restrictions do not impose the same level of rigorous permitting, monitoring, and enforcement that characterize the environmental regulation of air and water emissions from individual firms in other sectors of the economy.

The government has used voluntary conservation programs to address farm externalities. The federal budget for these programs has grown to more than $5 billion annually, but the programs still only enroll a small share of U.S. farmland and California receives a disproportionately small share of the payments (3% in 2005). Recent analyses of the three largest programs funded by the 2002 farm bill (CRP, EQIP, and CSP) suggest that they all generate environmental benefits that exceed their program costs. However, the current approach of paying farmers to implement conservation practices regardless of the environmental outcome fails to align farmers' financial incentives with public environmental goals. Creating a system of incentives based on measurable environmental outcomes is the key challenge for those who seek to improve the efficiency of existing conservation programs or to design new policies for environmental services provided by California farms.

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