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WORKING PAPER NO. 547

THE POTENTIAL IMPACT OF HE MEDITERRANEAN FRUIT FLY, *CERATITIS CAPITATA* (WIE UPON ESTABLISHMENT IN CALIFORNIA: AN UPDATE

by

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

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DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS
DIVISION OF AGRICULTURE AND NATURAL RESOURCES
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EXECUTIVE SUMMARY :THE POTENTIAL ECONOMIC IMPACT OF THE MEDITERRANEAN FRUIT FLY,CERATITIS CAPITATA (WIED.), UPON ESTABLISHMENT IN CALIFORNIA, AN UPDATE, SEPTEMBER 1, 1991

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This study updates a 1981 study that was conducted on the economic impact of establishment of Medfly in California. Many of the same assumptions that went into that study were used in this one. Additionally, some assumptions were updated based on information and data that has been developed and reported since 1981.

This study considered many of the same crops as the 1981 study as suitable for Medfly hosts. A total of 22 different commodities were included: Apples, Apricots, Avocados, Bell Peppers, Cherries, Dates, Figs, Grapes, Grapefruit, Kiwis, Limes, Mandarin Oranges, Nectarines, Olives, Peaches, Pears, Persimmons, Plums, Prunes, and Tomatoes. These commodities represent 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 going to Japan and other asian countries.

The study estimated two basic sets of costs: 1) the cost of controlling Medfly in the field through increased pesticide applications, and 2) the cost of post harvest treatments to comply with quarantine regulations in order to ship out-of-state. In estimating these costs, it was assumed that no fruit would be lost in the field due to Medfly damage, but that varying levels of fruit would be lost due to damage caused by the quarantine treatments.

Total annual continuing costs were estimated to range from a low of $493 million to a high of $875.3 million. Annual continuing costs due to field application of pesticides to control Medfly was estimated to be in a range of $349.6 million to $731.9 million. Continuing costs due to post harvest treatment under quarantine regulations was estimated to be $135.3 million. In addition, increased costs of transportation to and from treatment facilities were estimated to be $8.1 million. In addition to the continuing costs identified, it was estimated that $86.7 million would be required to construct additional cold storage and fumigation facilities with an additional $10.7 million required to upgrade packing and shipping facilities to conform to quarantine regulations.

These estimated costs have varying impacts on the commodities considered and range from slight (in the case of fresh tomatoes) to significant (in the case of avocados and citrus). In these latter cases, it is difficult to see how the producers of these crops can continue to produce without significant changes occurring that would lessen the costs of controlling the Medfly. An

examination of the market impacts of increasing prices to recoup some of the increased costs that would occur in combating the Medfly could actually lead to decreased total revenues to producers. Hence, market impacts will only add to the problem of increased costs rather than assisting in their mitigation in most cases. Further research is needed in this area.

In a long run sense, adjustments will take place in the production of California crops if Medfly becomes an established pest. Much will be dictated by the market and competing products and areas of production. However, it appears likely that the production base in California for many of its speciality crops will shrink and many producers and packer/shippers will fail to survive. The likely outcome is that as California producers of the crops considered become less competitive due to higher costs, other areas will develop competing sources of supply. California is a unique production area of the world. To substitute its production capacity completely would be difficult. However, the net long run result to consumers of the impact of Medfly establishment in California is likely to be higher prices, a decrease in quality, and a lessening of choice.

In addition, the crops considered in this study are all high value and value added commodities which employ high amounts of labor and contribute significantly to local economies. While no attempt was made in this study to assess the economic effects on other sectors of the economy that are tied in to the crops studied here, a future study may well show that the impact of the Medfly will go significantly beyond the costs and impacts identified.

The impact on integrated pest management was considered. With the heavy application of pesticides, it is likely that integrated pest management programs, not only for the crops considered but other crops as well, will not be successful, particularly those using beneficial organisms. Producers using organic and sustainable agriculture methods will likely have to shift to using pesticides to avoid uneconomic crop losses. While additional costs will occur to control secondary outbreaks of pests, they were included in the estimates for field applications of pesticides to control Medfly.

This study was based on a number of assumptions. The central hypothesis is that establishment of the Medfly in California will result in significant costs to those crops and related industries affected by it. Estimates developed in this study have given validity to this hypothesis. Remaining questions center around how these costs will impact the producers of the commodities, related industries, and ultimately, the consumer.

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THE POTENTIAL ECONOMIC IMPACT OF THE MEDITERRANEAN FRUIT FLY, CERATITIS CAPITATA (WIED.), UPON ESTABLISHMENT IN CALIFORNIA AN UPDATE, SEPTEMBER 1, 1991

Background.

Beginning in 1989 and continuing through the first part of 1990, infestations of the Mediterranean Fruit Fly, Ceratitis capitata (Wied.) were discovered in Southern California. With the discoveries, the California Department of Food and Agriculture (CDFA) and the U.S. Department of Agriculture, APHIS, launched a series of programs designed to eradicate the pest. Part of the programs involve aerial applications of malathion treated lure (bait) to decrease the numbers of medfly so that a sterile male program could eliminate the rest of the infestation. The aerial application of malathion treated bait brought out public concern over the safety of the program. This concern has threatened the termination of aerial applications which in turn could allow establishment of the Medfly as a permanent pest in California and spread from pockets in Southern California to other parts of the state. With the threat of the Medfly outbreak has come concern over the economic impact of the pest if it were to spread to other areas.

This situation is similar to one that existed in Santa Clara county in California during 1980-81. At that time similar public concern was expressed during the eradication program. The infestation was ultimately eliminated at great expense to the State of California. During the infestation and eradication program, the question was asked as to what economic impact the Medfly would have on California agriculture if it were to become established throughout the state. At that time a study was conducted by Daniel Galt and Barbara Albertson under the supervision of Dr. Gordon Rowe of the University of California.[1] This study estimated the economic effects of Medfly establishment in the agricultural sector of California - specifically, the impact on commercial farms of the state. It analyzed the potential impact of the pest were it to become established in the known Medfly host crops in California.

The 1981 study estimated quantifiable, practical costs involved with complying with the then current Medfly internal quarantine regulations as set forth by USDA-APHIS. The estimated costs in that study included 1) use of more insecticides for pest control in producers' fields, 2) the loss of fruit caused by Medfly damage, 3) post-harvest fruit lost by quarantine compliance (either fumigation or cold storage damage), 4) costs of fumigation (both construction and annual treatment), 5) costs of cold storage (both construction and annual treatment), 6) increased transportation, and 7) upgrading existing packing and shipping facilities. The study estimated that during the first

year of Medfly establishment, estimated total costs were likely to range between $370.7 and $810.5 million of which $54.4 million were one-time, initial costs with the remainder recurrent and expected to occur annually.

With the current outbreak of Medfly in 1989-90, some of the same concerns and questions have been raised regarding the eradication programs. More specifically, interest has been expressed in updating the 1981 study to include current economic data.

Objectives of the Study.

The purpose of this study is to provide a current estimate of the economic effects of the establishment of the Medfly in commercial agricultural areas of California. The 1981 study essentially laid a solid foundation for the estimation of the economic impact of the Medfly on California agriculture. This study will draw heavily on its structure and assumptions as well as a brief update that was presented to the California State Assembly in March 1990 by Dr. Harold O. Carter, Director, University of California Agricultural Issues Center.[2]

The basic assumption of the study is that if eradication efforts fail for one reason or another, the Medfly will expand from its current limited area of infestation in Southern California into commercial agricultural areas in the state. Further, once established, control of the Medfly will take substantial resources from those agricultural crops affected. Like the 1981 study, this study estimates the costs of controlling the Medfly to minimize direct damage it will cause, as well as complying with the quarantine regulations likely to be imposed on California by other countries, states and USDA-APHIS. In addition, markets are likely to be disrupted due to shifts in both demand and supply of California agricultural crops. It is also important to evaluate and estimate the economic impact of the disruptions that may occur in the marketplace. This study will address some of the issues relating to market shifts, but not in sufficient detail to satisfy the need for further study.

The study also assumes that costs that are incurred in the agricultural sector in producing and marketing fruits and vegetables will ultimately be borne by the consumer. The effects of increased costs may not, and usually, don't appear immediately in the marketplace. However, adjustments in supply and demand do occur over a period of time so that the impacts of increased costs will eventually occur. Hence, this study looks at the immediate occurrence of increased costs of combating the Medfly and leaves the long run effects to a future analysis much as in the 1981 study.

Finally, this study does not attempt to distinguish whether the establishment of Medfly will have different outcomes in different parts of the state. It assumes that once established, Medfly will become a significant problem for those crops identified.

The study is divided into four areas which will provide the basis for analyzing the economic impact of the establishment of Medfly in California. Included in these areas are 1) Medfly hosts; 2) Medfly control; 3) Post harvest quarantine treatment; and 4) Market impact. In addition to using the two studies already identified as background material, this study is based on numerous interviews with academic, government, and industry personnel as well as a number of other studies and data sources that are identified in the bibliography.

Medfly Hosts.

In the 1981 study, a total of 23 agricultural commodities or species were identified as hosting Medfly. The study analyzed 20 commodities which would be impacted if the Medfly were established in 1981. In 1990, the California Department of Food and Agriculture has identified a list of 35 commodities that could serve as possible hosts to the Medfly. This list, which appears in Appendix Table 1, includes 19 of the commodities from the 1981 study (loquat, prickly pear, quince, and strawberries are not on the list).

The 1990 list is divided into three different categories which suggest differing levels of impact of the establishment of Medfly. These categories are 1) Preferred Hosts, 2) Other Hosts, and 3) Reported Hosts. "Preferred Hosts" are those crops known to be preferred by the Medfly and are the most likely to be infested. "Other Hosts" are those crops where Medfly has been observed, but are secondary to the preferred hosts. The "Reported Host" category are those that have been reported in the literature as possible hosts, but have not been proven through field observations. In addition, USDA-APHIS has published a list of regulated articles subject to quarantine from Medfly infested areas in California effective February 16, 1990.[3]

If the original 1981 list of hosts is considered, the 1989 value of production in California amounts to $4.358 billion and the 1988 value of exports amounts to $1.078 billion (This data is taken from Appendix Table 2). If the suggested 1990 list of hosts is considered, the 1989 value of production is $6.528 billion and the 1988 value of exports is $1.708 billion. Obviously, defining the true biological (i.e. those that allow survival and reproduction) hosts for Medfly is very important in analyzing the potential impact.

A second consideration is the differences among commodities that could serve as host to the Medfly as far as impacts are concerned. Discussions with entomologists suggest that soft fruits such as peaches, nectarines, and plums would be highly susceptible to damage from the Medfly as well as postharvest treatments, and, hence, a higher economic impact is more probable than walnuts or almonds (which also have been identified as possible hosts). After considerable discussion with entomologists, the crops identified in Table 1 are likely hosts for Medfly and are the ones included in this study. Also indicated in Table 1 is

Table 1: Acres, Production, and Indicated Field and Quarantine Treatment Requirements for Medfly Host Crops.

	1989 Calif. Acres (000)	1989 Calif Prodn. (tons)	Field Treatment	Quarantine Treatment
Apple, All	29.10	337,500	X	X
Apricot	17.40	118,000	X	X
Avocado	75.20	165,000	X	X
Bell Pepper	17.96	200,028	X	X
Cherry, Sweet	10.20	26,000	X	X
Date	5.00	22,000	X	
Fig	16.90	48,000	X	
Grapes, Raisin	271.00	1,864,000	X	
Grapes, Wine	290.00	2,766,000	X	
Grapes, Table	80.70	760,000	X	X
Grapefruit	19.90	262,750	X	X
Kiwi	7.10	40,000	X	
Lime	1.00	5,820	X	X
Mandarin (Tang.)	8.00	76,500	X	X
Orange	177.60	2,208,750	X	X
Olives	29.80	123,000	X	
Nectarines	23.80	200,000	X	X
Peach, Fresh	26.90	164,000	X	X
Peach, Processed	27.60	596,000	X	
Pear, Fresh	2.20	81,000	X	X
Pear, Processed	20.80	234,800	X	
Persimmons	1.20	5,745	X	X
Plums, Fresh	40.60	216,000	X	X
Prunes (Fresh wt.)	76.90	754,840	X	
Tomato, Fresh (Pink & Red Ripe)	38.40	499,200	X	X
Tomato, Processed	276.50	8,585,330	X	
Total	1,591.76	20,359,463		

whether field treatment and/or quarantine treatment is necessary. It should be pointed out at this point that there are other non-agricultural hosts (i.e. ornamentals and wild hosts) that are not considered in this study.

From Table 1, it can be seen that a total of 26 crops are listed with a total acreage of nearly 1.6 million acres. It should be noted that grapes, peaches, and pears have been divided into fresh and processed components. The significance of this division is that while all of the crops listed will receive a field treatment of a pesticide to eradicate or control Medfly, quarantine treatment for Medfly will take place only for the fresh component of the crop. A later section of this report will provide more detail on quarantine treatment during post harvest.

Table 2 provides an overview of the total value of the crops listed in Table 1 as well as their relative importance in U.S. production. The 1989 farm value of the crops in this study amounted to slightly over 4.25 billion dollars. The relative importance of the crops to total U.S. production varies. Significantly, California grows 100 percent of the bell peppers, dates, figs, kiwis, raisin grapes, nectarines, olives, persimmons, and prunes in the U.S. Other significant crops as a percent of U.S. production are apricots, avocados, wine grapes, table grapes, processed peaches, plums, and processed tomatoes. It can be argued that decreased production due to Medfly damage in these crops will be difficult to replace from U.S. sources.

Many of the crops in this study are exported. Their export value is listed in Table 3. As observed from this table, exports play a significant role in many of the crops listed. The total value of exports at the farm level amounts to $558,984,000 or 13.2 percent. Much as California is a significant factor in the production of many crops in the U.S. that could be impacted by the Medfly, the state has a significant share of U.S. exports also.

Overall, the crops that would be possible hosts to the Medfly if it were to become established in California have a significant impact both in terms of the value of farm production and export markets.

Table 2: Farm Value and California Production as a Percent of U.S. Production for Specified Medfly Hosts.

	1989 Calif. Value($000)	1989 Calif. % of U.S.
Apple, All	101,023	6.77
Apricot	37,821	98.30
Avocado	207,900	85.94
Bell Pepper	95,429	100.00
Cherry, Sweet	24,418	13.37
Date	21,780	100.00
Fig	18,341	100.00
Grapes, Wine	745,200	82.09
Grapes, Raisin	663,880	100.00
Grapes, Table	283,005	90.88
Grapefruit	51,099	9.24
Kiwi	14,800	100.00
Lime	2,566	10.60
Mandarin (Tang.)	28,733	21.70
Orange	462,264	24.69
Nectarine, Fresh	79,645	100.00
Olives, Fresh	60,030	100.00
Peach, Fresh	64,288	31.63
Peach, Processed	115,268	95.80
Pear, Fresh	25,346	17.82
Pear, Processed	59,904	50.63
Persimmons	6,961	100.00
Plums, Fresh	96,146	83.08
Prunes (Fresh wt.)	176,054	100.00
Tomato, Fresh(Pink & Red)	239,616	27.81
Tomato, Processed	569,207	90.52
Total	4,250,724	

Table 3: Farm Value of California Agricultural Exports, 1989.

	% CA Crop Exported	CA Export Value($000)	% CA Share U.S. Exports
Apple, All	-	-	-
Apricot	15.2	6,366	99
Avocado	8.5	17,066	80
Bell Pepper	4.1	3,929	22
Cherry, Sweet	59.6	14,562	54
Date	22.5	4,434	100
Fig	12.3	2,046	100
Grapes, Wine	6.5	47,199	73
Grapes, Raisin	24.1	79,327	100
Grapes, Table	22.3	100,148	98
Grapefruit	29.9	16,549	10
Kiwi	33.3	6,129	100
Lime	-	-	-
Mandarin (Tang.)	21.4	6,128	62
Orange	28.9	111,097	95
Nectarine, Fresh	(included with peaches----------)		
Olives	3.2	1,457	100
Peach, Fresh	9.6	15,374	72
Peach, Processed	2.8	2,775	100
Pear, Total	4.5	6,617	37
Pear, Fresh			20
Pear, Processed			93
Persimmons			
Plums, Fresh	28.0	26,539	93
Prunes (Fresh wt.)	39.2	52,518	100
Tomato, Fresh (Pink & Red)	7.6	18,765	31
Tomato, Processed	3.9	18,856	90
Total		558,984	

Production Costs to Control Medfly.

At issue in this category is the field cost of controlling the Medfly on host commodities. The 1981 study estimated cost of control as well as losses due to Medfly damage. This latter cost was assumed to be 7.5 percent of the value of the crop for all commodities. Extra insecticide applications costs ranged from $39.452 to 193.199 million while value of crop losses was estimated to be $194.699 million.

If insecticides are not used, then crop losses would definitely occur based on past Medfly studies. No firm estimates of losses are known for each specific commodity. It is likely that different losses would occur for different crops depending on their susceptibility to the Medfly.

However, for purposes of this study, it is assumed that producers of affected crops would use insecticides to control Medfly. Discussions with entomologists point towards a strategy of applying malathion or malathion treated bait that would control medfly to the point that no additional loss would occur. While there is a likely possibility of a crop loss even with the use of insecticides due to non-uniformity of treatment, organic growers, and abandonment of crops, this study assumes that significant losses due to damage from the Medfly would not occur with a regular treatment schedule. The major costs to growers would be the cost of insecticide and costs of application.

One area that will be impacted significantly with a possible establishment of Medfly will be organic growers, those who are practicing the emerging concept of sustainable agriculture, and producers of home grown produce. Given the destructive capability of the Medfly, it is highly probable that crop losses would be too great to continue the practice of organic farming or sustainable agriculture in those affected crops. In addition, growers of home grown produce will likely find that crop losses would be considerable and either abandon the crop or use increased amounts of pesticides. In the case of growers using organic and sustainable agriculture methods, it is assumed in this study that they will turn to controlling Medfly through the use of pesticides and their increased costs will be reflected in the total costs estimated in this study. There is no reliable estimate of the value of home grown produce; hence, this study makes no attempt to evaluate the losses and increased costs that might occur. However, it is likely that the total costs associated with an establishment of Medfly in California will increase due to the home grown produce factor

.

Costs of controlling the Medfly in the field are dependent on two main factors. The first is the number of days that a crop would be susceptible to Medfly and consequently the number of applications needed to control it. The second factor is the cost of the material used to control Medfly and the cost of application. Table 4 presents this information for each of the crops considered. Some explanation is needed for this table.

In constructing Table 4, a number of factors were considered. First, the 1981 study was reviewed which had similar assumptions regarding days susceptible to Medfly and number of applications. Note that for these two categories, low and high ranges are given. The reason for the range is that it is dif-

ficult to precisely estimate the number of days a particular crop may be susceptible to Medfly and the number of applications needed. It is assumed that at a minimum, crops will be susceptible to Medfly for 30 days. The basis for this assumption is the current emergency regulation from APHIS that crops that are treated for 30 days before harvest within a quarantine zone will not require a post harvest quarantine treatment.[4] Hence, it can be implied that at a minimum, each crop will be susceptible for at least 30 days prior to harvest. The exception to this assumption is avocados and the citrus crops. In these crops, normal cultural and harvest practices have indicated longer harvest seasons.

In avocados fruit is generally left on the tree year round with new fruit sets during this period of time. The tree effectively acts as a storage medium prior to harvest. It may well be that if Medfly becomes an established pest, growers of avocados will adopt different cultural practices to lessen exposure to Medfly. As will be seen later in this report, cost increases will dictate some changes in cultural practices that will have to take place. However, at this time, not enough information is available to indicate what those practices are and what cost impacts they might have. Oranges also have a long harvest season, partly due to prorate operations of the valencia and navel orange marketing orders. Under current practices, fruit is stored on the trees in a ripe condition. Whether this practice is feasible under Medfly conditions will have to be evaluated. Mandarin oranges (tangerines) also have an extended harvest season which will have to be evaluated in the same light as for other citrus.

Estimated number of applications is also given low and high numbers. The reason for this procedure is the range of days between applications of pesticide is seven to ten days. Hence, on the low side, ten days was assumed when applying this factor to the low number of days of susceptibility. On the high side, seven days was assumed to be the interval between pesticide applications. The exception to this rule was in the case of avocados, oranges, and mandarin oranges where the harvest season extends into periods of cold weather when longer durations of pesticide applications of from two to three weeks can occur. One factor not taken into account is weather. Pesticide applications cannot be made during rainy periods and must be reapplied after it has rained.

Cost of pesticide applications varies widely according to type of crop and location. In 1981, an average of $15.00 per acre was assumed. Since that time, both materials and application costs have become more expensive for a variety of reasons. Cost of manufacture of pesticides has increased much as other manufactured goods have increased. Factors that have led to increased costs since 1981 are high costs of regulation and increasing regulation of toxic materials for environmental and

health and safety reasons. Environmental and health concerns in particular have caused a shift to more sophisticated insecticides which, although used at much lower rates per acre, have higher costs per application. In addition, large numbers of materials have been recalled with pesticide manufacturers having to re-register many pesticides. Costs of labeling or re-labeling pesticides has increased as testing procedures have become more complex.

As material costs have increased, so have application costs. Inflation of application costs have occurred due to two factors. One is the normal inflation due to increased labor and equipment costs. The other, and even more significant, is increasing regulation. California has the most restrictive pesticide application laws and regulations in the U.S. While justified in terms of environmental and health and safety considerations, these regulations have nevertheless added to the cost of applying pesticides.

In order to determine the costs of applying pesticides on the crops considered in this study, a survey was conducted of industry, government, and University of California personnel, particularly Cooperative Extension specialists and farm advisors. A listing of these people can be found in the Appendix.

Costs of applying pesticides to combat Medfly vary considerably. The material that is being used in combination with sterile Medflies by the state to eradicate the infestation is malathion treated bait or lure.[5] The Medfly is attracted to the lure and is killed on exposure to it. Growers treating for Medfly can use either the bait(lure) or apply malathion or some other pesticide in a less diluted form. Discussions with entomologists indicate that the cost will be the same in either case, although further study based on efficacy data might indicate otherwise. The entomologists did indicate that use of the bait(lure), might have a lesser impact on beneficial insects than massive spraying of malathion directly. However, because of the make-up of the bait(lure), its application is more complex and new skills would have to be acquired by those responsible for its application.

The actual costs of applying pesticides in California vary by crop and by location. Costs per acre will vary considerably depending on whether a commercial applicator will perform the operation or a farmer will use existing equipment and labor. In addition, costs will vary according to the crop canopy being treated with heavier canopied and larger trees costing more than field crops. In the testimony submitted to the California State Assembly in March 1990, it was assumed that the pesticide costs per acre was $36.00 for non-citrus crops and $50.00 for citrus crops for the reasons mentioned.

Table 4: Estimated Days of Susceptibility, Numbers of Applications, and Control Costs per Acre for Medfly Host Crops.

	Days Susceptible		Number of Applications		Control Costs/ Acre/Application
	Low	High	Low	High	Dollars
Apple, All	30	60	3	8.5	30
Apricot	30	45	3	6.5	30
Avocado	90	180	9	26.0	45
Bell Pepper	30	30	3	4.0	25
Cherry, Sweet	30	45	3	6.5	30
Date	30	60	3	8.5	30
Fig	30	90	3	13.0	30
Grapes, Raisin	30	90	3	13.0	30
Grapes, Wine	30	90	3	13.0	30
Grapes, Table	30	90	3	13.0	30
Grapefruit	210	210	21	30.0	45
Kiwi	30	45	3	6.5	30
Lime	30	90	3	13.0	45
Mandarin (Tang.)	60	150	6	23.0	45
Orange	210	210	23	30.0	45
Olives	30	90	3	13.0	45
Nectarine, Fresh	30	45	3	6.5	30
Peach, Fresh	30	45	3	6.5	30
Peach, Processed	30	45	3	6.5	30
Pear, Fresh	30	45	3	6.5	30
Pear, Processed	30	45	3	6.5	30
Persimmons	30	60	3	8.5	30
Plums, Fresh	30	45	3	6.5	30
Prunes (Fresh wt.	30	45	3	6.5	30
Tomato, Fresh (Pink & Red)	30	45	3	6.5	25
Tomato, Processed	30	30	3	4.0	25

After a considerable number of interviews on the subject of cost of pesticide applications and review of a number of cost study sheets prepared by University of California farm advisors, a per acre cost of $25.00 for row crops, $30.00 for non-citrus tree crops and vines, and $45.00 for citrus and avocados was assumed for this study. These costs include materials and application. The per acre costs by crop are found in Table 4. Obviously, actual costs for any one grower can vary higher or lower from these costs for the reasons mentioned.

The estimated costs of controlling Medfly through applications of malathion treated bait are found in Table 5. For each crop, a range of control costs is estimated based on the previous tables. In addition, the costs are converted to a cents per pound basis by dividing them by the volumes produced. As can be seen from Table 5, the crops most highly impacted are the ones

with the longest times of susceptibility to the Medfly which include avocados and oranges. As can be seen from Table 5, the total field costs of controlling Medfly in the crop production phase is estimated to range from a low of $349.6 million to a high of $731.9 million.

Table 5: Estimated Costs of Controlling Medfly Through Applications of Malathion Treated Bait.

	Range of Control Costs ($1,000)		Cents per Lb. of Produce	
	Low	High	Low	High
Apple, All	2,619	7,421	.39	1.10
Apricot	1,566	3,393	.66	1.44
Avocado	30,456	87,984	9.23	26.66
Bell Pepper	1,347	1,796	.34	.45
Cherry, Sweet	918	1,989	1.77	3.83
Date	450	1,275	1.02	2.90
Fig	1,521	6,591	1.58	6.87
Grapes, Raisin	24,390	105,690	.65	2.84
Grapes, Wine	26,100	113,100	.47	2.04
Grapes, Table	7,263	31,473	.48	2.07
Grapefruit	18,806	26,865	3.58	5.11
Kiwi	639	1,385	.80	1.73
Lime	135	585	1.16	5.03
Mandarin (Tang.)	2,160	8,280	1.41	5.41
Orange	183,816	239,760	4.16	5.43
Olives, fresh	4,023	17,433	1.64	7.09
Nectarine, Fresh	2,142	4,641	.54	1.16
Peach, Fresh	2,421	5,246	.74	1.60
Peach, Processed	2,484	5,382	.21	.45
Pear, Fresh	198	429	.12	.26
Pear, Processed	1,872	4,056	.40	.87
Persimmons	108	306	.94	2.66
Plums, Fresh	3,654	7,917	.85	1.83
Prunes (Fresh wt.)	6,921	14,996	.46	.99
Tomato, Fresh(Pink & Red)	2,880	6,240	.29	.63
Tomato, Processed	20,738	27,650	.12	.16
Total	349,626	731,881		

This data can be arrayed in another manner as exhibited in Table 6. In this table, the field costs of controlling Medfly are compared to the 1989 crop value for both the high and the low figures. What the estimates show is that for some crops, the cost impact will be minimal in terms of the total value of the crop at the farm level. For others, such as avocados and citrus, the impact is significant under the assumptions of this study. Whether these costs can be absorbed into total farm expenses at

this level is doubtful. It is also doubtful that costs of this magnitude can be passed on to consumers in the form of higher prices. This question will be discussed in greater detail in the market impact section.

Table 6: Estimated Pesticide Application Costs as a Percentage of 1989 California Farm Production Value.

	Control Costs as % of 1989 CA Value	
	Low	High
Apple, All	2.59	7.35
Apricot	4.14	8.97
Avocado	14.65	42.32
Bell Pepper	1.41	1.88
Cherry, Sweet	3.76	8.15
Date	2.07	5.85
Fig	8.29	35.94
Grapes, Raisin	3.67	15.92
Grapes, Wine	3.50	15.18
Grapes, Table	2.57	11.12
Grapefruit	36.80	52.57
Kiwi	4.32	9.35
Lime	5.26	22.80
Mandarin (Tang.)	7.52	28.82
Orange	39.76	51.87
Nectarine, Fresh	2.69	5.83
Olives	6.70	29.04
Peach, Fresh	3.77	8.16
Peach, Processed	2.15	4.67
Pear, Fresh	.78	1.69
Pear, Processed	3.13	6.77
Persimmons	1.55	4.40
Plums, Fresh	3.80	8.23
Prunes (Fresh wt.)	3.93	8.52
Tomato, Fresh(Pink & Red)	1.20	2.60
Tomato, Processed	3.64	4.86

Impact on Integrated Pest Management. During the past decade, California agriculture has embarked on an intensive program of integrated pest management which has the goal to reduce significantly the amount of pesticides used in production and yet maintain yields and net value to the grower. The program is based on research conducted by the University of California and others on which pest and disease management strategies are based. In addition, the program has been greatly assisted by the growth of a professional corps of pest management advisors who are educated and licensed to provide advice to farmers and others using pesticides.

This program has resulted in a significant reduction in the amounts of pesticides used in the crops selected for the program. Some crops now rely solely on beneficial organisms to control crop damaging pests. Other crops have reduced pesticide usage through the use of pheromones which disrupt insect mating. Through integrated pest management research and applications, the control of pests and diseases with non-pesticide methods has increased.

If the increased use of malathion or some other pesticide is applied to the crops listed in this report, it is likely that the integrated pest management programs will be less successful, particularly those using beneficial organisms. Data is not available at this point to evaluate the impact of increased applications of malathion on integrated pest management programs. However, it is likely that pests other than Medfly that are now controlled through integrated pest management can re-emerge to once again threaten crops (commonly referred to as secondary outbreaks). The options open to a farmer under a secondary outbreak would be 1) allow the pest to survive without additional applications of pesticides to control it and accept the economic damage from crop from reduced yields, or 2) apply pesticide applications to control the additional damage from the pest which will result in increased costs.

Under the first option, the major impact would come from reduced yields. In the 1981 study, it was assumed that an economic loss of 2.5 percent would occur from secondary pest outbreaks. If this figure is applied to the 1989 farm value of the crops considered in this study, a loss of $106.3 million would result. The second option would involve the application of a pesticide to control the pest. This application may be in addition to the Malathion used to control the Medfly, but would likely be combined. In this case the additional cost may result from any increase in the cost of materials used. It is likely that a more toxic material than malathion would be used, but this will depend on the pest to be controlled.

In summary, the use of malathion to control the Medfly will have significant impact on integrated pest management programs. An estimate of the additional cost that will result from a decreased use of integrated pest management will depend on the crop, pests involved, and the control strategies selected.

Post Harvest Quarantine Treatment.

If Medfly is established in California, the state will likely be placed under quarantine for shipments of affected commodities out of the state. This quarantine will likely affect both domestic shipments to other states and exports, particularly to the the rapidly growing markets of the Pacific Rim. In order to ship agricultural products under the quarantine, they would

have to be treated to insure that they are not contaminated by Medfly. Since 1981, the use of ethylene dibromide for this purpose has been canceled. It was the most effective method of post harvest treatment causing little damage to the commodity and providing good control.

Two alternatives now exist for most commodities: methyl bromide and cold treatments. It should be noted that while methyl bromide is currently approved for use, it may not remain a viable alternative in the future due to questions being raised abut its impact on the environment and food health and safety. In addition, a vapor heat treatment exists for some commodities which cannot be treated with methyl bromide or cold treatments.[6] While these treatments are effective, research indicates that product losses would occur due to shortened shelf life, deterioration of quality, and other physical damage to the fruit brought on by the treatments.

The 1981 study estimated damage to commodities damaged by quarantine compliance at $48.030 million to $334.049 million. The study also estimated continuing costs of $8.387 million in fumigation, $13.727 million in cold storage, and $12.328 million in increased transportation. In addition the study estimated one-time costs of $54.395 million to build and upgrade fumigation, cold storage, and packing/shipping facilities. It is likely that the same costs will occur in 1990 only at an increased level, in large part due to inflation.

For purposes of this study, it is assumed that all fresh produce that is shipped out of California will be subject to post harvest quarantine treatment. This assumption at first appears to conflict with that in the section on production costs dealing with a 30 day minimum in estimating crop susceptibility. However, as pointed out in that section, the 30 day rule was used only to establish a basis for estimating minimum susceptibility requirements and might not continue if a state-wide establishment of Medfly were to occur. Upon the establishment of Medfly on a state-wide basis, quarantine treatments are likely to be required for shipment out of state. This section estimates the costs of complying with quarantine requirements for shipment of produce out of California.

Quarantine treatment ideally should take place at the packing facility to minimize the transportation and handling of the fruit. However, the time and location of treatment will vary depending on the characteristics of the fruit, treatment to be used, and location of the treatment facility. For example, a number of commodities can be treated with methyl bromide. This treatment can be accomplished with either a chamber constructed for this purpose or with the use of a tarp. It is doubtful that enough facilities exist for the use of methyl bromide, and, hence, the tarping method will likely be used. If methyl bromide

is used, it is likely that the fumigation will take place at the packing facility. On some commodities, the fumigation is more effective when the fruit is loose in bins, while for others the fumigation will take place after it is packed. This study will not be concerned with the exact details of how the treatment will take place, only that it will and at a cost.

While the use of methyl bromide is approved, cold treatment is preferred because of toxic effects and subsequent fruit damage. Citrus fruits are in this category. If cold treatment is used, it is doubtful that treatment will take place at a packing house unless it has a facility that can bring the internal temperature down to 32 degrees F and hold it for at least 10 days. Hence, it is likely that most cold treatment will be done at a facility away from the packing plant which will entail additional transportation.

In addition, cold treatment can take place while the fruit is being shipped in containers. APHIS must certify the container and the importing country must allow this method to be used. Japan has been especially difficult in allowing cold treatment to be used in transit and has generally insisted that the treatment take place before the product is shipped. One possibility identified in the 1981 study was to rent these containers for cold treatment use at the packing house in lieu of transferring produce to a cold storage facility.

In order to determine the costs of complying with the quarantine of California products, the amounts of product affected and the per unit costs of treating them must be estimated. Table 7 presents estimates of affected product that is shipped out of California.[7] This table was constructed using per capita consumption data developed by U.S.D.A. and using it to determine California consumption. After subtracting the amount of product going to processing from production, the difference was determined to be the amount of fresh product shipped from California and subject to quarantine restrictions. No distinction is made from that product shipped from California for export vs. that for domestic consumption in other states. It is assumed that any fresh product shipped from California will be subject to quarantine and, hence, have to be treated for possible Medfly contamination.

The cost for post harvest quarantine treatment varies according to the treatment used. Not all commodities can be treated with methyl bromide. Commodities that can't will have to use the cold treatment or vapor heat treatment. In order to determine what the costs of these various treatments are, various industry personnel were surveyed. Based upon the information received, fumigation treatment costs are estimated to be at the rate of one cent per pound of product treated and cold treatment costs at the rate of 2.5 cents per pound of product treated.

Table 7: Estimated Shipments in of Fresh Fruits and Vegetables from California (Tons)

	Calif. Prodn	Utilized Production Fresh	Utilized Production Processed	Fresh Ship. from Calif.
Apples[8]	337,500	139,500	198,500	55,670
Apricot	118,000	14,600	103,000	13,692
Avocados	165,000	153,000	12,000	130,912
Bell Pepper*	200,028	120,017	80,011	108,015
Cherries, Sweet	26,000	18,500	7,500	10,798
Dates	22,000	22,000	0	18,658
Figs	48,000	1,500	46,500	1,355
Grapefruit	262,750	180,425	82,325	80,739
Grapes	5,390,000	760,000	4,630,000	660,459
Kiwi	40,000	37,000	0	34,478
Mandarin (Tang.)	76,500	55,313	21,188	37,875
Orange	2,208,750	1,522,500	686,250	1,339,548
Nectarines**	200,000	199,000	1,000	177,929
Peaches	760,000	164,000	562,000	102,968
Pears	315,000	81,000	234,000	32,029
Plums	216,000	216,000	0	194,203
Tomato, Fresh	499,200	499,200	0	239,086

* Bell Pepper utilized production and shipments estimated using proportions for 1988.

** Nectarines fresh and processed utilized production assumed to be same as in 1988.

Products are being treated using the vapor heat treatment in Hawaii, but costs were not readily available as in the case of fumigation in California where a number of commodities are already being treated. Hence, a rate of one cent per pound was assumed for those products treated with the vapor heat treatment. It is likely to be higher given that it is a relatively new technology and there are still many aspects to be learned regarding its application.

The results of applying these rates to the various commodities involved are found in Table 8. In this table, all of the crops were assumed to be treated with methyl bromide according to the USDA-APHIS Quarantine Treatment Manual other than oranges, mandarin oranges, grapefruit, and kiwi which were assumed to be treated via the cold treatment method. The reason for this assumption came about in discussions with industry personnel who stated that methyl bromide treatment was unsuitable for these crops and would cause too much damage. Bell peppers were assumed to use the approved vapor heat treatment which is the only option for them.

Table 8: Estimated Costs of Quarantine Treatment for Medfly.

	Treatment Costs($)	Treatment Damage(%)	Treatment Loss ($)	Total Treat. Costs ($)
Apple, All	1,113,400	2.00	333,271	1,446,671
Apricot	273,840	2.50	109,713	383,553
Avocado	2,618,240	2.00	3,298,982	5,917,222
Bell Pepper	2,160,294	2.00	1,030,629	3,190,924
Cherry, Sweet	215,960	.00	0	215,960
Date	373,160	2.00	369,428	742,588
Fig	27,100	2.00	10,355	37,455
Grapes	13,209,180	2.00	4,918,768	18,127,948
Grapefruit	4,036,950	2.00	314,039	4,350,989
Kiwi	1,723,900	2.00	255,137	1,979,037
Mandarin (Tang.)	1,893,725	2.00	284,509	2,178,234
Orange	66,977,400	2.00	5,607,016	72,584,416
Nectarine	3,558,580	5.00	3,542,789	7,101,369
Peach	2,059,360	2.50	1,009,086	3,068,446
Pear	640,580	2.00	200,446	841,026
Plums, Fresh	3,884,060	2.50	2,161,093	6,045,153
Tomato, Fresh	4,781,720	2.00	2,295,226	7,076,946
Total	109,547,449		25,740,488	135,287,938

Note: Grapes' cost based on adjusted production but unadjusted value of 1989 grapes utilized for fresh market. Peaches and pears costs based on adjusted data.

In addition to the costs of quarantine treatment, certain losses in damage to the fruit can be expected. In the 1981 study, a range of two to ten percent was assumed. Since 1981, a number of research studies have been conducted, particularly for the effect that methyl bromide has on various commodities. These studies were conducted by the U.S.D.A. Agricultural Research Service and the University of California. Appropriate references can be found in the bibliography. A loss factor of two percent was assumed for this study unless research reports indicated otherwise. The loss factors used for each commodity is indicated in Table 8. These factors seem reasonable given the reports reviewed but may change in the future as more experience is acquired.

As can be seen from Table 8, the quarantine treatment costs are estimated to be $109.5 million. Another $25.7 million is estimated due to damage from treatment for a total estimated cost of $135.3 million.

Facilities. One question that needs to be dealt with is whether there is adequate capacity for treatment of commodities under quarantine. The 1981 study estimated that additional fumigation and cold storage facilities would be needed for compliance with quarantine treatment. Costs of these facilities was estimated to be $47.2 million.

In discussions with industry personnel, it has been reported that a number of fumigation chambers were built in the early 1980's which are now being used for storage. It is felt that these chambers can be easily restored for use. Taking into account peak shipments of the various commodities, it is estimated that approximately 205 additional fumigation facilities will have to be built in California. These estimates use many of the same assumptions built into the 1981 study. Using a cost of $6,500 per chamber[9], these estimates yield a cost of slightly more than $1.3 million dollars for construction of additional fumigation facilities. However, as long as the tarp method of fumigation is allowed by governmental regulations, it is likely that new facilities may not be required.

Cold storage facilities adequate for quarantine treatment under APHIS guidelines are another story. All industry personnel surveyed indicated that there are no available unused cold storage facilities and that additional capacity would have to be built. Using the 1981 calculations as a base and adjusting them for current levels of production, it is estimated that an additional 1.5 million square feet of cold storage would have to be built. These facilities would have to be built primarily for oranges, grapefruit, and kiwis and additionally for pears and apples if they opted for cold treatment either in coordination with or in place of methyl bromide treatment. An estimate of construction costs of $65 per square foot (without land costs) was obtained from industry sources. Hence, it is estimated that approximately $86.7 million dollars would be spent in new cold storage facilities.

The 1981 study also estimated costs of upgrading packing and shipping facilities. Under internal quarantine regulations for Medfly, facilities that pack and ship fruit subject to Medfly quarantine will be required to have fly-excluding screens over windows and around the entire work area where fruit is being transferred from field bins to shipping cases. In addition, all facilities handling fumigated, cold treated, or vapor heat treated fruit which has passed certification will need screening. Lastly, these facilities will need forced-air fans or air curtains at all entrances and exits where fruit will be moving.

The 1981 study estimated that $7.142 million would be spent on upgrading these facilities. If the same assumptions are used as the 1981 study for the amount of construction needed and a 50

percent inflation rate is used to bring these costs into line with 1990 levels, it is estimated that a construction cost of $10.713 million will result.[10]

Transportation. The 1981 study also estimated increased costs of transportation in order to treat fruit under quarantine. The study based its estimates on the assumption that fruit would have to be transported to and from fumigation and cold storage facilities in order to have the treatment done. In this update, it is assumed that most of the fumigation with methyl bromide will be done on site at the packing and shipping facility, especially if tarps are used. Cold treatment, however, will likely require transportation to and from cold storage facilities as it is doubtful that packing facilities will have the type of structure and equipment available for on site operations. The commodities needing cold treatment compose about 50 percent of the total volume needing treatment. Hence, using the 1981 study assumptions and applying an inflation rate for fuel and labor will result in an estimate of $8.124 million for increased transportation costs in 1990 (also assuming that only 50 percent of the volume is affected).

Market Impact.

The 1981 study did not analyze potential market impacts that would arise from Medfly damage in California. It identified as areas that needed further study as 1) costs to consumers in California, 2) costs to U.S. consumers in all states except California, and 3) costs associated with loss of export revenue assuming an international trade embargo. The March 1990 report to the California State Assembly assumed that any market effects would remain neutral.

At least two scenarios emerge with respect to market impacts. One scenario involves a thesis that current shipments of produce from California would continue as long as quarantine treatments are made and certified. This scenario reflects the assumptions contained in this report and involves an analysis of impact of increased prices or decreased volumes in the market.

A second scenario involves the impacts that would take place if selective embargoes were placed on out-of-state shipments from California. Examples of this scenario are if Japan or some state such as Florida refuses California produce under any condition. Analysis under this scenario would then have to look at the revenues given up under the embargo and the gains in revenues by redistributing the volume in other markets.

The assessment of market impact under the scenarios described above involves the effects that take place when changes in prices and quantity occur in a market. In order to appropriately analyze the changes that might take place, price

elasticity of demand or price flexibility measures must be available or calculated. The condition of the market as measured by these instruments is crucial to estimating potential impacts. For example, an inelastic demand for a commodity would result in less total revenue returned to a producer if additional quantities are sold. Conversely, total revenue would increase if less quantities are sold. Under a condition where the market has an elastic demand, the reverse flows of total revenue would take place. That is, an increase in price or a decrease in quantity supplied to the market will result in an overall loss of revenue to the farm sector. Hence, an appropriate measurement of price elasticities of demand or price flexibilities are essential for an appropriate market analysis.

A search of published works was conducted for these measures. Price flexibility measurements were found for apples, apricots, cherries, grapes, oranges, nectarines, peaches, pears, and plums.[11] The price flexibilities for these crops are for prices at the farm level and were calculated from annual prices for the period 1947-70. While measurements based on a more current price series would have been preferable, these price flexibilities were judged to be adequate for some limited analysis in this report. No elasticities or flexibilities were found for the f.o.b. or retail level that were judged suitable. A review of these price flexibilities suggests that most of the crops have the characteristic of an elastic demand at the farm level with the exception of and plums.

As a result of previous estimates of impact of the medfly in this study, two estimates of market impacts can be made. One is derived from Table 8 in which various losses from quarantine treatment of the Medfly were estimated. If these losses are applied to the price flexibilities for the crops identified, a slight loss in market revenue of $6 million would occur. If losses occur that are higher than the ones identified, the loss in revenue to the farm sector could be higher. This estimate, of course, assumes that current patterns of shipments would continue to occur with appropriate quarantine treatments.

The second estimate is based on data from Table 6 which displays the amount of pest control costs as a percent of the farm value of the crops considered in this report. If it is assumed that prices are increased on an average between the high and low figures given, then quantity demanded will decrease appropriately. For the nine crops identified, this action will result in a revenue decrease of $164 million to the farm sector. The price flexibilities and calculations that arrive at these figures are found in Appendix Table 3.

Another question that arises with respect to market impact is what happens if export markets are eliminated or decreased due to embargoes. Much of California agricultural exports go to the Pacific Rim countries. Table 9 displays data on the amount of

Table 9 : Value of California Agricultural Exports to Japan and Other Asian Countries, 1989 (Value at Port).

	---Exports to Japan---		Exports to Other Asian	
	CA ($000)	U.S. ($000)	CA ($000)	U.S. ($000)
Apples, fresh	32	72	4,073	64,140
Apricots, fresh	133	133	47	61
Apricots, processed	2,316	2,316	260	260
Avocados	1,669	1,698	91	91
Bell Peppers				
Cherries, Sweet	24,207	40,137	3,572	6,664
Dates	168	195	358	358
Figs	156	156	835	835
Grapes, Wine	20,222	22,227	4,873	5,026
Grapes, Raisin	33,970	33,974	10,477	10,494
Grapes, Table	5,415	6,002	42,355	43,508
Grapefruit	34,620	139,771	3,725	22,009
Kiwi, fresh	939	939	2,564	2,564
Lime	62	62		
Mandarin (Tang.)	12	12		
Oranges	82,433	82,907	70,529	70,863
Nectarine	----------inc. with Peaches----------			
Olives	1,312	1,312	272	276
Peaches, Fresh	527	533	1,534	1,552
Peaches, Processed	8,160	8,212	2,966	3,067
Pears, Fresh	26	26	81	740
Pears, Processed	48	269	58	147
Plums, Fresh	386	386	22,608	22,773
Prunes(Fresh wt.)	15,947	15,947	4,267	4,296
Tomatoes, Fresh			1,220	1,277
Tomatoes, Processed	9,302	9,703	8,306	8,698
Total	242,062	366,989	185,071	269,699

exports (valued at the port) which goes to Japan and other asian countries. This table shows that $427 million is exported to Japan and other asian countries in the Pacific Rim. Oranges and grapefruit account for nearly $191 million of this total. Cherries, table grapes, avocados, kiwis, peaches, and plums are also significant with a combined total of $106 million. Especially critical in exports to the Pacific Rim is Japan which is a premium market that emphasizes quality and has the available income to purchase California agricultural products that meet its specifications.

The Japanese market is one in which hard fought gains have been made in negotiations to open it up. It has been reported by trade experts, that as Japan goes, so will the other asian countries. If these export markets are lost or decreased, the impact on the California farm economy will depend on a number of factors, primarily those which relate to alternative markets. The gains in those markets will have to be compared to the losses in the markets which are lost. In order to appropriately estimate the impact of a Japanese embargo (and others like it) on California produce, elasticities of demand are needed for the markets that will receive the additional quantities that occur as a result of the embargo. At the current time, adequate data and economic measures do not exist in order to carry out a reliable analysis. Such an analysis will have to wait for future research endeavors. However, in general, it can be stated that a Japanese embargo will be costly to those industries affected by it. How costly will depend on how much additional revenue can be generated by moving the embargoed quantities into other markets.

The final note to make about market impact is the timing of the effects. It will take a number of years for market adjustments to take place before a new equilibrium is reached. For example, in the first year of Medfly establishment, the costs that have been identified in this report will likely fall mostly on the producer and packer. If these costs cannot be absorbed by the producer/packer, price increases will be attempted in subsequent years. Less efficient producers/packers will be forced out of the market if they are not able to compete with higher costs and subsequent decreases in quantities due to this elimination will result in higher prices. With higher prices will come an expansion of productive capacity (either in California or some other competing area) until at some point the market reaches a new equilibrium.

In summary, the limited market impact analysis carried out in this section suggests that initially it would be difficult to recapture losses incurred by producers and packer/shippers through the marketplace. Because of the nature of demand for the products considered, losses due to decreases in quantities packed or increased costs due to pesticide applications and quarantine control will actually result in less revenue, not more for the producers during the first phase of adjustments in the market.

Summary and Conclusions.

This study has updated a 1981 study that was conducted on the economic impact of a possible establishment of Medfly into California. Many of the same assumptions that went into that

study were used in this one. Additionally, some assumptions were updated based on information and data that has been developed and reported since 1981.

Many of the same crops as the 1981 study as suitable for Medfly hosts. A total of 21 different commodities were included. These commodities represent 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 going to Japan and other asian countries.

The study estimated two basic sets of costs: 1) the cost of controlling Medfly in the field through increased pesticide applications, and 2) the cost of post harvest treatments to comply with quarantine regulations in order to ship out-of-state. In estimating these costs, it was assumed that no fruit would be lost in the field due to Medfly damage if properly controlled. However,varying levels of fruit would be lost due to damage caused by the quarantine treatments.

Continuing costs due to field application of pesticides was estimated to be in a range of $349.6 million to $731.9 million. Continuing costs due to post harvest treatment under quarantine regulations was estimated to be $135.3 million. In addition, increased costs of transportation to and from treatment facilities were estimated to be $8.1 million. Total continuing costs are estimated to range between $493 million to $875.3 million. In addition to the continuing costs identified, it was estimated that $86.7 million would be required to construct additional cold storage and fumigation facilities with an additional $10.7 million required to upgrade packing and shipping facilities to conform to quarantine regulations.

These estimated costs have varying impacts on the commodities considered and range from slight (in the case of fresh tomatoes) to significant (in the case of avocados and citrus). In these latter cases, it is difficult to see how the producers of these crops will be able to continue production without significant changes occurring that would lessen the costs of controlling the Medfly. Market impacts will only add to the problem of increased costs rather than assisting in their mitigation in most cases.

In a long run sense, adjustments will take place in the production of California crops if Medfly becomes an established pest. Much will be dictated by the market and competing products and areas of production. However, it appears likely that the production base in California for many of its specialty crops will shrink and the likelihood that many producers and packer/shippers will fail to survive. The likely outcome is that as California producers of the crops considered here become less competitive due to higher costs, other areas will develop. California is a unique production area of the world. To sub-

stitute its production capacity completely would be difficult. However, the net result to consumers of the impact of Medfly establishment in California is likely to be higher prices, a decrease in quality, and a lessening of choice.

In addition, the crops considered in this study are all high value and value added commodities which employ high amounts of labor and contribute significantly to local economies. While no attempt was made in this study to assess the economic effects on other sectors of the economy that are tied in to the crops studied here, a future study may well show that the impact of the Medfly will go significantly beyond the costs and impacts identified.

This study was based on a number of assumptions. The central hypothesis is that establishment of the Medfly in California will result in significant costs to those crops and related industries affected by it. Estimates developed in this study have given validity to this hypothesis. Remaining questions center around how these costs will impact the producers of the commodities, related industries, and ultimately, the consumer.

FOOTNOTES:

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1. See Daniel Galt and Barbara Albertson, "The Potential Economic Impact of the Mediterranean Fruit Fly, Ceratitis Capitata (Wied.), Upon Establishment in California", Cooperative Extension and Giannini Foundation of Agricultural Economics, University of California, December 1981.

2. See Dr. Harold O. Carter, "Testimony on the Economic Implications of the Medfly Infestation", Assembly Hearings, March 6, 1990, University of California Agricultural Issues Center, Davis, CA.

3. See 7 CFR Part 301, Mediterranean Fruit Fly, published in the Federal Register, September 20, 1989, October 17, 1989, November 24, 1989, and February 16, 1990.

4. See "State of California Commodity Treatment Manual", Volume I, CDFA, 1989, p.55, for details. While this regulation is now in effect, it may or may not continue if the Medfly becomes established on a permanent basis in California. Hence, it should not be assumed that while this regulation removes the need for quarantine treatment at the present time that quarantine treatments may not be needed in the future.

5. For the formula as provided by the California Department of Food and Agriculture, see "The State of California Commodity Treatment Manual", Volume I, Treatments, CDFA, 1989, p.55. It provides "For ground and aerial applications, use a maximum of 2.8 ounces a.i. mixed with a maximum of 9.6 ounces of Staley's Protein Bait, Nu-Lure, or other similar bait material per acre.

6. Details of quarantine treatments can be found in USDA-APHIS "Plant Protection and Quarantine Treatment Manual", Reprinted to include amendments through March 1989.

7. The sources for this table are:
California Fruit and Nut Statistics, 1981-90, CASS, Sacramento.
California Vegetable Crops, Acreage, Production, & Value, 1981-90, CASS, Sacramento.
Fruit and Tree Nuts, Situation and Outlook Yearbook, August, 1990, ERS, USDA.
Vegetables and Specialities, Situation and Outlook Yearbook, November 1990, ERS, USDA.

8. California fresh apple shipments are estimated by subtracting fresh arrivals in California from California consumption of fresh apples, and then subtracting this result from California production utilized for fresh market.

9. This figure was estimated by adjusting the $4,320 cost per

unit determined in the 1981 study by an inflation cost index of 150%. This index was estimated using data from "Survey of Current Business", U.S. Department of Commerce, and from "Economic Indicators", Prepared for the Joint Economic Committee of Congress by the Council of Economic Advisors, U.S. Government Printing Office.

10. This estimate is based on material cost and labor indexes found in "Survey of Current Business", U.S. Department of Commerce, Bureau of Economic Analysis, March 1990, Volume 70, No. 3.

11. See Nuckton, Carole Frank, "Demand Relationships for California Tree Fruits, Grapes, and Nuts: A Review of Past Studies", University of California, Giannini Foundation, Special Report, August 1978.

Appendix Table 1: Regulated Articles Under Medfly Quarantine

Common Name	Scientific Name	Included in Analysis
Almond with Husk	Prunus dulcis P. amygdulus	No
Apple	Malus sylvestris	Yes
Apricot	Prunus armaniaca	Yes
Avocado	Persea americana	Yes
Black Myrobelan	Terminalia charbula	No
Cherries (Sweet & Sour)	Prunus avium, P. cerasus	Yes
Citrus citron	Citrus medica	No
Date	Phoenix dactylifera	Yes
Fig	Ficus varica	Yes
Grape	Vitus app.	Yes
Grapefruit	Citrus paradisi	Yes
Guava	Psidium guajava	No
Japanese persimmon	Diospyros kaki	No
Japanese plum	Prunus salicina	No
Kiwi	Actinidia chinensia	Yes
Kumquat	Fortunella japonica	No
Lemon (Except smooth skinned lemon of commerce that is cleaned and waxed)	Citrus limon	No
Lime, sweet	Citrus aurantiifolia	Yes
Loquat	Eriobotrya japonica	No
Mandarin orange	Citrus reticulata	Yes
Mango	Mangifera indica	No
Mock Orange	Murraya exotica	No
Mountain apple	Syzigium maloccensa Eugenia maloccsensa	No
Natal Plum	Carisso macrocarpo	No
Nectarine	Prunus persica var. nectarina	Yes
Olive	Olea europea	No
Opuntia cactus	Opuntia spp.	No
Orange calamondin	Citrus reticulata x.Fortunella	No
Orange chinese	Fortunella japonica	No
Orange king	Citrus reticulata x. C. sinensis	No
Orange Sweet	Citrus sinensis	Yes
Orange Unshu	Citrus reticulata v.Unshu	No
Papaya	Carica papaya	No
Peach	Prunus persica	Yes
Pear	Pyrus communis	Yes
Pepper	Capsicum fruteacans, C. annuum	Yes
Pineapple guava	Feifoa sellowiana	No
Plum	Prunus american	Yes
Pomegranate	Punica granatum	No
Prune	Prunus domestica	Yes
Pommelo	Citrus grandia	No

Regulated Articles under Medfly Quarantine, Continued

Common Name	Scientific Name	Included in Analysis
Quince	Cydonia oblonga	No
Rose apple	Eugenia jamboa	No
Sour Orange	Citrus aurantium	No
Spanish cherry (Brazilian Plum)	Eugenia domboyi (E. brasiliensis)	No
Strawberry guava	Psidium catttlejanum	No
Tomato (pink and red ripe)	Lycopersicon esculenium	Yes
Walnut with husk	Juglans spp.	No
White sapote	Casimiroa adulis	No
Yellow oleander, bestill	Thevetia peruviana	No

POTENTIAL HOSTS OF THE MEDFLY AS REPORTED BY CDFA

PREFERRED HOSTS	OTHER HOSTS	REPORTED HOSTS
Apple, all	Almond	Asparagus
Apricot	Avocado	Beans
Citrus, exc. lemons	Bell Pepper	Dry
Grapefruit	Cherimoya	Limas: green, baby
Lime	Cherry, sweet	String
Mandarin (Tang.)	Lemon, all	Cucumber
Orange	Cotton	Melons, all
Fig	Date	Cantaloup
Nectarine	Grapes, all	Honeydew
Peach, all	Wine (& canned)	Watermelon
Fresh	Table	Other
Processed	Raisin	Persimmon, medlar
Persimmons	Guava, pineapple (Feijoa)	Pumpkin
Plum, all	Kiwi	Eggplant
Fresh	Olives, fresh	Squash, all
Prunes, fresh wgt.	Tomato, all (pink & red)	
	Fresh	
	Processing	
	Walnut	

Appendix Table 2. Acres, Production, Value, and Farm Value of Exports for Crops Potentially Affected by Medfly in California.

	1989 Acres CA (000)	1989 Prodn. CA (Tons)	1989 Value CA ($000)	1989 Export CA ($000)
I. Preferred Hosts				
Apple, All	29.10	337,500	101,023	
Apricot	17.40	118,000	37,821	6,366
Grapefruit	19.90	262,750	51,099	16,549
Lime	1.00	5,820	2,566	
Mandarin (Tang.)	8.00	76,500	28,733	7,168
Orange	177.60	2,208,000	462,264	111,097
Fig	16.90	48,000	18,341	2,046
Nectarine, Fresh	23.80	200,000	79,645	***
Peach, Fresh	16.72	164,000	64,288	15,374
Peach, Processed	37.75	596,000	115,268	2,775
Pear, Fresh	6.68	81,000	25,346	6,617
Pear, Processed	16.36	234,800	59,904	
Persimmons	1.20	5,745	6,961	
Plums, Fresh	40.60	216,000	96,146	26,539
Prunes (Fresh wt.)	76.90	754,840	176,054	52,581
Total, Preferred	489.91	5,308,905	1,325,459	247,112
II. Other Hosts				
Almond	409.00	245,000	480,930	363,010
Avocado	75.20	165,000	207,900	17,066
Bell Pepper	17.96	200,028	95,429	3,929
Cherry, Sweet	10.20	26,000	24,418	14,562
Lemon, Fresh	48.40	391,400	189,520	66,642
Lemon, Processed		224,200	11,151	
Cotton, Lint	1,059.00	645,120	929,179	589,036
Cotton, Seed		1,048,100	98,521	31,125
Date	5.00	22,200	21,780	4,434
Grapes, Wine	354.37	2,766,000	817,921	47,199
Grapes, Raisin	196.94	1,864,000	424,264	79,327
Grapes, Table	90.52	760,000	449,900	100,148
Kiwi	7.10	40,000	14,800	6,129
Olives, Fresh	29.80	123,000	60,030	1,457
Tomato, Fresh	38.40	499,200	239,616	18,765
Tomato, Processed	276.50	8,585,330	569,207	18,856
Walnut, In Shell	177.00	229,000	245,030	100,188
Total, Other Hosts	2,795.39	17,833,378	4,879,596	1,461,873

*** Included with peaches.

Appendix Table 2. Continued

	1989 Acres CA (000)	1989 Prodn. CA (Tons)	1989 Value CA ($000)	1989 Export CA ($000)
III. Reported Hosts				
Asparagus	37.50	54,400	71,978	15,155
Beans, Dry	184.00	171,800	118,886	26,462
Beans, String		2,248	1,948	
Cucumber	4.30	52,460	12,958	
Melons, Cantaloup	80.80	767,600	193,435	23,992
Melons, Honeydew	21.30	202,350	47,755	
Melons, Watermelon	14.26	183,100	26,664	
Melons, Other	4.00	36,300	11,047	
Persimmon, Medlar		5,745	6,961	
Pumpkin	3.57	54,277	4,362	
Eggplant	0.56	3,766	2,500	
Squash, All	7.93	59,559	25,238	
Total, Reported	358.23	1,593,605	523,732	65,609
TOTAL	3,643.52	24,735,888	6,728,787	1,774,594

Appendix Table 3. Calculation of Market Losses due to Medfly Using Average Price Increases.

	1989 Value ($000)	Price Flexibility	Price Change%	Quantity Change%	Estimated Value 000$
Apples	101,023	-.363	.05	-.138	91,463
Apricots	37,821	-.465	.07	-.151	34,376
Cherries	24,418	-.467	.06	-.128	22,558
Grapes	449,900	-.981	.07	-.071	281,208
Oranges	462,264	-.886	.46	-.519	324,503
Nectarines	79,645	-.629	.04	-.064	77,563
Peaches	64,288	-.364	.06	-.165	56,913
Pears	25,346	-.609	.01	-.016	25,179
Plums	96,146	-1.133	.06	-.053	96,518
Total	1,173,956				1,010,281

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