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POTENTIAL ECONOMIC IMPACT OF A FRUIT FLY INFESTATION ON THE U.S. CITRUS INDUSTRY

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Abstract. **This paper analyzes economic effects on certain areas of the U. S. delineated into potential and marginal zones of infestation of 4 species of the fruit fly (Mediterranean, oriental, melon and Mexico). All or parts of 4 citrus producing states (Florida, California, Texas, and Arizona) are within these zones. Eighty-one percent of the 1972-75 production of citrus was in the zone of probable (potential plus marginal zones) infestation.**

Total production losses at a low of 10% in the potential zone and 5% in the marginal zone would amount to 26.7 million boxes of citrus with a value of $70.1 million at 1975 farm-level prices. The estimate of losses at the retail level for oranges and grapefruit is $218.7 million. Export losses and treatment costs are also examined and discussed in the paper.

Fruit Fly Zones and Analytical Procedures

Four fruit fly species (Mediterranean, oriental, melon and Mexican) may survive winter conditions in the Continental U.S. in areas where the average year exhibits no more than a 60-day period with an average temp below 14°C (1, 3, 4). This "potential zone" roughly includes all of Florida south of the 30th parallel, the lower delta of Louisiana, the lower Rio Grande Valley in Texas, a coastal strip along the Gulf of Mexico from Brownsville to Galveston, Texas, the Imperial Valley of California, and the Yuma and lower Gila River areas in Arizona. A fifth fruit fly, the Caribbean fruit fly, is established as a pest in Florida, but its potential range in southern U.S. has not yet been determined.

Areas with a 60 to 90 day period with an average temp below 14°C appear to be marginal for fruit fly reproduction and immature stage development. In the U.S., this "marginal zone" includes an Atlantic coastal strip extending from the 30th parallel north to Charleston, South Carolina, other parts of Florida north of the 30th parellel, extensive areas in southern Georgia, Alabama, Mississippi, Louisiana, and Texas, the Greater Gila and Salt River valleys of Arizona, including the Phoenix area (3, p. 764). The Death Valley and Coachella Valley regions of Southern California, and the lower Colorado River Valley area inland as far south as the southern tip of Nevada are also included.

Excessively hot, dry summer conditions may be expected to inhibit build up of damaging infestation of *Ceratitis*. Harris reported that the Mediterranean fruit fly strain in Tunisia is an exception and reaches the highest levels during the hottest and driest part of the year (2). Fig. 1 is a map which delineates the "potential" and "marginal zones" of infestation.

The zone boundaries in Fig. 1 were extrapolated to a U.S. county map in order to use county data to estimate production losses of various infestation levels. Counties were included if any part of the county was crossed by the appropriate marginal or potential zone lines. Only in Florida do all counties fall either in one zone or the other. Counties included by states in the potential and marginal zones, respectively include: Florida-47,20; South Carolina-0,5; Georgia-0,66; Alabama-0,18; Mississippi-0,24; Louisiana-14,29; Texas-44,72; California-3,0; and Arizona-3,3.

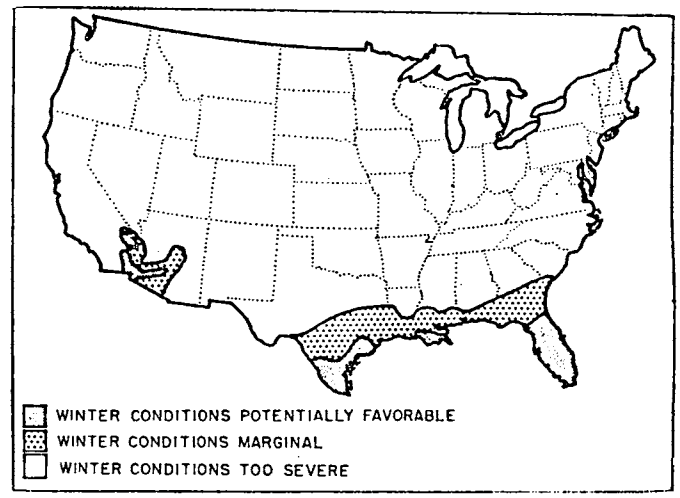

Fig. 1. Potential and marginal fruit fly infestation zones in the U.S. Source: (3, p. 764).

Definite infestation rates from which to project losses are not available. Loss rates in this report were considered for a range from 10 to 75% in the potential zone. Five successive generations per year of the oriental fruit fly are produced under conditions typical of the potential zone (3, p. 761). Between 2 and 3 generations reproduce under conditions typical of the marginal zone. These data served as a basis for the assumption in this study that losses would occur in the marginal zone at one-half the rate in the potential zone. Total loss rates are denoted by 10/5 or 30/15%.

County agricultural production data were used to develop zone production data where entire state production did not fall within a zone. Average production for 1972-75 was used to derive an average annual production base rate for citrus. Use of a three-year average modified the influence of abnormal production years. Price data for 1975 were used.

Production and Value Losses

Four states produce citrus in the U.S. with all or part of their production in the potential zone. Florida, Texas, Arizona, and California produced a total 1972-75 annual average of 328.8 million boxes of citrus. Eighty-one percent of this production was in the potential zone. All limes, tangelos, and temples produced in the U.S. are in the potential zone (Table 1). U.S. grapefruit, tangerine, orange and lemon production in the potential zone occurs at the rate of 98, 83, 81, and 31%, respectively. California, the only state where citrus is produced outside the marginal and potential zones, produced only 13% inside the zones.

Estimated volume of losses at various damage rates are given in Table 1. At a 10/5% rate a total of 26.7 million boxes (for metric conversions see table at front of this

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[1]This paper evolved from research accomplished by the authors in support of a report prepared for the United States Agency for International Development by the UC/AID Pest Management and Related Environmental Protection Project at the University of California, Berkeley.

Table 1. Projected citrus fruit production losses for Florida, Texas, Arizona, California and the U.S. for a series of assumed damage rates that might occur as a result of fruit fly infestation.

	1972-75 Statewide Average 1,000 boxes[z]	Percent in Probable Zone[y]	Projected Losses at Various Damage Rates[x] 10/5%	30/15%	75/37%
Florida					
All Oranges	169,000	100	16,960	50,880	127,200
Grapefruit	46,033	100	4,603	13,809	34,524
Limes	1,083	100	108	324	812
Tangelos	3,833	100	383	1,149	2,874
Tangerines	2,966	100	296	889	2,224
Temples	5,233	100	523	1,569	3,924
Total	228,748	100	22,873	68,620	171,558
Texas					
All Oranges	6,313	100	631	1,893	4,734
Grapefruit	9,933	100	993	2,979	7,479
Total	16,246	100	1,624	4,872	12,213
Arizona					
All Oranges	4,480	100	448	1,344	3,360
Grapefruit	2,488	100	249	747	1,866
Lemons	4,900	100	490	1,470	3,675
Tangerines	607	100	61	182	455
Total	12,475	100	1,248	3,743	9,356
California					
All Oranges	45,867	5	229	688	1,720
Grapefruit	5,717	74	423	1,269	3,173
Lemons	18,233	12	219	656	1,641
Tangerines	1,500	42	63	189	473
Total	71,317	33	934	2,802	7,007
Total U.S.					
All Oranges	226,260	81	18,269	54,806	137,015
Grapefruit	64,171	98	6,269	18,805	47,014
Limes	1,083	100	108	324	812
Lemons	23,133	31	709	2,126	5,316
Tangelos	3,833	100	383	889	2,224
Tangerines	5,073	83	420	1,261	3,152
Temples	5,233	100	523	1,569	3,924
Total	328,786	81	26,681	79,780	199,457

[z]Source: Computed from (4).
[y]Based on county data taken from (7). Delineated into zones based on maps in (2).
[x]Loss rates are potential/marginal zone proportions (10/5%, etc.) and totals may not add exactly due to rounding error.

Table 2. Projected citrus fruit farm value losses for Florida, Texas, Arizona, California, and the U.S. for a series of assumed damage rates that might occur as a result of fruit fly infestation.

Crop	1975 Average Price	Projected Losses at Various Damage Rates 10/5%	30/15%	75/37%
	dollars per box	millions of dollars		
Florida				
All Oranges	2.56	43.418	130.253	325.632
Grapefruit	2.66	12.244	36.732	91.833
Limes	7.22	.833	2.501	6.269
Tangelos	2.36	.904	2.712	6.783
Tangerines	4.84	1.433	4.303	10.764
Temples	2.31	1.208	3.624	9.064
Total		60.040	180.125	450.345
Texas				
All Oranges	1.91	1.205	3.616	9.042
Grapefruit	2.30	2.284	6.852	17.202
Total		3.489	10.468	26.244
Arizona				
All Oranges	2.67	1.197	3.588	8.971
Grapefruit	2.10	.523	1.569	3.919
Lemons	3.30	1.617	4.851	12.128
Tangerines	4.73	.288	.861	2.152
Total		3.625	10.869	27.170
California				
All Oranges	3.24	.742	2.229	5.573
Grapefruit	2.51	1.061	3.185	7.964
Lemons	4.03	.883	2.644	6.613
Tangerines	3.92	.247	.741	1.854
Total		2.933	8.799	22.004
Total U.S.				
All Oranges	—	46.562	139.686	349.218
Grapefruit	—	16.112	48.338	120.918
Limes	—	.833	2.501	6.269
Lemons	—	2.500	7.495	18.741
Tangelos	—	.904	2.712	6.783
Tangerines	—	1.968	5.044	12.618
Temples	—	1.208	3.624	9.064
Total		70.087	209.400	523.611

volume) of citrus would be lost in the U.S. Percentage shares of the total loss would be 68.5% for oranges and 23.5% for grapefruit, for a total of 92.0%. Florida would suffer 85.7% of the total loss followed by Texas, Arizona, and California with 6.1, 4.7, and 3.5%, respectively. Loss estimates for rates as high as 75/37% are also given in Table 1.

The U.S. value of projected losses at 1975 farm prices for the 10/5 percent rate would be $70.1 million (Table 2). The value of oranges lost would be $46.6 million or 66.4% of the total. Grapefruit loss would be $16.1 million or 23.0% of the total. Florida would suffer the greatest loss at $60.0 million or 85.6% of the total. These potential loss estimates are at the farm level.

Estimated total U.S. retail loss at a 10.5% infestation rate for oranges is $159.9 million (Table 3). This total loss would be made up of $118.0, $15.5 and $26.4 million in frozen concentrate, fresh, and all other orange markets, respectively. Loss in the retail grapefruit market would be $58.8 million. The retail market loss would be allocated to the frozen concentrate, fresh and all other markets at levels of $7.1, $28.7, and $23.0 million respectively.

Production declines would be expected to cause an increase in prices. Consumers will pay more to purchase the commodity as it becomes less available. Price flexibilities relating the percentage change in product price to a percentage change in quantity make possible more accurate estimates of the total loss from a possible production decline.

Total losses using slightly higher prices resulting from production declines are also shown in Table 3. Farm level losses at the 10/5% loss rate were $46.6 million at 1975 prices of $2.71 per box. Losses for oranges with adjusted prices were $39.9 million. This estimate was obtained by first calculating total U.S. value of all orange production at $2.71 per box. Using the price flexibility of −.22, the change in price from a 10/5% decrease in production resulted in a new price of $2.76 per box. This adjusted price was then multiplied by production levels reflecting the 10/5% loss. The difference between total production at 1975 prices and production adjusted for a 10/5% loss at the adjusted price then made up the estimated loss of $39.9 million. Retail value losses were then estimated to reflect the slight price increase at lower production levels to arrive at a total retail loss of $137.1 million. This compares to a retail loss estimate without price adjustment of $159.9 million.

Loss estimate adjustments due to price increases were also estimated for grapefruit (Table 3). Losses at the farm level using 1975 prices were $16.1 million. Retail losses for grapefruit without price adjustments were estimated to be

$58.8 million. After slight price increases due to lower quantities produced, the estimated loss is revised downward to $36.6 million.

Retail level losses for lemons, limes, tangelos, tangerines, and 'Temples' are not given. Market data necessary to make comparable estimates to those for oranges and grapefruit are not available. Farm level loss for these commodities are given in Table 2.

International Considerations[2]

The previous analysis of physical crop loss provided estimates of farm losses for all affected citrus crops. In addition, estimates were also given for major citrus commodities at the U.S. retail levels, assuming the crop losses would be totally absorbed by the domestic market. However, citrus is exported by the U.S. and these exports may be affected because of fruit fly infestation. A lack of demand parameters, complete export statistics and market relationships make precise estimates of export market effects difficult. Consequently, limited estimates are presented using rather simplifying assumptions.

Exports of fresh oranges represent a relatively small proportion of the total production of oranges in the U.S. Average exports of fresh oranges for 1972-74 amounted to 9.6 million boxes annually (6). This represents 4.24% of the U.S. production during the same period. A ban of fresh U.S. oranges in the export market due to fruit fly infestation would increase the total supply on the domestic market by 4.24 percent. Using the price flexibility of −.22 (Table 3) for oranges at the farm level would mean that the 4.24% increase in domestic orange supply would result in a price decrease of approximately .93%. Total orange production revenue in the U.S. at 1975 farm level prices was $645.2 million with an average price per box of $2.71 (6). If the exported production were forced on the domestic market, price would have fallen to $2.68 per box in 1975 and total revenue would have been $638.7 million. The total revenue loss would be 6.5 million due to increased supply on the domestic market. Total domestic retail loss due to a 10/5% infestation rate was previously estimated to be $159.9 million (Table 3) compared to $46.6 million at the farm level. Retail loss was greater by a factor of 3.4336. Using this same factor in this case results in a loss estimate of $22.2 million at the retail level due to losing the fresh orange export market. These estimates assume that previously exported oranges would enter the domestic U.S. markets in the same product form proportions as existing domestic supplies.

A complete ban and full realization of a potential $22.2 million loss in orange exports probably would not occur because treatment programs would be initiated. Based on fumigation treatment costs for grapefruit in Florida the cost for treating the 9.6 million boxes exported would be $1.123 million.[3] This estimate is a maximum treatment cost because not all countries receiving U.S. orange exports would quarantine for medfly. Given the value of fresh exports, treatment costs would represent 4% of the total export value. While this percentage may appear relatively low and possibly not significant on a cost basis, a 4% increase in price could cut into the competitive position of the U.S. fresh orange exports, resulting in a reduction in share of the world market.

Table 3. Estimated U.S. losses in oranges and grapefruit sales with a 10/5 percent infestation rate.

Price Conditions	Farm Value	Retail Value: Frozen Concentrate	Retail Value: Fresh	Retail Value: All Others	Retail Value: Total
	millions of dollars				
			Oranges		
1975 Prices	46.56[z]	117.96[x]	15.52[w]	26.39[v]	159.87
Price adjusted with flexibilities. U.S. market assumed	39.92[y]	101.13[x]	13.31[w]	22.62[v]	137.06
			Grapefruit		
1975 Prices	16.11[z]	7.11[t]	28.72[s]	22.98[r]	58.81
Price adjusted with flexibilities. U.S. market assumed	14.13[u]	2.83[q]	17.99[p]	15.79[o]	36.61

[z]From Table 2.
[y]Given price flexibility equal to −.22 and 1975 price of $2.71 per box.
[x]Given 76% allocated to frozen concentrate market and farm value representing 30 percent of retail value (6).
[w]Given 7% allocated to fresh market and farm value representing 21 percent of retail value (6).
[v]Given 17% allocated to all others and farm value representing 30 percent of retail value (6).
[u]Given price flexibility equal to −.14 and 1975 price of $2.58 per box.
[t]Given 19% allocated to frozen concentrate.
[s]Given 41% allocated to fresh market and farm value representing 23 percent of retail value.
[r]Given 41% allocated to all other uses and a 1975 equivalent price of $0.80 per box.
[q]Given price flexibility equal to −.67.
[p]Given price flexibility equal to −.42.
[o]Given price flexibility equal to −.42.

Exports of grapefruit during 1972-74 averaged 6.2 million boxes annually. Most grapefruit exports are fresh fruit, but single strength juices, concentrates, blended juices and some sections are also exported. Fresh grapefruit exports amounted to 4.7 million boxes or 76.4% of total grapefruit exports during this period. Fresh grapefruit exports during 1972-74 were 7.35% of the annual U.S. grapefruit production of 64.2 million boxes. Elimination of fresh grapefruit exports would increase total supply on the domestic market by 7.4% and result in a price decrease of 1.029% based on the grapefruit price flexibility of −.14 (Table 3). Average 1975 grapefruit price was $2.58 per box with a total revenue of $158.3 mililon at the farm level. If the fresh exports would have remained in the domestic market, prices would have dropped to $2.55, and total revenue would have been $156.7 million. This would have represented a loss of $1.6 million at the farm level. Using the ration of total retail value loss to farm value loss at 1975 prices, the 10/5% infestation rate (Table 3) would result in an estimated retail loss of $4.1 million due to adding the normally fresh exports to the domestic market. Previously exported fruit were assumed to enter the domestic supply in the same product form composition that currently exists in the domestic market.

U.S. grapefruit exports are presently fumigated, and the cost, based on the 4.7 million box annual export average for the 1972-74 period, is $556,579. This present cost represents 4.5% of the fresh export value. Additional treat-

[2]Some countries may prohibit susceptible host fruits and others may require treatment as a basis for entry. A ban is unlikely because treatment would undoubtedly be initiated. This analysis begins by assuming that no export would be possible without treatment and the estimates then provide a basis for a feasibility comparison with treatment costs.

[3]9.6 million boxes is 864 million pounds or 22,737 truckloads at 38,000 pounds per truck and $1,136,842 for treatment costs where total costs per truck including facilities, labor and materials are $50 per truck (5).

ment costs for medfly may be detrimental to the U.S. competitive position.

Other citrus fruit exported are lemons, limes, and tangerines. Total annual exports based on the 1972-74 average were 5.39, .07, and .28 million boxes annually for lemons, limes, and tangerines, respectively (6). These export levels amount to 23.3, 4.7, and 5.6% of total U.S. production for these fruits. Projected losses of lemons, limes, and tangerines at the 10/5% infestation rate were 709, 108, and 420 thousand boxes, respectively. These losses are greater than average exports for limes and tangerines, and amount to 13.2% of lemon exports. Adequate data are not available to estimate losses that might occur from an embargo on exports of fresh lemons, limes, and tangerines.

Additional Research Considerations

A possible embargo on fresh fruit exports of citrus could take several forms if an infestation did occur. Since citrus is produced in several states, an embargo might be placed on certain states or infected areas. Another possibility would be the banning of all U.S. exports of certain fruits, although only small areas and a small percentage of total production might be infested.

Estimating the effect of a fresh fruit export embargo on a certain state or area would require demand equations by state or area for the fruit. These equations are not available for some fruit which would make a total evaluation of this embargo form impossible. Also lacking for this type of analysis are interstate movement data on fruit since export data by state are not available in adequate detail. Because of these shortcomings, the approach used to evaluate the effect of fresh fruit embargos was to analyze the effects of a total embargo on the domestic market in the form of total revenue losses. This assumes that exported fresh fruit remained in the domestic market and caused price reductions. Seasonal prices and production patterns were not considered.

Summary and Conclusions

The potential costs of a fruit fly infestation of the U.S. could be substantial for the citrus industry. Or in other words, the benefits associated with maintaining the U.S. free from the various fruit fly species are extensive when viewed from the perspective of potential losses in both domestic and export citrus sales. The degree of loss depends on the amount of infestation damage realized. The loss was shown to be substantial at a 10% loss rate in this paper.

Further research is warranted to determine the economic feasibility of pest management required for potential fruit fly infestations. This research specified economic losses to be expected at varied levels of crop damage. Precise estimates of the degree of infestation that might occur and the costs associated with suppression and/or eradication of the pest now need to be investigated. The question of whether the U.S. should now be heavily involved in helping contain the fruit fly in Central America and Mexico appears to be of sufficient importance to justify further research. An answer to this question requires more careful thought and analysis by both pest management and agricultural economics researchers.

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MARKETING ALTERNATIVES FOR THE FLORIDA CITRUS GROWER[1]

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Abstract. **The Florida citrus grower has 2 basic methods of marketing his fruit—either he can choose to make an outright sale of the fruit where he relinquishes all interest or else retain ownership through the packing or processing functions and receive a payment based upon the selling price *of the final product.* This paper will focus on the relative importance of specific marketing alternatives and discuss the advantages and disadvantages of each option.**

The Florida citrus grower has a number of marketing options he can choose for both fresh and processed fruit. The basic decision, however, is to choose between giving up the ownership of the fruit while it is in its raw form or retaining ownership through the packing or processing of the fruit. In the first case, the grower makes an outright sale where he relinquishes all interest in the fruit and its products. This is referred to as priced fruit and comes from the cash market either as spot sales (price at delivery) or forward priced as shown in a schematic diagram (Fig. 1). In the second case, the grower retains interest in the fruit and its resulting products. The payment will then depend upon the sale of the final product and the expenses involved. This is referred to as deferred priced or non-priced fruit and is primarily participation plan or cooperative fruit. Each of the options shown in Fig. 1 has its advantages and disadvantages. They will be discussed in turn.

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