June 1978 election.

Further evidence that property tax collections were not rising disproportionately is shown in total property taxes as a share of total California personal income. They actually declined, although at a relatively insignificant rate, between fiscal years 1968 and 1975 as well as between 1975 and 1978.

The story on the expenditure side is similar. If local government spending was getting out of control, it was at a very slow pace. Total local government expenditures grew 11 percent between fiscal years 1968 and 1975, increasing to 12.2 percent in the three years preceding the election. However, after adjustments for inflation and population growth, these increases appear much smaller. Real total local government expenditures per California resident rose at a 1.9 percent annual rate between fiscal years 1968 and 1975, and only 2.9 percent between fiscal years 1975 and 1978. If households are used instead of population to measure the "units served" by local governments, the numbers are even smaller.

Real expenditures per California resident by all of the county governments grew at a slower pace in the three years preceding the June 1978 election than in the earlier period. Real expenditures per pupil (as measured by average daily attendance) by all of the schools grew only slightly faster in the later period. These conclusions are further supported by regression tests, which show that the differences between the two time periods in the growth of real local government expenditures per California resident were statistically insignificant.

Between fiscal years 1968 and 1975, there was little change in the pattern of property taxes collected on the different types of property (table 2). Roughly one-third of property taxes were collected on single family dwellings, one-sixth on other residences, and between 40 and 45 percent on commercial and industrial property. By fiscal year 1978, however, the pattern had changed dramatically. In just three years, the share of property taxes collected on single-family dwellings increased by almost 9 percentage points, while those collected on nonresidential property declined by almost 7 percentage points.

Two simple calculations confirm that homeowners' property taxes had risen substantially during the three years preceding the June 1978 election, but they do not support the view that increases in local government expendures were the main reason for these increases. First, while total property taxes rose by 11.8 percent between fiscal years 1975 and 1978, those collected on all single-family dwellings rose by 74 percent and those per single-family dwelling rose by 62.9 percent (calculated by multiplying the shares of property taxes according to property type by the total property taxes collected). Second, had real local government expenditures per California resident been constant between fiscal years 1975 and 1978, property taxes collected would still have risen 59.5 percent for all single-family dwellings and 49.4 percent for each single-family dwelling (calculated by holding constant actual total property taxes as a share of actual total government expenditures; this assumes the actual rate of inflation for the period 1975 to 1978).

Thus, increases in local government expenditures explain less than one-fourth of the increases in actual property taxes collected from homeowners. The bulk of the increase before the June 1978 election was caused by a shift in the property tax burden from commercial and industrial property to single-family dwellings.

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TABLE 2. Distribution of property taxes collected by type of property, selected fiscal years

Type of property	Taxes collected, fiscal year: 1968	1975	1978
	%	%	%
Single family dwellings	35.0	33.9	42.2
Other residences	13.4	13.2	12.4
Nonresidential property*	41.7	45.7	38.9
State assessed †	9.9	6.8	6.6

Sources: Single-family dwellings: California State Board of Equalization estimates published in William Oakland, "Proposition 13, Genesis and Consequences," Federal Reserve Bank of San Francisco, *Economic Review*, Winter 1979. Other types of property: estimates based on distribution of net assessed value published by Oakland.
Note: Numbers may not add because of rounding.
*Includes commercial and industrial property.
† Includes personal property of utilities.

There is enough money involved to justify detailed evaluation

Navel orangeworm, considered the most important insect pest of almonds in California, caused annual damages estimated at $35 million during 1978-80. Research at the University of California shows that orchard sanitation (removal and destruction of mummy nuts), early harvest (just at or slightly after 100 percent hullsplit), and the use of an occasional in-season spray will reduce damage from navel orangeworm (NOW), *Amyelois transitella* (Walker), by as much as 70 percent.

Despite this evidence, growers usually like to see the economic feasibility demonstrated before they adopt new practices. They want to know: (1) how much the recommended practices will increase costs; (2) how much benefits can be expected to increase; (3) if unit costs are influenced by the size of the operation; (4) how benefits and costs behave for varying levels of pest damage; and (5) how price received for the crop affects the feasibility of the recommended practices.

One way to provide such information is through the use of partial enterprise budgeting, which allows one to relate changes in revenue and costs to changes in management practices and to impute the net benefits to the particular practices as they are added or removed from the budget.

The model production unit

For this analysis, a hypothetical 320-acre almond operation was established to identify the scale of operation and to provide some basis for judging the reasonability of results. Per-acre partial budgets were then prepared to reflect the results of using various insect pest management practices to deal with NOW damage. These budgets can be adapted to any size of operation by adjusting overhead costs.

The model assumes that all almond acreage is bearing, planted at 75 trees per acre, with 214 acres in the Nonpareil

Economic analysis of navel orangeworm control in almonds

Joseph C. Headley

variety and 53 acres each in Merced and Mission.

All trees are 12 to 15 feet in height. (The budgets do not apply to large trees that tend to be found in northern California.)

Total meat yields at maximum nut removal are 1,500 pounds per acre for Nonpareil and Mission and 1,200 pounds per acre for Merced.

Harvesting equipment consists of two self-propelled shakers, one self-propelled pickup unit, two rakes, and six carts.

Shaker performance at 1½ hours per acre will allow the Nonpareil harvest to take place in 13 days, each 12 hours in length, using two shakers.

New cost of harvest machinery is: self-propelled shakers, $38,000 each; self-propelled pickup machine, $15,000; rakes, $7,000 each; and carts $667 each.

Estimated useful life of a new shaker is 3,000 hours with a salvage value of $10,000.

Harvest machinery depreciation is strictly proportional to use.

Wage rates are $6.05 per hour including social security and benefits. Employees are paid 1.5 times the wage rate for time over 60 hours per week. During harvest, the work week is 72 hours.

The model assumes that a May spray of Guthion, properly timed, or a spray of Imidan at initiation of hullsplit will reduce NOW damage by 50 percent. A foliage spray for web-spinning mites in June or July is required.

Sanitation through winter cleanup will reduce NOW damage 50 percent, substituting for a May spray and reducing probable need for mite treatments by one-half.

Early harvest at about 100 percent hullsplit will reduce NOW damage by 40 percent.

A combination of sanitation and early harvest will reduce NOW damage by 70 percent.

All acres in the orchard are treated for control of twig borer, *Anarsia lineatella* Zeller, with a dormant spray consisting of petroleum oil plus an organophosphate. This treatment also controls European red mite, brown mite, and San Jose scale.

All acres are at least 0.25 mile from external sources of NOW infestation.

Irrigation and other management practices are independent of insect pest management practices.

Insect management program

Five possible approaches to NOW management were analyzed through the use of the partial enterprise budgets:

I. Benchmark. The only pest management is a dormant spray for peach twig borer and mite eggs, the usual disease control, and a separate mite spray in half of the years, on average.

II. May spray. A May spray for NOW control and separate mite spray.

III. Sanitation. Winter cleanup of mummies by hand poling with no poling after shakers. No sprays for NOW. An in-season mite spray in half of the seasons on the average.

IV. Sanitation with early harvest. Winter cleanup of mummies by hand poling and early harvest of Nonpareils and Merceds with no poling after shakers. Assume Nonpareil yield reduced 4 percent due to early harvest. An in-season mite spray half of the seasons on the average.

V. Sanitation with early harvest and poling after shakers. Winter cleanup of mummies by hand poling, early harvest of Nonpareils and Merceds, and poling after shakers. Assume that 4 percent yield of Nonpareils lost in alternative IV is recovered. An in-season mite spray in half of the seasons on the average.

In the programs, sanitation is substituted for a May insecticide treatment and half of the miticide treatments. University of California research shows that if the mummy count is only two or three per tree by February, a May spray will probably not be needed.

Where early harvest is included, it was assumed that the removal of nuts just as 100 percent hullsplit occurs will result in a loss of 4 percent in nut removal for Nonpareils. Hand poling following the shaker can recover these nuts, but at a cost. Therefore, the importance of monitoring the NOW population as hullsplit approaches becomes evident. If it appears that the NOW infestation is not developing very rapidly at 95 to 100 percent hullsplit (0.25 percent or less per day), then early harvest and the poling after the shaker might not be necessary.

The per-acre costs of the various practices were developed as follows:

May spray for NOW control — $35.10.

Mite control — $50.50.

Sanitation (winter mummy removal by poling) — $34.00.

Early harvest (costs of adding one shaker, one pickup, one rake, and three carts) — $15.40.

Early harvest with hand poling after shaking — $44.40.

The costs for sanitation and early harvest are especially scaled for the 320-acre operation, because the fixed machine costs are spread over the 320 acres.

Budgeting results

Using the assumptions, the various pest management programs, and the costs of the selected insect pest management practices, partial budgets were computed for each approach under conditions of varying prices and varying levels of NOW infestation in an untreated orchard. Effects of NOW-related insect pest management and mite control practices on net revenues were computed for meat prices of $0.70, $1.00, $1.25 and $1.50 per pound and for untreated

Mummy almonds remaining on trees after harvest are hosts for navel orangeworm. Removal and destruction of mummy nuts and other control practices can reduce NOW damage by as much as 70 percent.

damage levels of 20, 10, and 5 percent (see table).

In addition to showing the effects of various pest management practices, the figures in the table demonstrate the possible financial losses resulting from rejects due to insect damage from whatever source. They also demonstrate what growers might be able to spend per acre to reduce these losses. For instance, the difference in gross revenue per acre for the model operation at 20 percent and 5 percent rejects is $253, even with good meat priced at $1.00 per pound ($1341 – $1088).

The relative financial standing of the different pest managment practices is best seen when the benchmark revenue is subtracted from net revenue for each alternative. When the potential NOW damage is 20 percent, sanitation with early harvest and poling after the shaker (alternative V) gives the best financial results for all meat prices between $1.00 and $1.50 per pound. For meat prices of $0.70 per pound, sanitation with early harvest (alternative IV) is best.

When the potential damage is 10 percent, the best financial results are obtained by using only sanitation (alternative III) at prices of $0.70 and $1.00 per pound and sanitation with early harvest plus poling after the shaker (alternative V) at meat prices of $1.25 and $1.50 per pound. However, when potential damage drops to 5 percent, alternative III (sanitation through winter cleanup) is clearly superior to the others.

If absolute financial results are considered, the May spray (alternative II) does not generate financial benefits to cover the added cost at prices in the $0.70 to $1.00 range when the potential damage is as low as 5 percent. In addition, given 5 percent potential damage, sanitation with early harvest (IV) does not cover the associated added costs over the entire price range. This latter result occurs, because the value of the 4 percent Nonpareil nut loss due to early harvest adds more to the cost than it contributes in reducing damage to the rest of the crop.

This analysis demonstrates the interaction of production management and economic variables in the management of pests. The table shows that the financial results of different pest management practices applied to navel orangeworm in almonds depend on the grower's price expectations for the crop, the knowledge or perception of the damage threat from the insect, and the efficacy and cost of the management practice.

Budgeting results show that the same pest management practice is not likely to be optimal for both a heavily infested and a lightly infested orchard. Evidence that early harvest of Nonpareil entails a cost in reduced nut yield, unless an additional cost to harvest the remaining nuts is incurred, suggest that the size and rate of growth of the NOW infestation at hullsplit must be carefully evaluated before this practice is used. Therefore, it appears that early harvest, defined as at or about 100 percent hullsplit, should not be a general recommendation.

A major conclusion of this analysis is that, given the efficacy co-efficients used in budgets, cultural practices such as cleanup of mummies in winter and early harvest, or some combination of these practices, are profitable pest management tools in navel orangeworm control in almonds.

Conclusions

This study demonstrates that there are enough dollars involved in navel orangeworm damage to justify considerable analysis. Each grower will need to analyze his own operation for each season to choose the best control approach. For that purpose, a worksheet has been developed (see model worksheet), which is also adaptable to other pest management practices. (Copies of the worksheet for grower use can be obtained from the Almond Board of California, Attention Dale Morrison, Division of Research, P.O. Box 15920, Sacramento, CA 95813; telephone: [916] 929-6506.)

Based on this study, winter cleanup (sanitation) may be a profitable substitute for a May "in-season" spray. Winter cleanup also seems the best alternative strategy in terms of financial reward when potential damage is low.

If early harvest and sanitation are combined with hand poling after the shaker, the poling tends to be more profitable as potential damage levels increase and as nutmeat prices increase. If poling after the shaker to salvage nuts at harvest will leave low enough mummy counts to substitute for winter cleanup, then the practice will probably be profitable over a wide range of meat prices and levels of potential damage.

As the level of navel orangeworm infestation is reduced, winter cleanup improves in profitability relative to a program that also includes early harvest. This advantage is due to the yield loss that can result from early harvest.

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The author gratefully acknowledges the assistance of Robert Curtis of the Almond Board of California, Stephen Heinrichs, of the California Almond Growers Exchange, Clyde Harter of Tenneco West, and growers Thomas Almberg, Clarence Downing, and Del Gruebele, as well as the technical advice of Wilbur Reil and John Labavitch of the Department of Pomology. Credit is due to Dale Morrison of the Almond Board of California and to Martin Barnes of the University of California at Riverside for their counsel and encouragement.

Net revenues per acre under selected navel orangeworm control alternatives, almond prices, and untreated damage levels, California

	Net revenues at following prices and untreated damage levels:											
	$0.70/lb			$1.00/lb			$1.25/lb			$1.50/lb		
Alternative*	20%	10%	5%	20%	10%	5%	20%	10%	5%	20%	10%	5%
I. Benchmark	$729	$872	$929	$1,088	$1,267	$1,341	$1,387	$1,596	$1,685	$1,686	$1,924	$2,030
II. May spray	812	868	916	1,200	1,281	1,338	1,529	1,625	1,689	1,864	1,969	2,041
(Added revenue/acre)	(83)	(−4)	(−13)	(113)	(14)	(−4)	(143)	(29)	(4)	(178)	(44)	(11)
III. Sanitation	838	895	942	1,227	1,307	1,364	1,556	1,651	1,715	1,981	1,995	2,067
(Added revenue/acre)	(109)	(23)	(14)	(139)	(41)	(23)	(169)	(56)	(30)	(205)	(71)	(38)
IV. Sanitation with early harvest	842	887	924	1,240	1,295	1,337	1,571	1,635	1,682	1,903	1,975	2,026
(Added revenue/acre)	(113)	(15)	(−5)	(152)	(28)	(−4)	(185)	(39)	(−3)	(217)	(51)	(−3)
V. Sanitation with early harvest plus poling after shakers	839	883	924	1,248	1,305	1,349	1,589	1,655	1,703	1,929	2,004	2,058
(Added revenue/acre)	(110)	(11)	(−5)	(160)	(38)	(7)	(202)	(59)	(18)	(243)	(80)	(29)

* Added revenue/acre: Values in parentheses represent the difference between the net revenue of NOW pest management costs for each alternative (II through V) minus the same value for alternative I, the benchmark.

Model worksheet for budgeting added costs and returns of almond insect management practices

Steps	Example
1. Expected delivered meat yield and reject level for Nonpareil: #/acre (%) Pollinator 1: #/acre (%) Pollinator 2: #/acre (%)	1500 (20) 1200 (20) 1500 (1)
2. Penalty or premium for reject level on Nonpareil, California, Neplus, Drake, and IXL (obtain from processor)	− 7¢
3. Expected good-meat price/pound	$1.50
4. Gross revenue/acre (a) Variety yield × reject level	(a) 1500 × .20 = 300 1200 × .20 = 240 1500 × .01 = 15
(b) Subtract reject pounds in (a) from variety yield to give good-meat yield	(b) 1500 − 300 = 1200 1200 − 240 = 960 1500 − 15 = 1485
(c) Multiply good meet yield by expected price for each variety	(c) 1200 × 1.50 = 1800 960 × 1.50 = 1440 1485 × 1.50 = 2227.50
(d) Add or subtract premium or penalty for each variety	(d) 1800 − 105 = 1695.00 1440 − 84 = 1356.00 2227.50 − 0 = 2227.50
(e) Multiply results for each variety in (d) by fraction of orchard represented by each variety	(e) 1695 × .666 = 1128.87 1356 × .1625 = 220.35 2227.5 × .1625 = 361.96
(f) Add results in (e) for weighted average gross revenue/acre	(f) 1128.87 + 220.35 + 361.96 = 1711.18
5. Added navel orangeworm control practice	Winter cleanup of mummies
6. Expected reduction in rejects	50%
7. Reject level after control practice	Nonpareil 10% Pollinator 1 10% Pollinator 2 1%
8. Gross revenue/acre after added insect control practice (repeat step 4) (a) Variety yield × reject level	(a) 1500 × .10 = 150 1200 × .10 = 120 1500 × .01 = 15
(b) Subtract results in (a) from variety yield to give good-meat yield	(b) 1500 − 150 = 1350 1200 − 120 = 1080 1500 − 15 = 1485
(c) Multiply good-meat yields by expected price	(c) 1350 × 1.50 = 2025 1080 × 1.50 = 1620 1485 × 1.50 = 2227.50
(d) Add or subtract premium or penalty for each variety	(d) (2¢/pound) 2025 − 30 = 1995 1620 − 24 = 1596 2227.50 − 0 = 2227.50
(e) Multiply results of each variety in (d) by fraction of orchard represented by each variety	(e) 1995 × .666 = 1328.67 1596 × .1625 = 259.35 2227.50 × .1625 = 361.96
(f) Add results in (e) to give weighted average gross revenue/acre	(f) 1328.67 + 259.35 + 361.96 = 1949.98
9. Subtract 4(f) from 8(f) to give revenue change due to new practice	1949.98 − 1711.18 = 238.80
10. Added cost of practice	$34.00
11. Net benefits (losses) from added practice (step 9 minus step 10)	$204.80