Photo courtesy of Sunkist Growers Inc.

If medfly infestation triggered a trade ban . . .

Embargo on California produce would cause revenue, job loss

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The establishment of the medfly in California would have significant impacts, particularly on the citrus industry. This study investigates the economic impacts that might arise if Asian countries imposed an embargo on California produce. Increased costs of controlling an established medfly,

whether or not an embargo were imposed, would range from $493 million to $875 million. The imposition of an embargo would result in additional revenue losses of $564 million. The state economy could lose $1.2 billion in gross state product and more than 14,000 jobs.

This report focuses on the economic impact that an establishment of the Mediterranean Fruit Fly, *Ceratitis capitata* (Wied.), or the medfly, would have on California agriculture. Two scenarios are considered. The first scenario assumes that with appropriate production and postharvest controls, fresh produce could be shipped from

California. The second scenario looks at additional impacts from market adjustments if Japan, Korea, Taiwan and Hong Kong imposed a trade embargo.

The medfly is an imported pest whose infestations have serious consequences for California agriculture as documented by R.V. Dowell in a 1983 *HortScience* 18(1) article, "The Medfly in California: The Threat." A 1980–81 infestation was ultimately eliminated at great expense — reported to be over $100 million — to the state of California and the federal government. Since then, significant public funds have been spent on eradication efforts for subsequent infestations. In 1989–90 another medfly infestation occurred (similar to the 1980–81 infestation) and medfly findings continued to be reported in 1994.

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

Two previous studies have examined how establishment of the medfly would impact California agriculture. The first was done in 1981 by Daniel Galt and Barbara Albertson, UC Berkeley; the second study, completed in 1991 by Siebert and Pradhan, was an update of the first with further elaboration of market and integrated pest management consequences. Both studies focused primarily on the increased costs that would be borne by California agriculture, but the second study quantified the potential export market that would be affected if an embargo were put in place.

The recent outbreak of the medfly in the 1993–94 season has raised the specter of a possible embargo of California products by Japan, and in turn, Korea, Taiwan and Hong Kong, which usually follow Japan's lead. This concern has increased with the discovery that the medfly has spread eastward into Riverside County and near commercial citrus orchards. Japan has intimated that if a fertile female medfly is found in a commercial orchard, it will consider placing an embargo on shipments of fresh fruits and vegetables from California. (While the question could be raised regarding why the embargo should affect the entire state when only a small part of its production area is affected, it should be noted that the issue of trade sanctions is a political one, and not necessarily based on science.) A major question arises as to what the economic impact of an embargo would be on the California agricultural sector and the California economy.

Costs of controlling medfly

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

The assumption made in the production-cost study was that through periodic and regular applications of malathion-treated bait in commercial operations, a marketable product would be produced. Increased costs would come from the application of bait and, for crops shipped from Cali-

fornia in a fresh state, the additional costs of a postharvest treatment using methyl bromide or a cold treatment to meet U.S. Department of Agriculture quarantine requirements. This postharvest treatment would not be an option under an embargo because the importing countries would probably prohibit all fruits and vegetables.

The annual cost increases are summarized in table 1 and are based on interviews with government, industry and UC personnel. Under this scenario, increased costs to the industry would range from a low of $349.6 million to a high of $731.9 million. The reason for this range is that effective application of pesticides depends on weather conditions and the length of the season. The estimated cost for postharvest quarantine treatments was $135.3 million, which includes the cost of the treatment and the loss of fruit due to treatment damage. An additional $8.1 million in transportation costs was also estimated for movement to and from treatment facilities. Hence, total annual costs of controlling the medfly were estimated to range from a low of $493 million to a high of $875.3 million. Compared to the 1992 total value of production for the crops affected, these costs are substantial.

Market impacts of an embargo

The second scenario introduces consideration of a trade embargo. Previous production-cost studies did not estimate the economic impact of a trade embargo. In this study, the products affected are fresh shipments of apples, apricots, avocados, bell peppers, sweet cherries, dates, figs, table grapes, grapefruit, kiwis, lemons, limes, tangerines, oranges, nectarines, peaches, pears, persimmons, plums and tomatoes. These commodities do not match those of the 1991 study. The reason for this disparity is due to the nature of an embargo that would likely include all exported commodities to the countries in question due to the political reasons discussed previously. For example, in the 1991 production-cost study, lemons were excluded due to scientific data that

excluded them as hosts. However, under an embargo, the importing countries are likely to be more concerned with potential contamination than in whether protective steps can be taken, and tend to err on the side of total exclusion. Hence, for this study, lemons are considered.

According to statistics published by the California Agricultural Statistics Service, the 1992 farm value of these products was $2.1 billion and the farm value of total exports was $354.8 million. These crops were grown on 655,000 acres, 8.5% of the total 1992 harvested acres in California. The 1992 total f.o.b. value (representing the value of the product in packed form, ready for transportation to a buyer, but excluding transportation costs) of these products was $2.9 billion. This estimate includes both domestic and export products, but excludes tomatoes for which there was no available data. The total f.o.b. export value was $605.5 million, and the f.o.b. value of shipments to Japan, Korea, Taiwan and Hong Kong was $376.3 million, amounting to 62.1% of total exports for these products. 1992 export data for each product potentially affected by an embargo are listed in table 2.

Model for estimating impacts

The loss of markets in Japan, Korea, Taiwan and Hong Kong would be significant. These particular markets are the result of 5 to 10 years of difficult trade negotiations and investments in promotion and advertising. They are lucrative markets characterized by growing economies and a rising level of per capita income. If these markets were lost due to an embargo, the products would probably be shipped to the U.S. domestic market on a short-term basis because alternative markets are not readily available. Short-term, in this context, is defined as a period long enough to develop alternative markets — perhaps 2 to 5 years— through the same process that was involved in developing the lost markets.

If alternative export markets are not developed, the long-term impact would likely be a shrinking of the industries affected to pre-export levels.

In addition to the loss in sales, this would result in a significant loss in acres, assets and jobs, as well as decreasing the costs of controlling the medfly as affected crop acreages diminish. Estimating the long-term impacts would require a more complex model and data that are not readily accessible.

The short-term impact would come about through a decrease in income from export sales, coupled with a significant domestic price decrease as these quantities are redirected initially to the domestic market, and, over time, to other export markets that will have to be developed. The estimation of this impact may be described as follows:

IMPACT = TRC–TRR

where TRC = Current Total Revenue or [TRD + TRE]
TRD = Total Revenue Domestic Sales
TRE = Total Revenue Export Sales

TRE = Total Export Revenue (Japan, Korea, Taiwan, Hong Kong) [TRE(JKTH)] + Total Export Revenue (Other)

and **TRR = Revised Total Revenue** which equals [RTRD + RTRE]
RTRE = Revised Export Revenue or TRE – TRE(JKTH)
RTRD = Revised Domestic Revenue

In order to estimate revised domestic revenue (RTRD), the following relationships were used, which involved price elasticities of demand, a numerical indicator of the relationship be-

TABLE 1. Estimated costs of controlling the medfly through applications of malathion-treated bait and postharvest treatment

	Production costs		Postharvest treatment costs
	Low	High	
	.... $1,000		$1,000
Apples, all	2,619	7,421	1,447
Apricots	1,566	3,393	384
Avocados	30,456	87,984	5,917
Bell peppers	1,347	1,796	3,191
Cherries, sweet	918	1,989	216
Dates	450	1,275	743
Figs	1,521	6,591	38
Grapes, wine	26,100	113,100	—
Grapes, raisin	24,390	105,690	—
Grapes, table	7,263	31,473	18,128
Grapefruit	18,806	26,865	4,351
Kiwis	639	1,385	1,979
Limes	135	585	—
Mandarins (tangerines)	2,160	8,280	2,178
Nectarines, fresh	2,142	4,641	7,101
Olives, fresh	4,023	17,433	—
Oranges	183,816	239,760	72,584
Peaches, fresh	2,421	5,246	3,068
Peaches, processed	2,484	5,382	—
Pears, fresh	198	429	841
Pears, processed	1,872	4,056	—
Persimmons	108	306	—
Plums, fresh	3,654	7,917	6,045
Prunes, (fresh wt.)	6,921	14,996	—
Tomatoes, fresh (pink & red)	2,880	6,240	7,077
Tomatoes, processed	20,738	27,650	—
Total	349,627	731,883	135,288

Note: Cost of grapes based on adjusted production but unadjusted value of 1989 grapes utilized for fresh market; Cost of peaches and pears based on adjusted data.
Source: Siebert, Jerome and Vijay Pradhan. "The Potential Impact of the Mediterranean Fruit Fly, *Ceratitus capitata* (Wied.), Upon Establishment in California: An Update." Working Paper No. 547. Department of Agricultural and Resource Economics, UC Berkeley. September 1, 1991 (p. 12).

tween a relative change in demand and the price of a good.

$$RTRD = [TQC + TQE(JKTH)] \times PR$$

where TQC = Total Current Domestic Sales
TQE(JKTH) = Total Current Export Sales to Japan, Korea, Taiwan, Hong Kong
PR = The revised price due to increased quantities sold domestically

The revised price (PR) is estimated by applying price elasticity of demand estimates to the change in domestic supplies. The theoretical relationship assumes that as supplies increase bewhile demand remains static, the price will decrease. The size of the decrease depends on the value of the price elasticity of demand. Hence, the specific price elasticity used becomes highly important in estimating the impact of reduced exports using the model described above.

Data used in estimation

The data used in estimating the changes in revenues were obtained from various industry sources. Most of the commodities affected operate under a marketing order or commission that compiles the needed data; industry organizations also gathered some of the data. We used 1992 crop year data for the commodities evaluated. Table 2 shows the domestic shipments, total export shipments, average domestic price, average export price, and total revenues for each commodity for 1992. Table 3 shows the volume of shipments to Japan, Korea, Taiwan, and Hong Kong, as well as prices for those markets if available. If prices were not available, we used the average export price. For most commodities, the average export price exceeded the average domestic price.

The price elasticities of demand used in the study are listed in table 4. Sources for this data came from one of two primary sources. The first is a USDA Economic Research Service study estimating elasticities of demand by Kuo S. Huang ("A Complete System of US Demand for Food," USDA-ERS Technical Bulletin No. 1821, September 1993). The second is the California Agricultural Resource Management Model, Department of Agricultural Economics, UC Davis, which developed price flexibilities for use in estimating changes in impacts on agriculture from water allocation shifts. While price flexibility estimates do not wholly substitute for price elasticity of demand estimates (See Kuo S. Huang, "Flexibilities versus Elasticities," *American Journal of Agricultural Economics*, Vol. 76(2), May 1994), they provide an indication of the responsiveness of price changes to shifts in supply as considered in this report.

TABLE 2. Domestic and export shipments, average prices and revenues for selected commodities impacted by a medfly embargo, f.o.b., 1992

Commodity	Domestic shipments	Export shipments	Domestic price	Export price	Total gross revenue
	1,000 lb		cents/lb		$ million
Apples	755,594	84,406	0.38	0.72	347,898
Apricots	25,486	7,498	0.25	0.59	10,727
Avocados	459,132	19,253	0.37	0.39	177,142
Grapefruit	404,693	207,510	0.29	0.20	160,212
Kiwis	75,073	14,966	0.50	0.50	45,020
Lemons	663,974	240,996	0.34	0.45	334,374
Navel oranges	2,186,738	295,650	0.19	0.24	482,457
Valencia oranges	813,450	469,800	0.21	0.27	299,843
Peaches/nectarines	842,919	5,436	0.36	0.36	305,408
Plums/prunes	252,880	67,073	0.37	0.37	118,383
Table grapes	1,066,204	301,531	0.40	0.50	578,507

Sources: California Granny Smith Association; California Apricot Advisory Board; California Avocado Board; California Table Grape Commission; California Tree Fruit Agreement; Kiwifruit Administrative Committee; Lemon Administrative Committee; Navel Orange Administrative Committee; Valencia Orange Administrative Committee.

TABLE 3. Export shipments to Japan, Korea, Taiwan and Hong Kong for selected commodities affected by an embargo, f.o.b., 1992

Commodity	Japan	Korea	Taiwan	Hong Kong
	1,000 lb			
Apples	0	368	25,205	374
Apricots	0	0	34	32
Avocados	6,957	42	13	279
Grapefruit	102,412	1,200	4,762	3,112
Kiwis	579	1,316	7,209	548
Lemons	184,718	4,674	—	18,772
Navel oranges	122,475	3,900	525	119,662
Valencia oranges	219,038	0	18,188	150,975
Peaches/nectarines	0	0	1,207	4,228
Plums/prunes	154	0	48,246	18,673
Table grapes	6,819	0	32,946	42,838

Sources: California Granny Smith Association; California Apricot Advisory Board; California Avocado Board; California Table Grape Commission; California Tree Fruit Agreement; Kiwifruit Administrative Committee; Lemon Administrative Committee; Navel Orange Administrative Committee; Valencia Orange Administrative Committee.

TABLE 4. Price elasticities of demand for selected commodities affected by an embargo

Commodity	Elasticity
Apples	-1.60
Apricots	-2.80
Avocados	-0.54
Grapefruit	-0.45
Kiwis	-2.05
Lemons	-0.88
Navel oranges	-0.85
Valencia oranges	-0.85
Peaches/nectarines	-0.49
Plums/prunes	-0.67
Table grapes	-1.18

Impact estimates

Estimates of changes in revenue in 1992 due to an export embargo are detailed in table 5. Included are the estimated percent of change in domestic supplies, the estimated percentage change in domestic price, the estimated revised domestic price level, the revised revenue for the commodity, and the change in revenue or revenue lost. In most cases, the estimated change in price was small and not very significant as reflected in the lost revenue figure. However, for the citrus crops — grapefruit, lemons, navel oranges, and Valencia oranges — which were the most impacted, the estimated revenue loss was highly significant (fig. 1). For grapefruit, the loss in revenue is estimated to be 51% of the 1992 levels; for lemons, 38%; for navel oranges, 15%; and for Valencia oranges, 55%. The loss in revenue for all of the commodities considered was $564.2 million or 20% of the 1992 value of shipments.

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

the levels that existed before an embargo.

The total impact of a medfly infestation on the industries involved should also take into account the costs of controlling the pest. When these costs are added to the embargo estimates, they indicate even higher losses to the industry. The total impact on the commodities would range from a low of $1.057 billion to a high of $1.44 billion. Included in these costs are expenses for postharvest treatment since USDA protocol calls for treatment of commodities shipped from infested areas. These figures represent losses to all segments of the industries involved — from pesticide application costs to control the medfly to losses in revenues due to lost export markets and price decreases in domestic markets.

In the short run, the domestic consumer would benefit from an embargo, particularly from citrus. As seen in table 5, price decreases range from no change in the case of apricots, to over 60% for grapefruit. How long the consumer will benefit from these price decreases will depend on how long it takes for the industry to readjust its production or to find new
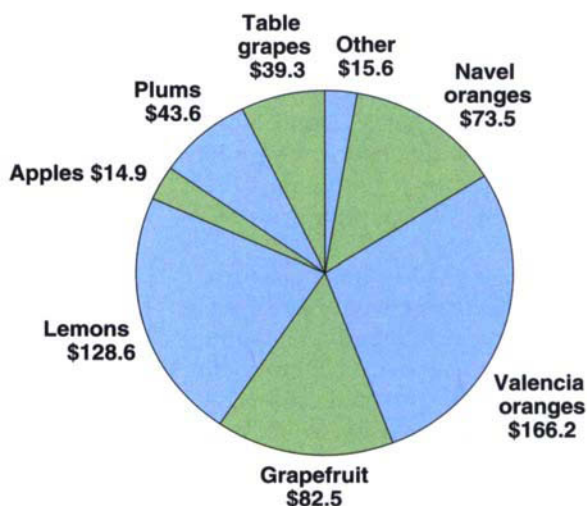

Fig. 1. Losses by commodity from medfly ($ million). Total losses equal $564.2 million.

markets. Price decreases of the magnitude estimated for the citrus industry are expected to last no longer than 2 years before production adjustments are made.

In the long run, producers will eventually decrease production in order to raise prices enough to regain lost revenues and adequately cover capital investments. If only the effects of an embargo are considered, production would be decreased enough to raise prices to pre-embargo levels. However, if the increased costs of controlling the medfly are included, then prices might rise even more to cover higher costs for production, packing and shipping. This assumes no new technologies have been employed to offset these additional costs.

Impact on California's economy

Another significant impact of an export embargo due to medfly establishment would be the loss in revenue to the California state economy. The losses in revenue to the industries concerned would have an impact through a multiplier effect. However, in estimating this effect, we only considered the revenue losses from the embargo. While the net revenue from production and packing operations would decrease due to increased costs in a broader analysis, the effect would not be similar to that of an embargo. In a broader analysis, production cost in-

TABLE 5. Estimated changes in domestic shipments, domestic price and revenues for commodities affected by an export embargo

Commodity	Shipment	Price	Revised total revenue	Revenue lost
	.... % change		$1,000	$1,000
Apples	3.43	-2.15	332,967	14,931
Apricots	0.26	-0.09	10,716	11
Avocados	1.59	-2.94	171,901	5,241
Grapefruit	27.55	-60.60	77,749	82,463
Kiwis	12.86	-6.27	38,598	6,422
Lemons	31.35	-35.63	205,807	128,567
Navel oranges	11.28	-13.27	408,953	73,504
Valencia oranges	47.72	-56.14	133,688	166,154
Peaches/nectarines	0.64	-1.32	301,389	4,019
Plums/prunes	26.52	-39.59	74,772	43,611
Table grapes	7.75	-6.57	539,181	39,326
Total revenue lost				564,249

creases would lower net revenues to growers and packers, but also result in more work for pesticide applicators to control the medfly; hence, the net impact would likely leave the impact on the California state economy unchanged.

However, the loss in revenue from an export embargo would affect the state economy differently. The same costs would be incurred in production, but market effects would cause a decline in net income. This would mean a loss in income that would otherwise be spent on goods and services in the California economy. The impact of this is measured through a set of multipliers developed under the IMPLAN program, which measures changes in one sector of the California economy on the total. The net changes in output, total income, total gross state product and employment for California relative to 1992 levels are shown below:

Economic Variable	Net Change
Output	−$991.7 million
Total income	−$1,165.0 million
Gross state product	−$1,233.1 million
Employment	−14,190 jobs

These figures represent losses to the California state economy in addition to revenue losses directly resulting from the export embargo. While these losses are small in relation to the overall size of the California economy, they are marginally significant when considering that California has recently undergone restructuring from a long-lasting recession and a large number of firms have left the state, creating a need for new business opportunities to support its workforce.

Domestic embargo

An additional embargo of California produce by other states could also occur. Southern states, such as Florida and Texas, that have large fruit and vegetable industries might consider such an embargo. In fact, Texas did consider an embargo due to the medfly infestation in the early 1980s, but the dispute was quickly resolved. An analysis of this potential situation was not attempted due to a significant lack of data. However, the same model would be used, and the expected outcome of the analysis would be an even larger loss in revenue for the industries concerned.

Summary

The Mediterranean fruit fly poses a significant economic threat to California agriculture if it becomes established. In considering the estimated impacts, it should be borne in mind that they were developed under assumptions that reflect the upper limits of conditions that may occur and do not take into account changes in management practices, the extent of an infestation, development of new markets, and changing technologies that may mitigate the extent of the increased costs and revenue losses.

In estimating the impacts, two scenarios were considered. Under the first scenario, additional costs would be necessary to control the medfly in order to produce a marketable quantity of produce. The increase in costs could make some products non-competitive with other production areas. In the second scenario, we introduced the threat of an export embargo by Japan, Korea, Taiwan and Hong Kong, which would result in additional significant costs to the industries affected, particularly citrus. If an embargo were to occur, domestic consumers would realize a short-term gain through lower prices. Longer term consequences would include a significant downsizing, particularly in the citrus industry. A loss of income to producers, packers and shippers from an embargo would have an impact on the California state economy, as well as a direct impact on the industries involved. Hence, policies to eliminate medfly infestations have a broader impact that need to be taken into account when considering changes.

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Fruit was inoculated with brown rot and held for 5 days. Results show fruit from trees fertilized with 100 lb N/ac/yr, *above*, had fewer brown rot symptoms than fruit from trees fertilized with 325 lb N/ac/yr, *below*.