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Pesticide Use and Air Quality in the San Joaquin Valley

by

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The California Department of Pesticide Regulation proposes to limit the maximum emission potential of pesticides formulated as emulsifiable concentrates to 20 percent. Many crops use pesticides that do not meet this requirement currently.

Air quality in the San Joaquin Valley is a significant concern for residents and policymakers alike. According to the California Air Resources Board (ARB), "The San Joaquin Valley experiences some of the worst ozone and particulate air pollution in the U.S., with both high levels and frequent episodes" (ARB, 2004, p.1). Sufficiently high concentrations of ozone in the troposphere, which begins at ground level, can be harmful to human health, causing respiratory sicknesses and irritation. Volatile organic compounds (VOCs) and nitrogen oxide combine with sunlight to form ozone. VOCs are emitted by a number of sources, including vehicles, livestock waste and pesticides.

The federal Clean Air Act requires each state to develop an implementation plan to improve air quality and meet air quality standards, including a standard for tropospheric ozone. The San Joaquin Valley Air Basin has failed to meet these standards, and is classified as an extreme nonattainment area. As part of efforts to bring it into compliance, the California Department of Pesticide Regulation (CDPR) will seek to reduce emissions of VOCs from pesticides through regulations, and through research and extension efforts regarding alternatives. At a February 23, 2005 meeting of its Pest Management Advisory Committee, CDPR announced that it intended to reduce VOC emissions from pesticides in the San Joaquin Valley by setting a maximum emission potential (EP) of 20 percent. This requirement mandates that all emulsifiable concentrate pesticides with an emission potential currently above this level must be reformulated in order to continue to be used in California.

The purpose of this analysis is to provide information that can aid in assessing the potential costs of the 20 percent maximum EP reformulation requirement, by providing information regarding the scope of the requirement's impact on agricultural production. Determining the net benefit would require information regarding the profit difference between growers' next best alternatives for each commodity-pest pair, given all the pesticide products affected by the requirement, and the effect of these alternatives on VOC emissions.

Background

A CDPR report (cited at the end of this article on page 5) regarding estimated VOC emissions from pesticides for 1990-2002 is a key summary document that is helpful for discussion of pesticides' contributions to VOCs. In the San Joaquin Valley, the major pesticide contributors are fumigants and products with emulsifiable concentrate (EC) formulations. Three fumigants, metam sodium (29.9 percent), 1,3-dichloropropene (14.2 percent), and

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Table 1. Use of EC Pesticides with an Emission Potential Greater than 20 Percent

	Any Use	Intensive Use All EC[a]	Intensive Use Single Active Ingredient[b]	Intensive Use Single Product[c]
Number of Commodities	58	40	14	12
Value of Production ($1,000)	$14,326,571	$9,050,031	$3,351,680	$3,001,680
Share of 2002 CA Production	78.5%	49.6%	18.4%	16.5%

a. Total application-acres for all EC products are 50% or more of total harvested acres.
b. Application-acres are 50% or more of total harvested acres for EC active ingredient with greatest application-acres.
c. Application-acres are 50% or more of total harvested acres for EC product with greatest application-acres.

methyl bromide (6.4 percent) accounted for about 47.5 percent of all VOC emissions from pesticides during the May-October ozone season for 2002. Because fumigants are themselves VOCs, they have an emission potential of 100 percent. By nature, they cannot be reformulated, and are excluded from CDPR's proposed reformulation requirement.

For ECs, it is mostly the formulation ingredients (rather than the active ingredients) that collectively account for about 37 percent of VOC emissions. EC products with the active ingredient chlorpyrifos are the third largest contributor, accounting for 8.5 percent of all VOC emissions from pesticides during the May-October ozone season for 2002. The most important crops in generating emissions from ECs are cotton (estimated at 13 percent of the total VOCs), almonds (8 percent) and oranges (5 percent). However, these summaries overlook the complexities of the contributions from these crops. First, each crop uses multiple pesticides that emit VOCs. Second, eliminating currently available products by requiring reformulation may result in greater total pesticide use by growers, due to the need to use less effective alternatives for certain pests. Even if this increase in applications does not result in a net increase in VOC emissions, it may have other adverse environmental or human health effects. In cotton (for aphids) and citrus (for citricola scale), the EC formulation itself is currently believed to be critical to the effectiveness of chlorpyrifos at controlling specific pests. In these two cases, chlorpyrifos EC seems to be the safest and most effective way to control the pests, at least currently.

Research Approach

In order to evaluate the importance to California agriculture of EC pesticide products that would be affected by a maximum EP requirement, we linked data regarding pesticide use, pesticide formulations and emission potentials, value of production and harvested acreage. Our analysis was limited to a subset of agricultural crops for which it was possible to match information regarding pesticide use to information regarding acreage and the value of production.

It is difficult to quantify the importance of ECs for a large number of very diverse crops. Evaluating application acres at this aggregate level abstracts from other factors that are critical determinants of the economic value of ECs, such as the availability and efficacy of non-EC substitutes. Similarly, it is difficult to assess the extent to which two different ECs may be substitutes. If two products are substitutes for the control of a specific pest, then the sum of their use will provide a more accurate measure of their importance than will evaluating the two products individually. In contrast, if two products control two different pests, then their importance should be evaluated separately. There is also no direct information regarding the importance of ECs that are used on a small share of acreage to control a specific pest problem, and have no economically viable alternatives. This aggregate analysis can be used to identify commodities that require more detailed investigation, however, by identifying intensive users.

We report four measures of the importance of EC pesticides to California agriculture. Three measures compare harvested acres to the acres to which specified pesticides are applied for each crop for each commodity. First, we identify commodities that report EC application acres that sum to 50 percent or more of total harvested acreage, which we refer to as "intensive EC use" commodities. Second, commodities for which a single active ingredient is applied as an emulsifiable concentrate to 50 percent or more of harvested acreage, are referred to as "intensive single-active ingredient use" commodities. Third, commodities for which a single EC pesticide is applied to 50 percent or more of harvested acreage are referred to as "intensive single-product EC use" commodities. Finally, we report the number of EC formulation pesticides applied to each crop.

Clearly, these measures are only imperfect indicators of the importance of ECs to individual commodities. In particular, defining intensive use by comparing application acres to harvested acres does not differentiate between a product applied once to 50 percent of harvested acreage, and a product applied five times to 10 percent of harvested acreage. This limitation means that our calculation of the share of the value of production that relies on ECs may be too high. On the other hand, our measures do not reflect the value of a product that is the only effective control for a specific pest in a specific commodity, but that was not used on a substantial share of acreage in 2002. This limitation means that our calculations may understate the importance of ECs. It is also important to understand that these measures address the importance of pesticide use on an acreage basis and do not address the effect on VOC emissions. Depending on ECs and application rates, an intensively used product may account for a very small share of emissions, or a product that is not intensively used may account for a large share of emissions.

Our final summary measure of the importance of EC use to California agriculture is the number of EC products used by each commodity. The large number of products used by many commodities suggests that some EC products are likely to be substitutes. In turn, this suggests that the single-product use measure reported above underestimates the importance of ECs, although it is not feasible to determine to what extent this is the case, given our degree of aggregation.

Results: Twenty Percent Maximum Emission Potential

Table 1 summarizes our findings regarding the value of agricultural production that would be potentially affected by the maximum EP of 20 percent proposed by CDPR. Of the subset of commodities for which we could link pesticide use data and value of production and acreage data, 58 used one or more EC pesticides with an EP of more than 20 percent. These commodities accounted for about $14.3 billion of production, or 78.5 percent of California's total fruit and nut, vegetable, and field crop production in 2002 (henceforth referred to as California production). Figs are the only crop that uses pesticides affected by a maximum 20 percent emission potential requirement but does not use pesticides affected by a maximum 50 percent emission potential requirement.

Not all commodities that use ECs are intensive users of ECs. As shown in Table 2, of the 58 commodities that

Table 2. Use of EC Pesticides with an Emission Potential Greater than 20 Percent by Commodity

Commodity (Any EC Use)	Intensive Use, All EC[a]	Intensive Use, Single Active Ingredient	Intensive Use, Single Product[c]
Almond	x	x	x
Apple	x		
Apricot	x		
Asparagus	x		
Avocado			
Barley			
Bean, dried	x		
Bean, succulent	x	x	x
Boysenberry			
Broccoli	x	x	x
Cabbage	x		
Cantaloupe	x		
Carrot	x	x	x
Cauliflower	x	x	
Celery	x	x	x
Cherry	x		
Corn (forage fodder)			
Corn, human cons.	x	x	x
Cotton	x		
Cucumber	x		
Date			
Fig			
Forage hay/silage			
Garlic	x	x	x
Grapefruit			
Grapes			
Kiwi			
Lemon	x		
Melon	x	x	x
Mushroom			
Nectarine	x	x	
Oat	x		
Olive			
Onion, dry	x	x	x
Onion, green			
Orange	x		
Peach	x		
Pear	x		
Pecan	x		
Pepper	x		
Pistachio	x	x	x
Plum	x		
Potato	x		
Prune	x		
Pumpkin	x		
Raspberry			
Rice			
Sorghum			
Spinach	x		
Strawberry	x	x	x
Sugarbeet	x	x	x
Sweet potato			
Tangerine	x		
Tomato	x		
Tomato, processing	x		
Walnut	x		
Watermelon	x		
Wheat			

a. Total application-acres for all EC products are 50% or more of total harvested acres.
b. Application-acres are 50% or more of total harvested acres for EC active ingredient with greatest application-acres.
c. Application-acres are 50% or more of total harvested acres for EC product with greatest application-acres.

use any affected EC products, 40 are intensive users of all EC products, as indicated by an "X" in the second column of the table. These products have a value of production of $9.1 billion, or 49.6 percent of California production. Fourteen commodities are intensive users of EC products with a single active ingredient, as indicated by the third column of Table 2. These commodities accounted for 18.4 percent of California production or $3.4 billion. Twelve commodities are intensive users of a single EC product, and accounted for 16.5 percent of California production or $3.0 billion. These commodities are the same as the intensive users of a single active ingredient, excluding cauliflower and nectarines. Although it is not true for all of the commodities in our analysis, for the commodities that are intensive users of a single product the active ingredient in the most-used product is the same as the most-used active ingredient.

On average, each commodity within our set of 58 commodities that used any EC pesticides used 37.8 distinct EC products that would require reformulation under the 20 percent maximum EP requirement. The median number of affected products used by these commodities was 38.5. The maximum number of products used was 101, and the minimum was two. In total, there were 280 commodity-pesticide pairs in our sample that would be affected by a 20 percent maximum EP.

Results: Fifty Percent Maximum Emission Potential

Table 3 summarizes the value of agricultural production that would be potentially affected by a maximum EP of 50 percent for EC products. In California, 57 commodities use one or more EC pesticides with an EP of more than 50 percent. Together, these 57 commodities in our data account for about $14 billion, or 78.4 percent of California production. This is only one commodity fewer than the 58 that use one or more EC pesticides with an EP of more than 20 percent.

However, there is a substantial difference between the 20 percent maximum and the 50 percent maximum in terms of their effects on intensive users. Only 21 commodities are intensive users of pesticides affected by the 50 percent maximum, and these commodities account for 23.9 percent of California production, or about $4.4 billion. In contrast, recall that 40 commodities accounting for 49.6 percent of California production are intensive users of pesticides affected by the 20 percent maximum. Seven commodities, valued at $1.6 billion, are intensive users of a single active ingredient with an EP of more than 50 percent. The seven commodities are succulent beans, broccoli, cauliflower, celery, corn for human consumption, pistachios and strawberries. Six, valued at $1.4 billion, are intensive users of a single product (excludes cauliflower, relative to the previous list). While it is not the case for all commodities in our analysis, for the six single-product intensive use commodities, the most-used active ingredient is the same as the active ingredient in the most-used product.

Within our subset of 57 commodities, 51 used more than one affected EC product. The average number of products was 12.3, and the median was 12.0. The maximum number of products used by one commodity was 34. Relative to the 20 percent maximum EP requirement, many fewer product-commodity uses would be affected by a 50 percent maximum requirement. In total, there were 81 commodity-pesticide pairs in our sample that would be affected.

Reregistration and Minor Crops

A reformulated product will require reregistration. While in some cases reformulation may be achieved simply through changing formulation ingredients, and not the active ingredient or rate recommendation, in other cases reformulation will require registering a new pesticide product. Much of California's EC use is on so-called "minor crops." Registrants may conclude that the benefits of reformulating and reregistering a product for a minor use may be outweighed by the costs. Given the number of commodities that use ECs, and the complexity of the interactions among changes in EC formulations and product availability, it is difficult to estimate the potential effects of a reformulation requirement on product availability.

Implications and Further Research

In order for the San Joaquin Valley to achieve its VOC emission reduction objectives, VOC emissions from pesticides must be reduced. CDPR proposes to do so by imposing a 20 percent EP maximum on EC pesticides. EC pesticides are used by many California commodities, and either of the reformulation proposals we examined would affect pesticides used by a large majority of California's fruit and nut, vegetable, and field crops, as measured by the value of production. The intensive use of the affected products is more concentrated, but still accounts for a substantial share of the value of production. Our analysis suggests that the precise level of the maximum EP is a critical determinant of the scope of its potential effects on agriculture. A 20 percent EP limit affected roughly twice as many intensive users, accounting for twice the value of production, as a 50 percent EP limit.

Table 3. Use of EC Pesticides with an Emission Potential Greater than 50 Percent

	Any Use	Intensive Use, All EC[a]	Intensive Use, Single Active Ingredient[b]	Intensive Use, Single Product[c]
Number of Commodities	57	21	7	6
Value of Production ($1,000)	$14,308,484	$4,363,918	$1,588,890	$1,371,185
Share of 2002 Value of CA Production	78.4%	23.9%	8.7%	7.5%

a. Total application-acres for all EC products are 50% or more of total harvested acres.
b. Application-acres are 50% or more of total harvested acres for EC active ingredient with greatest application-acres.
c. Application-acres are 50% or more of total harvested acres for EC product with greatest application-acres.

Our aggregated analysis can only provide an approximation of the costs of a reformulation requirement. In addition to that information, it facilitates identification of commodities that have the greatest potential for incurring large losses due to reformulation, and hence require closer study. In some cases, these commodities would not be identified by an analysis done only on a per-active ingredient or per-product basis. For example, a commodity that intensively uses the group of impacted ECs as a whole, but does not intensively use any one active ingredient or product, should be examined more closely in order to determine if some ECs are substitutes.

Commodity-specific research can also serve as a means of identifying cases where there are relatively efficacious alternatives to using EC pesticides with high EPs. There are currently possible alternatives to some EC uses that could be promoted by training and permitting processes. However, due to the diversity of crops and pests for which EC pesticides are used, the necessary research and extension to reduce EC use will probably be complex and costly, and it will be necessary to prioritize research needs.

In this case, in order to maximize the expected net benefits of research, scarce research and extension resources should be directed to crop-pest cases where management alternatives to VOC-emitting pesticides will result in substantial declines in VOC emissions, and failing to obtain an effective alternative will result in a large potential value of production loss. For example, a high-value crop that accounts for relatively few production acres, but uses very high rates of a pesticide with a high EP would be a research priority, as would a lower-value crop with lower emissions per acre, but relatively many acres.

Translating this prioritization into practical terms, because of the relatively small contributions from so many other crops, the most cost-effective way to reduce the use of VOC-emitting ECs in the San Joaquin Valley will likely be to reduce the use of EC formulations of chlorpyrifos and other compounds in cotton, almonds and citrus. It also suggests that because fumigants are used at high rates on high-value crops such as carrots, potatoes and onions, and have a 100 percent emission potential, that any cost-effective approach to improving air quality in the San Joaquin Valley will likely include reductions in the use of fumigants, or in the VOC emissions per unit time. Alternatives to fumigant use should be another research priority.

For further information, the authors recommend the following sources:

Air Resources Board, State of California. 2004. “Proposed 2004 State Implementation Plan for Ozone in the San Joaquin Valley.” Staff Report. September 28. 42 pages. www.arb.ca.gov/planning/sip/sjv04/sjv_04_ozone_sip_staff_rpt.pdf.

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Spurlock, Frank. 2004. “2004 Update to the Pesticide VOC Inventory: Estimated Emissions 1990-2002.” California Department of Pesticide Regulation. Memo to John Sanders. May 17. 14 pages. www.cdpr.ca.gov/docs/pur/vocproj/060304em_inv.pdf.

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Sales and Brand Loyalty

by

Rui Huang, Jeffrey M. Perloff and Sofia B. Villas-Boas

Consumers surprisingly exhibit little loyalty to either national brands or private labels for orange juice. Consumers also switch frequently between frozen and refrigerated orange juice. Switching is enhanced when stores hold frequent sales of orange juice products. Ê

Some consumers, known as loyals, always buy a particular brand-name food. Other consumers, called switchers, chose which brand they buy in a given shopping trip depending on relative prices of the products. Stores try to induce these consumers to switch to a given brand by putting it on sale.

Is switching common? Which types of households switch between food brands? How does the frequency with which stores hold sales affect whether households buy on sale? Does a sale on one good affect which brands of related goods are purchased? We answer these questions for frozen and refrigerated orange juice (OJ), using grocery store scanner data: Information Resources Incorporated's (IRI) InfoScan® Household Panel data for 1997 through 1999.

Orange juice is a good choice for studying brand loyalty because the industry is moderately concentrated. The top two brands in the industry, Tropicana and Minute Maid, account for more than half of the market share in terms of dollar sales in either the frozen concentrate market or the refrigerated juice market.

We examine whether consumers switch between brands among only refrigerated OJ, only frozen OJ, and between both refrigerated and frozen OJ. We categorize consumers based on their loyalty or brand-switching behavior over a year. For the frozen and refrigerated samples, the first group consists of loyal consumers who purchase a top-selling national brand; the second group consists of consumers who are loyal to the store's private-label product; and the other two include people who switch between top national brands and private labels or who purchase other brands. The combined sample has customers who are loyal to a national brand, those who switch within a type, and those who switch between types.

How Common is Switching?

To our surprise, switching behavior is extremely common and brand loyalty is relatively uncommon for orange juice. Sixty-one percent of the frozen OJ customers and 77 percent of the refrigerated OJ customers switch or buy minor brands. Overall, 92 percent of the consumers switch within or between types of juice. Perhaps most striking is that 60 percent of all consumers switch between refrigerated and frozen orange juice products. If we look at loyalty for more than one year, we find that virtually no household is loyal to a single brand.

Roughly twice as many consumers of refrigerated or frozen juice are loyal to the leading national brands as to a private label. Of frozen orange juice consumers, 25 percent are loyal to a leading brand-name product and 14 percent to the private label. In contrast for those who consume refrigerated orange juice, only 16 percent are loyal to the top brand name and only six percent to the private label.

Looking only within frozen or within refrigerated juices provides a misleading picture that there is more loyalty than when we take account of switching between types. We find substantially less national brand loyalty if we allow consumers to switch between frozen and refrigerated products than if we look at just one or the other type of juice: The share of consumers who buy only leading national brands drops from 25 percent to three percent for frozen and from 16 percent to five percent for refrigerated.

What Affects Switching?

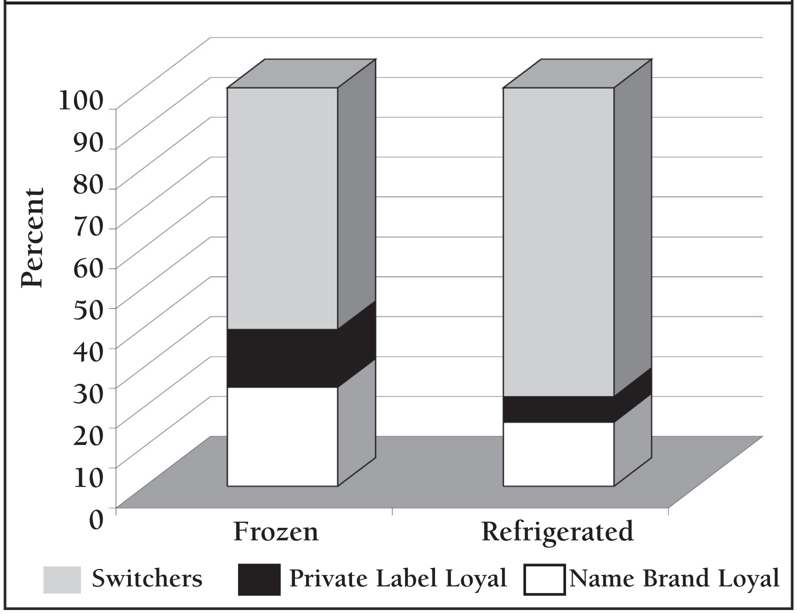
Is brand loyalty determined by household characteristics, the frequency of sales, or both? To answer this question, we used a statistical analysis. Among the consumer characteristics we considered were age, race, education, employment and occupation of female and male household heads, age of children, household size, household income and where they live.

For a given set of household characteristics, when the frequency of sales rises, fewer consumers of orange juice remain loyal to a national brand and switching behavior increases. If a store were to increase its frequency of sales from zero percent to 15 percent (the observed range), the probability of its refrigerated orange juice customers being loyal to a national brand, falls from eight percent to two percent, the probability of being loyal to a private label drops negligibly, so the share who are switchers rises from 86 percent to 93 percent. The comparable figures for frozen juice consumers are: 20 percent to four percent, 12 percent to six percent, and 68 percent to 90 percent.

We found that household characteristics generally affect whether a household is likely to switch in the manner that we expected, but the effects were generally relatively small. We calculated the effects of changing only one characteristic at a time, holding the other characteristics and the frequency of sales constant.

As household income rises, consumers are more likely to be loyal to a national brand, less likely to be loyal to a private label and less likely to switch. In short, wealthy households buy a leading national brand and stick with it, even though it may cost more than other brands. As household income rises from $30,000 to over $100,000, the share of refrigerated juice consumers who are loyal to the national brand nearly doubles from seven to 13 percent, while the share who buy frozen drops from six to three percent. The comparable figures for frozen juice consumers are 17 to 27 percent and 14 to nine percent.

Figure 1. Consumer Types in Frozen and Refrigerated Samples



As household size increases, consumers are more likely to buy a private label. The reward to buying inexpensive brands rises with family size. This increase comes at the expense of leading national brands; however, the share of switchers remains relatively unchanged. As the household size rises from two to five people, the share that are loyal to the national brand falls from eight to six percent and the share that buys the private label rises from five to seven percent for the refrigerated sample. The comparable figures for the frozen sample are 20 to 14 percent and 13 to 16 percent.

Renters are more likely to be loyal than are home owners. Surprisingly, renters are slightly more likely to be loyal to both leading national brands and to a private label than are home-owners. Consequently, renters are less likely to be switchers.

Race affects loyalty to a national brand for refrigerated orange juice. For refrigerated OJ, the probability that a white consumer is loyal to a leading national brand is eight percent compared to seven percent for Hispanic consumers, and six percent for black consumers. Race has negligible effects on loyalty to a private label or for frozen juice.

Senior citizens exhibit less brand loyalty for refrigerated orange juice than do younger consumers. In the refrigerated sample, older consumers are less likely to be loyal to either a name brand juice or a private label. This result contrasts with pharmaceuticals, where older consumers were more likely than others to buy a name brand instead of a generic drug. Age has virtually no effect on switching behavior in the frozen or combined samples.

Summary

Loyalty to brands of orange juice is rare. Consumers not only switch between brands for a particular type of orange juice; they also switch between frozen and refrigerated brands. There is relatively little difference across households' orange juice consumption due to income, family size, race, age of family heads, age of children, education, occupation or other factors. However, loyalty decreases substantially as sales become more frequent.

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Coho Salmon Recovery In California: A Summary Of Recent Economic Evidence

by

Alix Peterson Zwane and David L. Sunding

In 2003, with the input of stakeholders, the California Department of Fish and Game created the Recovery Strategy for California Coho Salmon, a guide for the process of recovering coho salmon on the north and central coasts of California. In this article we summarize our estimates of both the fiscal cost and the socioeconomic impacts of implementing the Coho Salmon Recovery Strategy (Recovery Strategy) for the Central California Coast (CCC) Coho Evolutionary Significant Unit (ESU) and the California portion of the Southern Oregon-Northern California Coast (SONCC) Coho ESU.

The Coho Salmon Recovery Strategy prepared under the direction of the California Department of Fish and Game (the Department) lays out actions to be taken in order to recover the coho in California. We estimated the cost of implementing the recovery strategy. In this note we summarize our estimates of both the fiscal cost and the socioeconomic impacts of implementing the Coho Salmon Recovery Strategy (Recovery Strategy) for the Central California Coast (CCC) Coho Evolutionary Significant Unit (ESU) and the California portion of the Southern Oregon-Northern California Coast (SONCC) Coho ESU. We find that the absolute costs of recovery, estimated to be about $5 billion, depend to a large extent on the amount of water acquired to improve in-stream flows for coho in the SONCC, which is unknown at this time. The magnitude of the cost estimate is typical for species that require changes in land use for habitat restoration.

We also find that publicly-financed coho recovery requires transferring state resources from urban centers to rural counties in California, potentially creating important new job opportunities in areas with structural unemployment. Whether the fiscal costs of recovery in these regions are borne by the private landowners or the public sector depends on the important unresolved role of increased enforcement of permits and take restrictions. Private timber landowners are likely to bear higher costs than private agricultural landowners.

Methodology

The fiscal or budgetary cost of a recovery action is the expenditure needed to physically perform the action. The socioeconomic impact of a recovery action includes income foregone because the recovery action is undertaken, and transfers to the local region (called a Hydrological Unit [HU]) from outside the region because the recovery action is undertaken. We present fiscal cost impacts of the various recovery recommendations as the current dollar cost of completing the project now. Though we know that in practice activities will take place under many conditions and at many different points in time, little is known about the specific sequencing of recovery recommendations or how state obligations would be financed. In order to develop cost and impact assessments, our primary unit of analysis is the hydrologic sub-area (HSA), a sub-unit of the HU.

Table 1: Estimated Recovery Costs by Hydrological Unit

Hydrological Unit	Cost ($1,000)
Big Basin	253,907
Bodega	17,574
Cape Mendocino	146,916
Eel River	612,527
Eureka Plain	22,403
Klamath River	849,118
Mad River	26,176
Marin Coastal	57,802
Mendocino Coast	780,043
Redwood Creek	23,866
Rogue River	7,035
Russian River	265,194
San Francisco Bay HUs	130,565
San Mateo	63,271
Smith River	21,865
Trinidad	21,865
Trinity River	564,392
Winchuck River	2,827
Total SONCC (w/o Scott/Shasta)	1,680,502
Total CCC	1,465,139
Total SONCC/CCC Restoration Costs	3,954,195
Total Scott/Shasta Restoration	371,584
Total Restoration Incl. Scott/Shasta	4,325,778

Source: Authors' calculation. Habitat restoration includes removal of barriers to fish passage, riparian revegetation and stream bank improvements, placement of LWD and improvements in instream complexity, and road treatment and decommissioning. Scott/Shasta is Shasta Valley and Scott River HSAs.

We estimated the unit cost of recovery recommendations common to many HSAs and identified ways in which costs vary systematically across HSAs. The commonly recommended recovery recommendations for which unit cost estimates were developed are:

- Removing or alleviating barriers to fish passage;
- Implementing riparian revegetation and other Ê stream bank improvements; Ê
- Improving in-stream complexity;
- Road treatment and/or decommissioning;
- Water acquisitions;
- Undertaking biological studies of salmon behavior;
- Watershed planning, and
- Education and outreach efforts.

We developed aggregate cost estimates for common recovery recommendations with a series of restoration cost models. These models combine unit cost estimates with information on the potential scale at which recommended activities could be undertaken when known (provided by the Department) and information about the ways that unit costs are likely to vary across HSAs. The socioeconomic impact that will occur as a result of habitat restoration is calculated as the amount of regional transfers stemming from these activities. These equal total fiscal costs less project costs attributable to permitting, planning and mobilization estimated from historical project budgets.

A major source of cost variation is likely to come from regional differences in wage rates since labor costs form a large part of the total unit cost of most recovery recommendations. Data on average wages paid to construction workers in California counties were used to identify how recovery costs are likely to vary across HSAs as a result of labor costs. We mapped the county-level wage data to HSAs using GIS.

Table 2: Range-Wide Costs

Cost Category	Cost ($1,000)
Monitoring, evaluation and planning	
Total excl. Scott/Shasta	44,000
Total Scott/Shasta	10,604
Total incl. Scott/Shasta	54,604
Education and outreach	
Total excl. Scott/Shasta	31,000
Total Scott/Shasta	8,833
Total incl. Scott/Shasta	39,833
Water management	
Total excl. Scott/Shasta	--
Total Scott/Shasta	10,334
Water use efficiency	
Total excl. Scott/Shasta	--
Total Scott/Shasta	3,200
Water acquisition	
Total excl. Scott/Shasta	UNKNOWN
Total Scott/Shasta	60,218
Other	
Total excl. Scott/Shasta	0
Total Scott/Shasta (Best management practices)	1,245
Timberland management	
	FEW INCREMENTAL COSTS

Source: Authors' calculation.
Scott/Shasta is Shasta Valley and Scott River HSAs

Table 3: Total Estimated Costs of Coho Salmon Recovery

Total Southern Oregon/Northern California Coho Costs, excluding Water ($1,000)	4,492,195
Total Scott/Shasta Costs ($1,000)	466,017

Source: Authors' calculation. Scott/Shasta is Shasta Valley and Scott River HSAs. No cost estimates are available for water acquisition in the CCC or SONCC excluding the Scott/Shasta. Excludes costs identified but not quantified.

Aggregate Cost Estimates

Tables 1 through 3 summarize the measured fiscal cost of coho recovery in California. Habitat restoration costs are presented by hydrological unit; other costs are presented on a range-wide basis. Tables 4 and 5 summarize the measured socioeconomic impacts of coho recovery. Habitat restoration impacts are presented by HU, while other costs are presented on a range-wide basis. These estimates include the cost of recovery in Scott/Shasta (the Shasta Valley and Scott River HSAs), which is shown separately.

The aggregate cost estimates presented in Tables 1 through 3 include not only the cost of performing recommendations that are common to many HU/HSAs, but also the cost of specific tasks that respond to the unique circumstances of each HU/HSA. Some of these items are a significant portion of the costs estimated here. For example, restoring coarse sediment transport near Iron Gate Dam (in the Klamath River HU) may cost as much as $500 million.

Restoration costs are higher in the SONCC Coho ESU than the CCC Coho ESU, likely because coho salmon are more widely distributed within the SONCC Coho ESU. An important unmeasured cost is the cost of water acquisition outside of Scott/Shasta. These costs are likely to be significant, especially in the SONCC, as are the associated socioeconomic impacts.

Monitoring, evaluation, planning, and education and outreach costs are about $90 million dollars; about two percent of total estimated fiscal costs.

The timberland management strategy proposal adopted by the Commission of Fish and Game entails land-use restrictions that will have costs around $1.7 billion. Because of the way we estimated the cost of habitat restoration, these costs are not in addition to the costs that we estimated, but subsumed in our estimates of the cost of recovery activities. This is a controversial, and costly, element of the recovery strategy that will have negative socioeconomic impacts, including timber employment impacts.

Restoration activities can generate positive socioeconomic impacts. Socioeconomic impacts generated from restoration equal about one-half of the fiscal costs of restoration or $2.1 billion. The socioeconomic impacts of water acquisition in the SONCC range will be negative (for Scott/Shasta these negative impacts equal about $6 million).

Table 4: Socioeconomic Impacts of Restoration

Hydrological Unit	Impacts ($1, 000)
Big Basin	157,582
Bodega	6,867
Cape Mendocino	87,121
Eel River	346,282
Eureka Plain	5,404
Klamath River	219,665
Mad River	15,304
Marin Coastal	36,888
Mendocino Coast	465,156
Redwood Creek	12,976
Rogue River	4,980
Russian River	169,652
San Francisco Bay HUs	82,074
San Mateo	42,082
Smith River	68,696
Trinidad	15,330
Trinity River	247,326
Winchuck River	1,918
Total SONCC (w/o Scott/Shasta)	1,082,3388
Total CCC	902,966
Total SONCC/CCC Restoration Costs	1,985,304
Total Scott/Shasta Restoration	159,296
Total Restoration Incl. Scott/Shasta	2,144,600

Source: Authors' calculation. Scott/Shasta is Shasta Valley and Scott River HSAs. Habitat restoration includes removal of barriers to fish passage, riparian revegetation and stream bank improvements, placement of LWD and improvements in instream complexity, and road treatment and decommissioning.

Outstanding Policy Issues

Moving from a Recovery Plan to Species Recovery. While our partial estimates of the cost of coho recovery are subject to uncertainty, the magnitude of the estimated cost of recovery is striking. The total estimated cost of recovery, $5 billion, is sufficiently high that it makes complete funding of this plan politically difficult. Even if a large portion of these costs is borne by private landowners, state funding of even a fraction of recovery could be a tough sell in Sacramento.

High species recovery costs are not unique to coho. Other estimates of the cost of species recovery, such as the spotted owl, have been of similar orders of magnitude. Costs are particularly high for the recovery of species where changes in land use are needed for habitat restoration. The high cost of recovery of species is largely responsible for the fact that few species have been recovered since the introduction of the Endangered Species Act. Coho salmon in California may be no exception.

Regional Equity Implications. The costs of coho recovery are not spread equally across California, or even across the coho range. Klamath, Trinity River and Mendocino HUs combined account for over 85 percent of measured restoration costs. A large fraction of costs will also be incurred in Scott/Shasta. Using the current level of information on the recommendations contained in this strategy, about $466 million, or nine percent of total costs will be incurred to implement recovery in the Scott and Shasta Valleys. While currently we do not know the cost of water acquisition in the SONCC outside of Scott/Shasta, if it is about 20 percent of total costs (as it is in Scott/Shasta), a disproportionate share of costs will still be incurred in Scott/Shasta.

The concentration of the recovery effort in a limited number of relatively rural areas has important regional equity implications. To the extent that coho recovery is financed by private landowners, these costs will be borne by rural residents. Since endangered species recovery has benefits for all residents of California (and all residents of the United States to a lesser extent), this amounts to a resource transfer from landowners in rural counties to urban Californians.

When recovery is financed by tax dollars, the situation is reversed. In this case, California tax revenue will provide state-wide benefits as a result of coho recovery, but it will also be used to subsidize economic activity in counties like Trinity and Mendocino. Restoration activity in particular will create jobs, at least in the short run. However, water acquisition efforts that result in fallowing and restrictions on timber harvest will have net negative impacts on economic activity in the same areas.

If the regions where restoration will be focused were in full employment, the generation of economic activity as a result of coho recovery efforts could increase the demand for labor and increase wage rates. While job creation is a real prospect, we consider wage impacts to be minimal. Most of the regions in which the bulk of the recovery recommendations will take place face structural unemployment.

Permitting Enforcement vs. Incentive Payments. A critical outstanding issue for the financing of coho recovery is the question of the division of responsibility between the public and private sectors. There is little question that the budgetary costs of coho salmon recovery to taxpayers can be reduced, dramatically in some cases, if state agencies undertake more rigorous enforcement of existing permits. For example, there is some amount of unpermitted water diversion from streams containing coho salmon, and some diverters use more than their allowable quantity. To take another example, existing take restrictions may require that ranchers be fencing and constructing troughs more than is currently the case.

The Recovery Strategy, as currently presented, says little about reducing unauthorized diversions of water. As discussed in the case of Scott/Shasta, the strategy appears to envision increasing in-stream flows for coho through voluntary measures, water acquisitions and the use of alternative sources.

In contrast, the Recovery Strategy imposes significant costs on the timber sector, where unauthorized logging is unlikely to be occurring. There is no analogous scheme of incentive payments to be made to timber harvesters like the payments to be made for water acquisitions. Instead, private timber firms will bear increased costs as a result of stricter harvest limits.

The reason for the unequal treatment of the timber and agricultural sectors is unclear. Regulatory oversight of the timber sector may be easier to achieve or politically more feasible. In other contexts it has also been the case that the allocation of funding among various environmental objectives is affected by the identity of the likely recipients of these funds. For example, there is a significant amount of Federal Conservation Reserve Program funding that is received by farmers in the Dakotas and Texas while miniscule amounts are allocated to procure environmental benefits in locations in the Southwest, despite the existence of substantial environmental amenities that could be preserved in that region.

Table 5: Range-Wide Measured Socioeconomic Impacts

Cost Category	Impact ($1,000)
Monitoring, evaluation and planning	
Total excl. Scott/Shasta	0
Total Scott/Shasta	0
Total incl. Scott/Shasta	0
Education and outreach	
Total excl. Scott/Shasta	0
Total Scott/Shasta	0
Total incl. Scott/Shasta	0
Water management	
Total excl. Scott/Shasta	--
Total Scott/Shasta	0
Water use efficiency	
Total excl. Scott/Shasta	--
Total Scott/Shasta	2,020
Water acquisition	
Total excl. Scott/Shasta	UNKNOWN
Total Scott/Shasta	(6,143)
Other	
Total excl. Scott/Shasta	0
Total Scott/Shasta	0
Timberland management	
	FEW INCREMENTAL IMPACTS

Source: Authors' calculation. Scott/Shasta is Shasta Valley and Scott River HSAs. No socioeconomic estimates are available for water acquisition in the CCC or SONCC excluding the Scott/Shasta.

Conclusion

Our analysis is only one step toward a cost-effective plan for recovering the coho and placing coho recovery in the context of broader environmental policy in California. The uncertainty associated with our estimates of the cost of recovery is matched by uncertainty about the benefits for coho of recovery actions. Without information about these impacts, the cost estimates that we have developed cannot be used to perform a cost-benefit analysis. Further economic and biological research is needed to achieve this goal.

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