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Reducing Citrus Revenue Losses from Frost Damage: Wind Machines and Crop Insurance

Raymond Venner
Steven C. Blank

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REDUCING CITRUS REVENUE LOSSES FROM FROST DAMAGE: WIND MACHINES AND CROP INSURANCE

the authors are:

Raymond Venner
Graduate Student
Agricultural Economics Department
University of California, Davis

Steven C. Blank
Extension Economist
Agricultural Economics Department
University of California, Davis

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INTRODUCTION

Yield losses due to adverse weather conditions influence the level and variability of revenues and profits of agricultural products. Each grower's optimal response to potential adverse conditions depends on their assessments of expected yield losses with and without alternative protection measures, as well as their own attitudes toward different risks. In general, strategies include using an input to reduce the expected level of yield losses and using crop insurance to protect against revenue losses should yield losses occur. In the case of citrus grown in California's San Joaquin Valley, the primary source of weather risk comes from frost damage. Historically, most citrus growers have used inputs such as wind machines to reduce frost damage, although some growers have purchased crop insurance as well.

This report is a case study designed to provide growers with information and analyses to improve their ability to choose among their alternative methods of reducing revenue losses from frost damage. Two primary responses of San Joaquin Valley citrus growers to cold temperatures are evaluated: wind machines and frost insurance. Wind machines protect oranges from freezing by warming orchards. Frost insurance protects grower revenues should their oranges freeze. A similar analysis may be carried out for other frost susceptible crops such as wine grapes or apples.

Objectives of the Study

Based on the single criteria, "maximizing wealth" (described later), this study seeks to answer the following questions. Should San Joaquin Valley citrus growers:

1. Continue to operate existing wind machines (diesel, electric, propane)?
2. Purchase new wind machines for installation on new acreage? If yes, then consider the optimal tree age at which to install the wind machine.
3. Replace existing electric with new wind machines (diesel, propane)?
4. Insure the fruit?
   With or without wind machines?
   With federal or private insurance policies?

In addition to answering these questions, this study develops and illustrates methods which citrus managers may apply in similar analyses. The methods are sophisticated enough to capture the important real world variables, yet simple enough to be applied at little cost.

Overview of Analysis Methods

A cost-benefit analysis is conducted for both wind machines and frost insurance. Wind machine benefits and costs are estimated for a 15 year period. Wind machines last longer, but this is a typical machine life used for tax reporting and assigning a salvage value to the wind machine at year 15 is equivalent to analyzing the feasibility for the entire lifetime of a wind machine. With competitive markets, any profits after year 15 are captured in the salvage value of the wind machine at year 15.

To analyze a long term investment such as buying a wind machine, an adjustment is needed to compare current with future profits, as one dollar next year is worth less than one dollar today. "Wealth" is such a measure because it discounts future profits. Wealth is the present value of all current and future profits. In this study, the discount rate used is a typical grower's borrowing rate.[1] Wind machines raise wealth if the sum of additional revenues plus the salvage value exceeds costs. All values are converted to an after-tax basis and are discounted to present value terms. By this criteria, a wind machine is a "profitable" investment if it raises wealth.

While wind machines are long term investments, frost insurance is an annual decision. To compare wind machines with insurance, the change in wealth due to wind machines must be converted to present value dollars per acre. This is accomplished by expressing change in wealth as an equivalent annual annuity. This value represents the average of discounted cash flows per year.

Year one of this analysis is the 1993-94 winter season. Prices are projected 1993-94 prices based on historical levels. Navel and Valencia oranges are evaluated separately. The value of wind machines are evaluated with and without the application of water for frost protection.

The benefit of wind machines equals the additional net after-tax revenues of citrus (over the life of the machine with future years' values discounted to current dollars). This benefit equals the

1 For example, for an annual interest rate of 8%, the cost of borrowing $1,000 for one year is $80.

quantity plus the quality (grade) effect. The value of the quantity effect equals the additional fresh yield times the fresh on-tree price.

To judge the value of crop insurance, this study simulates the premiums and indemnities that would have occurred had growers insured over past years. This leads to an estimate of the real "cost" of crop insurance. Whether the cost is justified by the reduced risk from insuring depends upon the risk attitude of the individual making the assessment; it will vary by person. Thus, this report provides guidelines for interpreting the results for crop insurance, but cannot offer a definitive recommendation for action.

San Joaquin Valley Citrus and Current Frost Protection Strategies

California's San Joaquin Valley is a prominent supplier of oranges throughout the US and the world. There are 141,000 acres of oranges with an annual farm value of $500 million and an annual wholesale value over $1 billion. The San Joaquin Valley is colder than other citrus producing areas, so citrus growers specialize in oranges.[2] Oranges are California's tenth most valuable agricultural commodity. Approximately three-fourths of California's oranges are destined to the fresh market. The remainder are processed into juice and other products. The juice market is a surplus outlet for lower quality oranges and generally offers prices which are not profitable for growers.

The San Joaquin Valley citrus industry has developed on perseverance, superior technology, fertile soil, available irrigation water, cool nights, and warm sunny days. Competition primarily from Florida, Texas, and Brazil causes California firms and cooperatives to aggressively promote their citrus. Growers have responded to input prices rising faster than citrus prices by innovating and creating efficient equipment such as that for mechanical separation and packing of fruit. In response to stricter pesticide regulations, the San Joaquin Valley citrus industry has developed integrated pest management practices such as raising legumes and other cover crops, and planting resistant rootstocks. As irrigation water became less certain and more expensive, many citrus growers replaced surface irrigation with microsprinklers so that less moisture is lost to evaporation. Another challenge is potential frost damage during cold winter nights. Frozen oranges either are not picked or are marketed as juice; neither option is profitable for growers. Therefore, growers seek to reduce frost damage.

A. Wind Machines

Wind machines are a primary frost protection tool today. About 120,000 wind machines are installed on San Joaquin Valley citrus orchards (Synder), covering 85% of the bearing acreage. Most of the acreage not protected by wind machines is Navel orchards which are harvested before Christmas, prior to the coldest periods.

Wind machines are large fans on towers about 35 feet high. A principle underlying the value of wind machines is that during the day, the sun warms the soil and plants and at night, this lighter warm air rises, leaving a colder mass of air near the earth's surface. This higher, warmer air is called a temperature inversion. A typical inversion in the San Joaquin Valley is 5°F warmer than air at ground level. Wind machines blow the higher air down onto the orchards, mixing the warmer air with the colder air at the orchard level. The stronger the inversion, the more effective is a wind machine. Normally, one machine can cover 10 acres.

Growers typically install wind machines when trees are 7 to 8 years old, the age at which fruit is deemed to be worth enough to justify the expense. Wind machines only marginally protect young trees. During the severe 1990 freeze, growers reported that wind machines did not protect young trees.

Many wind machines are used over 30 years. Wind machine technology apparently has not advanced much in recent years, as old wind machines in working order are generally not replaced with new models. Rather than buy new machines, growers often repair existing ones. Installing a new motor costs less than one-third the price of a new machine. Repair costs depend largely on the age of a machine and the time operated.

Diesel, electricity, and propane all power wind machines. According to wind machine distributors, a wind machine with more horsepower offers more frost protection. New wind machines typically are 125 horsepower. Electric machines were once the least expensive to operate, but standby (fixed) electricity costs have increased sharply over the past five years. Southern California Edison and Pacific Gas & Electric are the two primary suppliers of electricity for California's electric wind machines. Existing electric wind machines range from 50 to 125 horsepower, but 75 to 100 hp are the most common.

Growers have tried to evaluate the effectiveness of wind machines, but have yet to establish clear

2 Citrus includes oranges, lemons, grapefruit, tangerines, and related varieties.

results. Often, fruit protected by wind machines is just as damaged as fruit not protected, but it is difficult to draw conclusions since the unprotected orchard may be harvested sooner or may be in a warmer or windier area. Wind has the same effect as wind machines; it mixes the higher warm air with the colder air at orchard level. High winds eliminate the temperature inversion, thus rendering wind machines ineffective.

B. Pre-planting considerations

A crucial frost protection feature is a southern exposure. Frost damage is also reduced by an abundant and reliable source of irrigation water, and a soil with good water drainage (Sentinel Frost Protection).

Frost damage is also influenced by the citrus rootstock used. A rootstock is chosen for its effect on fruit quality and yield and for its resistance to environmental conditions such as soil compactness, salinity, water availability, heat, and cold tolerance. Some citrus rootstocks lead to less frost damage of trees and fruits. The Citrus Repository in Riverside has rated the cold tolerance of many citrus rootstocks.

Orchards suffer less frost damage if they are planted parallel to the direction of night winds. If an orchard has windbreaks, opening the bottom 20 to 30 feet of the break will allow good ground level air movement through the break while still deflecting unwanted higher level wind (Sentinel Frost Protection).

C. Water as Frost Protection

Applying water significantly raises orchard temperatures. Water releases heat as it cools. Many growers moisten the soil before frosts to relieve stress and raise the cold tolerance of citrus trees. During cold nights, wetter soils retain more heat and maintain higher orchard temperatures. Young orange trees have rarely died when a sprinkler system was utilized. Growers reported that water saved some trees during the 1990-91 freeze. Where water was not applied, relatively more trees died. However, the water supply of most growers is limited. Sprinklers should be run during the entire cold period, but water may not be available for all orchards. To the extent possible, growers will continue to apply water for frost protection. The irrigation equipment is already installed and the trees often need water anyway.

D. Cover Crops.

Cover crops add organic material to the soil and provide a habitat for some beneficial insects. A negative consequence, however, is that cover crops form a barrier between the sun and the ground. The sun is less able to warm the soil, so nightly temperatures are about 1°F colder for orchards with thick cover crops. As a result, some growers plant cover crops in mid- to late-winter so there is little or no foliage during the coldest periods.

E. Helicopters

The principle of frost protection using helicopters is the same as with wind machines; they blow the higher, warmer air down into the orchard. Helicopters cover 160 to 300 acres each at a cost that is approximately the same as wind machines. However, few helicopters are available and several flying in the same area on a foggy night is hazardous.

F. Frost Insurance

Frost insurance helps maintain grower incomes during severe freezes. The federal government insures about 1.5% of San Joaquin Valley citrus against frost damage, and private firms insure about 15%.[3] Both types of insurance work in the same way: growers are partially compensated in cash for fruit which cannot be sold in the fresh market due to frost damage. The amount of compensation received as insurance indemnities depends on the specifics of the policy held by a grower. One problem is that frost damage is difficult to identify. Frost damaged oranges often appear identical to undamaged fruit. Also, there is no pattern to the damage within the same tree or between neighboring trees. Oranges at the bottom of one tree may be frozen, for another tree the damage could occur at its top or on one side. Since it is difficult to determine which oranges are damaged, all may be shipped for processing if the damage rate for a sample from an orchard is high, say 40%. After frosts, the high volume of fruit going to processing plants depresses the price sometimes to levels below the cost of shipping the oranges. Growers worry that an insurance company in such a case would claim that the loss was only 40%, whereas the financial loss could be 100%.

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3 FCIC data and insurance representatives.

WIND MACHINE RESULTS

This section presents the results of the analysis for wind machines; later sections explain the methods used to obtain these findings. Three types of wind machines are evaluated: diesel, electric, and propane. Similar frost protection is offered by 125 hp diesel, 125 hp propane, and 100 hp electric machines, which are the engine sizes considered. Both new and existing wind machines are evaluated.

Breakeven Frost Protection Levels

A wind machine's cost-effectiveness varies with average low temperatures during winter nights, and temperatures vary across the San Joaquin Valley. For example, Lindcove is generally warmer than Lindsay and Lamont. Within the citrus belt, wind machines offer more frost protection and are more profitable for orchards in locations which are colder, less windy, and do not have water applied as frost protection.

A breakeven frost protection level is the point at which wind machine benefits equal their costs. A wind machine is profitable if it offers greater protection than the breakeven level. A wind machine's protection is measured as the amount of oranges which would have been damaged but instead are sold to the fresh market due to the wind machine's effects. Two breakeven values are reported in Table 1 for each type of wind machine. The first breakeven value is expressed as the percent that a grower's fresh yield per acre must be increased by using the wind machine. The second breakeven value expresses the same information in terms of the additional cartons of oranges which must be sold in the fresh market, rather than in the juice market. Citrus growers can compare their actual frost protection from wind machines for each orchard to the breakeven values in Table 1. If the actual frost protection is greater than the breakeven value, then the wind machine is profitable.

For example, new 125 hp propane wind machines are profitable for an average orchard if the machines increase fresh Navel orange yields by 8.1% and Valencia yields by 9.7%. This is equivalent to stating that new propane wind machines pay for themselves if they lead to additional fresh market sales of 45 cartons per acre per year for Navel and 46 cartons for Valencia oranges.[4]

Table 1. Breakeven Frost Protection Levels for SJV Wind Machines

	Navel		Valencia	
	Percent of Fresh Yield	Additional Cartons of Fresh Yield	Percent of Fresh Yield	Additional Cartons of Fresh Yield
New Diesel	8.0	44	9.5	45
New Propane	8.1	45	9.7	46
Existing Electric (PG&E)	8.4	46	10.0	47
Existing Electric (SCE)	10.9	60	13.0	62
Existing Diesel	5.1	28	6.2	29
Existing Propane	6.4	35	7.8	37

Diesel and propane wind machines are 125 hp and electric machines are 100 hp. The existing machines are currently operated and are 20 years old. One carton equals 37.5 lbs. net. These values take into account a 2% quality premium. Wind machines are profitable for frost protection levels greater than these values.

4 Navel: 8.1% times 550 fresh yield=45; Valencia: 9.7%* 475 fresh yield=46. Both include a wind machine quality premium of 2.0% of the value of fresh shipments.

Profitability of New Propane Wind Machines for Different Levels of Frost Protection

The level of frost protection created by wind machines varies by orchard due to different temperatures and orchard conditions. Therefore, this section presents estimated profits for new wind machines at different levels of frost protection. The measure of frost protection is additional fresh (the increased percent of yield sold in the fresh market due to wind machines). As shown in Table 2, new propane wind machines are profitable when fresh market sales quantities increase more than 8.1% for Navel and 9.7% for Valencia oranges.

Table 2. Profits from New Wind Machines for Different Levels of Frost Protection

Additional Fresh (%)	Navel Profits ($/acre)	Valencia Profits ($/acre)
0	180	-186
2	-135	-148
4	-91	-109
6	-47	-71
8	-2	-33
10	42	6
12	86	44
14	131	82
16	175	120

Additional fresh is the increased percent of yield sold in the fresh market due to wind machines. This is in addition to a 2% quality premium. Wind machine profits equal benefits minus costs of wind machines.

Costs

Wind machine costs are shown in Table 3. These are annual after-tax values. Propane appears to be the less expensive alternative for new machines. A new propane wind machine costs $4,000 less than a diesel machine, propane fuel is $0.10 less per gallon and its price to expected to rise by 2.0% less than diesel, and labor costs for propane machines are lower. However, for 100 hours of operation, these savings are offset by the greater efficiency of diesel fuel; propane wind machines exhaust 13 gallons per hour while diesel machines burn 6 gallons per hour. Propane costs less than diesel for less than 100 hours of operation and propane costs more than diesel for greater than 100 hours of operation.

Table 3. Wind Machine Annual After-Tax Costs, 1993-94

	($/acre)
New Diesel	221
New Propane	224
Existing Electric (PG&E)	231
Existing Electric (SCE)	286
Existing Diesel	157
Existing Propane	187

Diesel and propane wind machines are 125 hp and electric machines are 100 hp. The existing machines are currently operated and are 20 years old.

San Joaquin Valley growers lose money by continuing to operate existing electric wind machines supplied by SCE. Existing 100 hp electric and new 125 hp diesel and propane wind machines offer identical frost protection, but the annual cost of operating a 100 hp electric wind machine supplied by SCE is $60 per acre per year higher than the annual costs of a new diesel or propane wind machine. Orchards in which new wind machines are cost-effective, growers would raise profits $60 per acre by replacing the SCE electric machines with new diesel or propane machines. For orchards in which new machines are not profitable, growers would increase profits by selling the SCE electric machines and not replacing them. In every case, citrus growers increase profits by liquidating existing electric wind machines for which the electricity is supplied by SCE.

Electric wind machines with power supplied by PG&E, in contrast, compare favorably with new diesel and propane wind machines in terms of costs. Existing diesel and propane machines have the lowest costs, implying that they may be the most profitable types of wind machines. The issue of profitability is discussed next.

Profitability

This project estimated the contribution to typical growers' profits from using wind machines. In addition to a 2% quality premium, these estimated profit levels are based on an expected 6.0% increase in fresh Navel yields and an expected increase of 7.0% in fresh Valencia yields. These levels of increased fresh market sales are expected for typical growers in the San Joaquin Valley. (These estimates are explained in a later section.) The results for new machines are shown in Table 4 and in Table 5 for existing machines.

The results indicate that for a typical grower, installing a new propane wind machine *lowers* after-tax profits by $47 per acre for Navel and $52 per acre for Valencia oranges. The least expensive type of existing wind machine is diesel and by far the most expensive is electric with power supplied by SCE. Existing diesel machines are profitable, on average. Existing propane costs slightly exceed average benefits.

Tables 4 and 5 also present the breakeven values for three variables: additional fresh, fresh yield, and price. Each breakeven value is calculated while holding all the other variables at their estimated values. For this analysis, the estimated additional fresh level is 6% for Navel and 7% for Valencia, the fresh yield is 550 cartons per acre for Navel and 475 for Valencia, and the fresh on-tree price is $5.00 per carton for Navel and Valencia.

To understand how to interpret breakeven results, consider an example. For new propane wind machines, benefits equal costs for Valencia oranges when fresh market yields are 620 cartons per acre. This breakeven Valencia fresh yield is estimated by holding all other variables at their estimated levels and raising yield from the estimated value of 475 to the fresh yield level which results in zero profits. In this case, profits are zero for fresh Valencia yields of 620 cartons per acre, and positive for yields above 620.

Breakeven values for fresh yield can also be used to determine the orchard age at which to install a wind machine. Machines should not be installed until an orchard's yield exceeds the breakeven level. For example, new propane wind machines raise profits for Valencia oranges when yields are over 620 cartons per acre. Some orchards do not yield 620 cartons per acre and, thus, should not have machines in them. For high yielding Valencia orchards which do exceed this yield, new propane wind machines increase profits once fresh yields surpass 620 cartons per acre.

Alternative Interest Rates

The interest or discount rate used in this type of study is the cost of borrowed capital. The relevant rate is the "real" rate of interest, which is the nominal rate minus the inflation rate. With a projected nominal rate of 8% and inflation of 5%, this study's real rate of interest is 3%.

Higher interest rates lower the profitability of most capital purchases because relatively more of the costs are incurred during earlier years of an asset's useful life and relatively more of the benefits are received during later years. New wind machines are no exception. The purchase and installation costs are often financed for five years, whereas the benefits often accrue over 30 years. Thus, using different interest rates in this analysis would change the profitability, as shown in Table 6 for new propane wind machines.

Table 4. New Wind Machines: Annual After-Tax Benefits and Costs: SJV Citrus, 1993-94

	New Diesel 125 hp	New Propane 125 hp	Estimated Values
NAVEL			
Benefit ($/acre)	178	178	
Cost ($/acre)	221	224	
Profit ($/acre)	-43	-47	
Breakeven Values			
Additional Fresh			
Percent	8.0	8.1	6.0
Cartons/acre	44	45	33
Fresh Yield			
(cartons/acre)	685	690	550
Price ($/carton)	6.20	6.30	5.00
VALENCIA			
Benefit ($/acre)	172	172	
Cost ($/acre)	221	224	
Profit ($/acre)	-49	-52	
Breakeven Values			
Additional Fresh			
Percent	9.5	9.7	7.0
Cartons/acre	45	46	33
Fresh Yield			
(cartons/acre)	610	620	475
Price ($/carton)	6.40	6.50	5.00

Additional Fresh is the increased percent of yield sold in the fresh market due to wind machines. Fresh yield is expressed in cartons (37.5 lbs. net) per acre. Price is the on-tree price of citrus destined for fresh consumption expressed in dollars per carton. The benefits include a 2% quality premium.

The Probability of Wind Machine Profits

Although the results presented in Tables 4 and 5 indicate that wind machines are not cost-effective, on average, there are circumstances in which profits occur. Many of the variables used in the analysis spreadsheets (presented in the appendix) vary over time and, in some cases, result in profits. These random variables include yields, market prices and other factors with significant influence on the outcome of the analysis conducted here. Therefore,

Table 5. Existing Wind Machines: Annual After-Tax Benefits and Costs: SJV Citrus, 1993-94

	PG&E Existing Electric 100 hp	SCE Existing Electric 100 hp	Existing Diesel 125 hp	Existing Propane 125 hp	Estimated Values
<u>NAVEL</u>					
Benefit ($/acre)	178	178	178	178	
Cost ($/acre)	231	286	157	187	
Profit ($/acre)	-53	-108	21	-9	
Breakeven Values					
Additional Fresh					
Percent	8.4	10.9	5.1	6.4	6.0
Cartons/acre	46	60	28	35	33
Fresh Yield					
(cartons/acre)	720	890	490	600	550
Price ($/carton)	6.50	8.00	4.40	5.30	5.00
<u>VALENCIA</u>					
Benefit ($/acre)	172	172	172	172	
Cost ($/acre)	231	286	157	187	
Profit ($/acre)	-58	-114	16	-14	
Breakeven Values					
Additional Fresh					
Percent	10.0	13.0	6.2	7.8	7.0
Cartons/acre	47	62	29	37	33
Fresh Yield					
(cartons/acre)	640	790	430	520	475
Price ($/carton)	6.50	8.30	4.60	5.40	5.00

Existing wind machines are machines currently operated with an age of about 20 years. Additional Fresh is the increased percent of fresh yield due to wind machines. Fresh yield is expressed in cartons (37.5 lbs. net) per acre. Price is on-tree price of citrus destined for fresh consumption expressed in dollars per carton. The benefits include a 2% quality premium.

Table 6. Profitability of New Propane Wind Machines for Alternative Interest Rates

SJV Citrus Profits (after-tax $/acre/yr)		
Interest Rate	Navel	Valencia
4%	$18	$12
6%	-$13	-$18
8%	-$47	-$52
10%	-$83	-$88

a simulation model was developed to estimate profits resulting from all realistic combinations of the random variables. In the model each random variable was allowed to vary around its current average value by amounts determined by its historical behavior. The simulation was run 500 times to calculate the possible outcomes which would indicate the probability of a profit occurring in any particular year. Table 7 presents the simulation results for each type of wind machine.

As expected, wind machines with the smallest average loses have the highest probability of generating a profit in a particular year. For navel oranges, for example, used diesel wind machines are profitable 65% of the time, while there is less than a 2% chance of benefits exceeding costs for existing electric machines using SCE power. Table 7 also shows that potential annual losses for electric machines are quite high, ranging over $500 per acre for navel oranges.

Effect of Wind Machines on the Uncertainty and Variability of Yields and Revenues

New wind machines lower expected profits an average of about $50 per acre (on a net present value basis), yet 85% of San Joaquin Valley citrus is protected by wind machines. Why?

Some possible explanations are:

1. Growers do not attempt to maximize wealth.
2. Growers attempt to maximize wealth yet fail due to lack of information. They may overvalue wind machines.
3. This study undervalues wind machines. This is unlikely, all the values were verified by citrus industry representatives.
4. The role of risk has not been addressed. Benefits of more certain yields have not been accounted for, and including these benefits may lead to positive wind machine profits.

The fourth explanation above is the most likely although the second explanation is certainly reasonable. Wind machines lead to more stable yields. This reduced risk lowers harvesting costs. This efficiency gain was not included as a benefit in the analysis because it varies between growers and is difficult to measure.

How is risk to be measured? A proxy for risk is "variability" and it may be measured using the coefficient of variation (CV), which is the standard deviation divided by the mean.

To appreciate the distinction between uncertainty and variability of yields, consider this example. Suppose a grower expects fresh Valencia yields of 500 cartons per acre and employs a harvesting crew and equipment which would minimize harvesting costs for a yield of 500. Now suppose freezing temperatures reduce fresh yields by 100 cartons per acre. This grower will have invested in harvesting capital and labor optimal for 500 cartons, yet be over-invested for an actual yield of 400. The yield uncertainty raises harvesting costs by the difference in average harvesting costs times the actual yield. By improving the certainty of yields, wind machines lower harvesting costs and raise profits. The potential benefits from reducing uncertainty with wind machines can be expressed as follows.

Let	$C(A)$	=	Additional cost due to the uncertainty ($/carton)
	AC^a	=	Actual average cost
	AC^*	=	Optimal (minimum) average cost
	Ya	=	Actual yield
Thus,	$C(A)$	=	$(AC^a - AC^*)Ya$

Now consider a case which has the same level of variance in yields over time yet a different level of certainty. The Valencia orange variety has alternate bearing tendencies; high yields one year are typically followed with low yields the next year and vice versa. Now imagine a grower's average Valencia yield over time is still 500 cartons per acre. But the grower has recorded previous yields and expects the alternate bearing effects to lead to a current yield of 400 cartons per acre. With this accurate projection, the grower minimizes harvesting costs by hiring the levels of capital and labor to minimize harvesting costs for a yield of 400.

For both cases, the variance in yield is identical; the average yield is 500 and the actual yield for one year is 400. Yet there is a difference in the level of uncertainty. Higher certainty enables the projected yield to be closer to the actual yield, thus lowering harvesting costs and increasing profits. The ability to plan hinges primarily on the uncertainty of production and not on price or revenues.

Simulations based on historical trends find that wind machines lower the coefficient of variation of yields by 7%. What is the value of the efficiency gain associated with 7% more stable yields? San Joaquin Valley fresh citrus yields are approximately 400 cartons per acre. $50 per acre is equivalent to $0.125 per carton ($50/400 cartons). Is the value of more certain yields worth $0.125 per carton? If so, then

Table 7. San Joaquin Valley Wind Machine Annual Profits per Acre

Type of Machine	Probability of Positive Profits(%)	Range of Profits with a 95% probability ($)
	Navel Oranges	
Diesel, new	15.6	-234 to 67
Propane, new	18.6	-288 to 75
Electric, PG&E, used	7.8	-537 to 140
Electric, SCE, used	1.8	-504 to 45
Diesel, used	65.0	-115 to 159
Propane, used	43.6	-265 to 138
	Valencia Oranges	
Diesel, new	22.8	-256 to 264
Propane, new	29.6	-305 to 316
Electric, PG&E, used	34.2	-308 to 322
Electric, SCE, used	9.2	-493 to 93
Diesel, used	50.6	-175 to 434
Propane, used	40.8	-299 to 304

the $50 per acre reduction in profits from using wind machines may be fully explained by the increased efficiency associated with more stable yields.

Harvesting and marketing costs are about $4.00 per carton of fresh oranges. The wind machine loss of $0.125 per carton is about 3% of the harvesting costs. So another perspective is that reduced yield risk is worth $50 per acre if it lowers harvesting and marketing costs by 3%.

Yield uncertainty greatly affects highly specialized and vertically integrated firms. The degree to which costs are fixed influences the decision of whether or not to reduce the risks of crop damage. If harvesting labor are seasonal employees, no labor cost will be incurred if the crop is destroyed because the labor will not be hired. If, however, a firm's harvesting crew are permanent employees, then the cost of lost production is greater because the labor expense is incurred even though no labor is needed. In this case, the firm is more likely to invest in inputs such as wind machines to reduce the chance of crop losses. Similarly, a grower who rents harvesting equipment bears a smaller cost of crop loss than a grower who owns harvesting equipment.

Market commitments may also raise the costs of uncertainty. A citrus processor may choose to not to accept a grower's fruit if it is known to have blemishes such as brown spots from frost. Also, if a grower has a contract to deliver certain quantities of citrus with specific qualities to a processor and the firm's crop is frost damaged, that firm may need to *buy* fruit from other growers to deliver on its contract. This can be quite expensive because if one firm's crop suffers frost damage, it is likely that other growers will have a small harvest as well and prices may be unusually high.

In addition to efficiency gains, more stable yields may increase revenues. Many growers forward contract and may receive a higher price. A grower with wind machines is more certain of yields and may contract a larger share of expected harvest and thus receive a higher price for the additional oranges contracted.

Another benefit of more stable yields is more stable revenues. While efficiency is vital to all citrus growers, certainty of revenues and cash flow is an important issue to highly indebted and undiversified growers. Predictable cash flows enable managers to better identify credit needs and to reduce the chance of default on loans.

In total, it is possible that the value of these benefits from the reduced risk of producing oranges protected by wind machines are enough to cover the financial losses reported in this study. However, many growers are beginning to question whether this is true under current market conditions. These growers believe that a lack of current information may lead them to overvalue wind machines.

This section presents a discussion of the costs of owning and operating various types of wind machines. The methodology used here is similar to the financial analysis presented by Blank *et al.* The data used were collected from published sources or directly from industry representatives in telephone interviews.

New Diesel and Propane Wind Machine Costs

The data collected indicated that costs of some items are fixed, while most cost items are variable between growers or suppliers. Therefore, this analysis allows some variables to be random to better reflect the situation faced by the entire citrus industry in the San Joaquin Valley. Tables 8A-C and Table 9 present each cost variable's average value and, if it is random, its standard deviation and type of distribution based on values from previous years.

A computer spreadsheet was used to evaluate these costs (along with the benefits) over the 15 year expected life of new wind machines. Tables A1 and A2 in the Appendix report the estimated values for each cost item over this period. The results in the appendix tables were estimated using a simulation program which made 500 iterations of the cost and benefit model. For each iteration, the model chose a value for each random variable according to its average value, standard deviation, and distribution and used them to obtain the final values for each random variable. The range of outcomes from the simulations are reported in Table 7.

Table 8A. Costs Common to All Wind Machines

Variable	Average (Mean)	Standard Deviation	Distribution
Corporate Income Tax Rate	40.0%	4.0%	Normal
Depreciation Rate For Income Tax Rate - Straight Line 7 years			
Depreciation Rate for Property Tax	7.0%	0.7%	Lognormal
Inflation - Predicted - over 15 years[5]			
Labor	5.0%	1.0%	Lognormal
Maintenance	5.0%	1.0%	Lognormal
Repairs	5.0%	1.0%	Lognormal
Insurance	$0.00		
Interest[6]	8.0%	2.0%	Lognormal
Management[7]	$30.00	$3.00	Lognormal
Number Annual Installments	5		
Property Taxes (% of value)[8]	1.2%	0.12%	Normal
Time Operate (hours/year)[9]	100	50	Normal

5 Inflation of intermediate goods averaged 5.9% from 1965 through 1992 (Council of Economic Advisors). Inflation has been lower since 1980, thus inflation is expected to remain lower than the average since 1965.

6 At the time of this study, 8% was the relevant average interest rate for SJV citrus growers. Many borrowed at 9%, some at 8%, and a few growers with surplus capital had invested funds in CDs at lower rates.

7 The costs of management time was estimated to be $30 per wind machine; it includes decisions to turn machines on and off and contracting for fuel, repairs, etc.

8 For Kern County, property taxes are 1.2% of the value of property: 1.0% is county taxes and typically 0.2% is a school tax (Kern County Tax Assessors Office, November 1993).

9 The 1978 Hasbargen study estimated the average amount of use to be 200 hours per year with a range from 15 to 300. A 1988 study by Hasbargen, Eidman and Pehrson estimated an average use time of 150 hours per year. Citrus managers interviewed in this study asserted that 100 hours is more accurate. Standard deviation of operating time was approximated from Table 4 of the 1988 study.

Table 8B. Costs of New Diesel Wind Machines, 125 hp

Variable	Average (Mean)	Standard Deviation
Fuel Usage (gallons/hour)[10]	6.0	NA
Labor ($/year)[11]	$304	$100
Diesel Fuel ($/gallon)[12]	$0.95	$0.25
Inflation - Predicted - next 15 years		
Diesel Fuel[13]	7.0%	1.0%
Purchase Price (Installed)[14]	$19,000	$1,900
Repairs ($/year)	$100	$50
Salvage Value - 15 years[15]	$7,500	$1,500

Table 8C. Costs of New Propane Wind Machines, 125 hp.

Variable	Average (Mean)	Standard Deviation
Fuel Usage (gallons/hour)	13.0	NA
Labor ($/year)[16]	$185	$50
Propane Fuel ($/gallon)[17]	$0.85	$0.25
Inflation - Predicted - next 15 years		
Propane fuel	5.0%	1.0%
Propane tank	5.0%	1.0%
Purchase Price (Installed)[18]	$15,000	$1,500
Repairs ($/year)	$100	$50
Salvage Value - 15 years[19]	$7,500	$1,500
Tank rental, 500 gal. ($/year)[20]	$80	$8

Table 9. Wind Machine Electricity Costs, 100 hp

	PG&E	SCE
Standby (fixed)		
Customer Charge ($/month)	16.00	15.20
Meter Charge ($/month)	6.00	0.00
Sum	$22.00	$15.20
Number months customer charges paid	12	12
Total	$264	$182
Demand Charge ($/kW/month)	1.75	1.25
kW/100 hp wind machine	85	85
Number months demand charges paid	6	12
Total Demand (Service)	$893	$1,275
Total Standby (fixed) Costs	$1,157	$1,457
Variable		
Energy Charge ($/kWh)	0.05964	0.09896
kW/hr (1hp=746 watts)	75	75
Hours Operated/Year	100	100
Total Variable Costs	$447	$742
Total Annual Cost		
per Wind Machine	$1,604	$2,200

PG&E: Dan Goozman. Rates effective July 1, 1993 through December 31 1994. For PG&E, the variable rate is the night rate (9:30 p.m. to 8:30 a.m.); 97% of the time the wind machines are operating are during this period.
SCE: Rosemead, CA. PA-1 schedule effective winter of 1993-94. Schedule PA-1 applies to customers for whom at least 70% of electricity usage is for agricultural purposes. The SCE Service Charge Rate is $1.75 per hp. Wind machine operators typically install a load disconnecting device to prevent use during the summer from noon to 6:00 p.m. and receive a $0.50 reduction in the Service Charge Rate.

10 Orchard Rite and Pacific Distributors, October 1993.
11 O'Connell and Pherson (1986) estimated that labor for diesel machines was $216 per machine. This cost includes mileage to fill the tanks. Compounding $216 annually at 5% for 7 years gives $304.
12 Red Triangle, Fresno, November 1993.
13 The trend of stricter air quality laws is expected to continue. This would lead to higher diesel prices; in this study diesel prices are expected to increase by 2% over the rate of inflation.
14 Orchard Rite and Pacific Distributors, October 1993.
15 Citrus managers' estimate.
16 O'Connell and Pehrson (1986) estimated that labor for electric machines was $96. Compounding $96 annually at 5% for 7 years gives $135. Since propane tanks are filled by another firm, propane involves less labor than diesel, yet slightly more than electric wind machines (according to citrus managers).
17 Red Triangle, Fresno, November 1993.
18 Installed, $14,800 minus quantity discount of $500, plus sales tax of $660, plus $25 for the pigtail and regulator equals $14, 985 (Orchard Rite and Pacific Distributors, October 1993).
19 Citrus managers' estimate.
20 Citrus managers' estimate.

Costs of Existing Wind Machines

Appendix tables A3-A6 present the results for used wind machines. Existing wind machines are assumed to be about 20 years old. For existing diesel and propane machines, the estimated current salvage value is $5,000 and projected salvage value in 15 years is $2,000. The current annual repairs are $250 for diesel and $200 for propane.[21]

The electricity for wind machines is supplied by Pacific Gas & Electric (PG&E) or Southern California Edison (SCE). PG&E's current schedule is AG 4-B-W SCE's schedule is PA-1. Table 9 presents the electricity costs for one 100 horse power electric wind machine for PG&E and SCE. 100 hp is the most common size and offers comparable protection to 125 hp diesel and 125 hp propane machines.

SCE charges total about $600 per year more than those of PG&E to supply electricity for a 100 hp wind machine. Since the SCE variable rate is also higher, more hours of operation lead to an even greater difference in electricity costs. SCE does not offer a discount night rate. SCE's Service Costs are higher mainly because their Service Charge applies for 12 months, whereas the Service charge for PG&E is paid only for 6 months.

Electricity prices have risen faster than the rate of inflation and this trend is expected to continue. "Since 1979 the average electricity costs to agricultural class customers (adjusted for inflation) increased by 36% for PG&E and 16% for SCE. An additional 14% is forecast by 1998"(California Energy Commission). This is 2.2% over the annual rate of inflation. The expected overall inflation is 5.0% for other costs, so the expected rate for electricity is 7.2%.

Electricity costs per kilowatt-hour are higher for wind machines than for other agricultural uses. Electricity costs average $0.105/kWh for all agricultural customers (California Energy Commission). For 100 hours of operation per year, the average cost per kWh for wind machines is twice the agricultural average for PG&E and three times the average for SCE (Table 10). Additional hours of use lower the average cost per kilowatt-hour of operation. Since wind machines are operated relatively few hours, the standby (fixed) charges lead to higher average cost per kilowatt-hour of operation.

Large Propane Storage Tanks

Propane is a profitable fuel source for existing wind machines for average Valencia orchards and it is nearly profitable for average Navel orchards. However, some growers are concerned that enough propane fuel may not be available when needed. Another concern is possible sharp increases in the price of propane during the winter.

Large propane storage tanks are one option to help alleviate both concerns. The estimated winter price of propane fuel is $0.85 per gallon for small tanks and $0.60 to supply large storage tanks, such as 30,000 gallons. In addition, the summer price is $0.40. By purchasing large tanks, growers could fill the large tanks at $0.40 in the summer and refill in the winter at $0.60. The quantity discount is 25 cents and the seasonal discount is 20 cents per gallon.

A propane wind machine consumes 1,300 gallons of propane fuel per year when operating 100 hours per year at 13 gallons per hour. Large tanks would save $325 per wind machine per year due to the quantity discount (1,300 gal. x $0.25/gal.) and up to $260 per year for the seasonal discount. Assuming that one-half of the purchased fuel qualified for the seasonal discount, large propane storage tanks would be cost-effective if the additional costs of the large tank were less than $455 per wind machine per year.

A new storage tank costs about $48,000. This is $40,000 for the tank, $5,000 for the concrete, and $3,000 for the engineering (Red Triangle, November 1993). Some used large tanks are available. Installing bulk tanks also incurs added expense of distributing propane to each wind machine. This involves either laying pipe to the wind machine or trucking it. Currently, distributing propane through pipe is prohibitively expensive, but one possibility is to devise a way to deliver propane as vapor to permit installing less expensive plastic tubing.

This study does not estimate whether the additional installation and distribution costs associated with buying large propane storage tanks are less than the savings of buying propane fuel in the summer and in bulk. Large propane tanks are more likely to be feasible if this fixed cost can be spread by also storing propane for well pumps.

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21 Pacific Distributors. Repair costs are higher for diesel due to the higher costs of diesel engines and parts.

Table 10. Annual Electricity Costs of a 100 hp Wind Machine, 100 hours of use, 1993-94

		PG&E			SCE			Agricultural Average*
Cost		Dollars	%	$/kWh	Dollars	%	$/kWh	$/kWh
Standby (fixed)	=	1,157	72	0.154	1,457	66	0.194	0.055
Variable	=	447	28	0.0596	742	34	0.989	0.060
Total	=	1,604	100	0.214	2,200	100	0.293	0.105

* The California Energy Commission reported that the average PG&E rate in 1991 was 10.0 cents per kilowatt-hour. An average increase of 2.2% over inflation over two years gives an approximate 10.5% average cost in 1993. One hour of operation = 75 kWh*100 hours of operation = 7,500 kWh/year.

Wind machine benefits are the additional net revenues received as a direct result of using wind machines. Benefits include the value of additional quality and quantity of oranges sold in the fresh market, as shown in Table 11N for Navel and 11V for Valencia. Higher quality leads to higher prices associated with the higher grade of oranges marketed as fresh. "Additional quantity" is valued as the additional oranges shipped fresh.

Total and Fresh Yields

Benefits are estimated using fresh yield, rather than total yield, because the value of wind machines lies in protecting the fresh yield. The estimated on-tree price for juice is zero. If an orange would not be shipped as fresh anyway, there is no economic loss if this orange freezes. The percent of harvest which goes to the fresh market varies from year to year due to changes in yields, demand, and weather conditions.

Since 1965, San Joaquin Valley Navel yields have increased 1.7% and Valencia yields 1.3% per year. Yields grew rapidly in the 1970s and slower before and since. In this study, annual yield increases of 1.0% per year for Navel and Valencia are projected over the next fifteen years. Final estimates of yields used in this study are shown in Table 12.

Additional Fresh

"Additional fresh" is the increased percent of total yield that is marketed in the fresh market due to wind machines. It is different for each orchard site due to unique weather and orchard conditions. Additional fresh is the most difficult variable to estimate, yet the most important in determining the cost-effectiveness of wind machines. This study's estimated additional fresh yield due to wind machines is 6.0% for Navel and 7.0% for Valencia. This is in addition to a 2% quality premium.

The next major section explains how these estimates were obtained. Briefly, Hasbargen concluded that the best estimate of additional fresh yield due to wind machines was 6.75%. Two extension specialists concurred with this level of frost protection. Also, FCIC data indicate that the difference in fresh yields with and without wind machines is between 6% and 7%. Finally, a model relating increased fresh yields with minimum temperature data was used in this analysis giving an expected value of 7% for Lindcove, and higher for orchards near the colder Lamont.

Citrus Prices

To estimate the cost-effectiveness of wind machines, several measures of Navel and Valencia prices are needed: on-tree fresh price, on-tree juice price, variability of prices, correlation of prices with yield, and expected average annual price increase (Table 13). The on-tree prices for oranges destined for juice and fresh consumption are projected from historical prices.

"On-tree price" is the net price a grower receives. It is the F.O.B. price minus the costs of harvesting and marketing. The economic loss from frost damage is the on-tree value of oranges for the fresh market minus the on-tree value of oranges for juice. A freeze lowers revenues by the F.O.B. value of damaged fruit but eliminates the need for harvesting and marketing costs. The F.O.B. price for juice is often below the costs of harvesting and marketing, so the on-tree price for oranges destined for juice is often negative. This study estimates the on-tree price for juice to be $0.00. Thus, the net loss is the on-tree value of fresh market citrus. The on-tree price of oranges destined for the fresh market is estimated by evaluating historical on-tree prices. California's on-tree fresh citrus prices are presented in Figure 1. Navel and Valencia on-tree fresh prices had moved in unison until 1980. Since 1980, Valencia prices have generally been higher than Navel prices. This is partly due to freezes in Florida during the 1980s (Takele). Florida processes over 90% of its citrus harvest into juice. Since relatively more of California's Valencia oranges are processed into juice, these Florida freezes especially benefited California's Valencia growers.

Table 12. San Joaquin Valley Citrus Fresh Yields, 1993-94 (Cartons/acre)

	Total Yields	Fresh percent	Fresh Yields	Standard Deviation	Coefficient of Variation
Navel	714	77%	550	138	0.25
Valencia	730	65%	475	147	0.31

Yields and percent of harvest shipped fresh data are from the Navel and Valencia Orange Administrative Committees. Total yields and percent fresh averages were computed from 1982-83 to 1989-90. Yields were projected to 1993-94 by increasing historical yields 1% per year.

Table 11N. Benefits - Additional Value of Navel Production ($/Acre)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	714	721	728	736	743	750	758	766	773	781	789	797	805	813	821
Percent Fresh%	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Fresh Yield (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Additional Fresh (%)	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Add'l Quant (cartons/acre)	32.99	33.32	33.65	33.99	34.33	34.67	35.02	35.37	35.72	36.08	36.44	36.80	37.17	37.54	37.92
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	165	173	182	191	201	211	222	233	244	257	270	283	298	313	328
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Add'l Rev. ($/acre/year)	55	58	61	64	67	70	74	78	81	86	90	94	99	104	109
Sum Add'l Rev. ($/acre/yr)	220	231	243	255	268	281	295	310	326	342	360	378	397	417	438
After Tax Rev. ($/acre/yr)	132	139	146	153	161	169	177	186	196	205	216	227	238	250	263
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value per period ($)	122	119	116	112	109	106	103	101	98	95	93	90	88	85	83
Present Value ($)	1,520														
Equiv. Annuity ($/acre/yr)	178														
Add'l Rev. (aft-tax,$/acre/yr)	**$178**														
Annual Yield Increase (%)	1.00%														
Annual Fresh Price Increase	4.00%														
Income Tax Rate	40.00%														
Interest Rate	8.00%														

Table 11V. Benefits - Additional Value of Valencia Production ($/Acre)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	730	737	745	752	760	767	775	783	790	798	806	814	823	831	839
Percent Fresh (%)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Fresh Yield (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Additional Fresh (%)	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Add'l Quant (cartons/acre)	33.22	33.55	33.88	34.22	34.56	34.91	35.26	35.61	35.97	36.33	36.69	37.06	37.43	37.80	38.18
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	166	174	183	192	202	212	223	234	246	259	272	285	300	315	331
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Add'l Rev. ($/acre/year)	47	50	52	55	58	61	64	67	70	74	78	81	86	90	94
Sum Add'l Rev. ($/acre/yr)	214	224	236	247	260	273	287	301	316	332	349	367	385	405	425
After Tax Rev. ($/acre/yr)	128	135	141	148	156	164	172	181	190	199	209	220	231	243	255
Present Value per period ($)	119	115	112	109	106	103	100	98	95	92	90	87	85	83	80
Present Value ($)	1,475														
Equiv. Annuity ($/acre/yr)	172														
Add'l Rev. (aft-tax,$/acre/yr)	**$172**														

Annual Yield Increase (%)	1.00%
Annual Fresh Price Increase	4.00%
Income Tax Rate	40.00%
Interest Rate	8.00%

The nearly identical Navel and Valencia on-tree prices from 1965 to 1980 suggest similar costs of production for Navel and Valencia.[22] The higher Valencia prices of the 1980s encouraged citrus growers to plant more Valencia trees. This will lower Valencia prices through the 1990s and beyond. Therefore, even though Valencia prices were higher than Navel prices in the 1980s, it is expected that prices will converge and move together as they did until 1980.

Based on prices from 1965-66 to 1991-92, the 1993-94 on-tree fresh Navel price was projected using a regression model to be $5.40 per carton. This projection was influenced by the prices of the 1980s, so the Navel and Valencia on-tree fresh prices used in this study were lowered to $5.00 per carton.

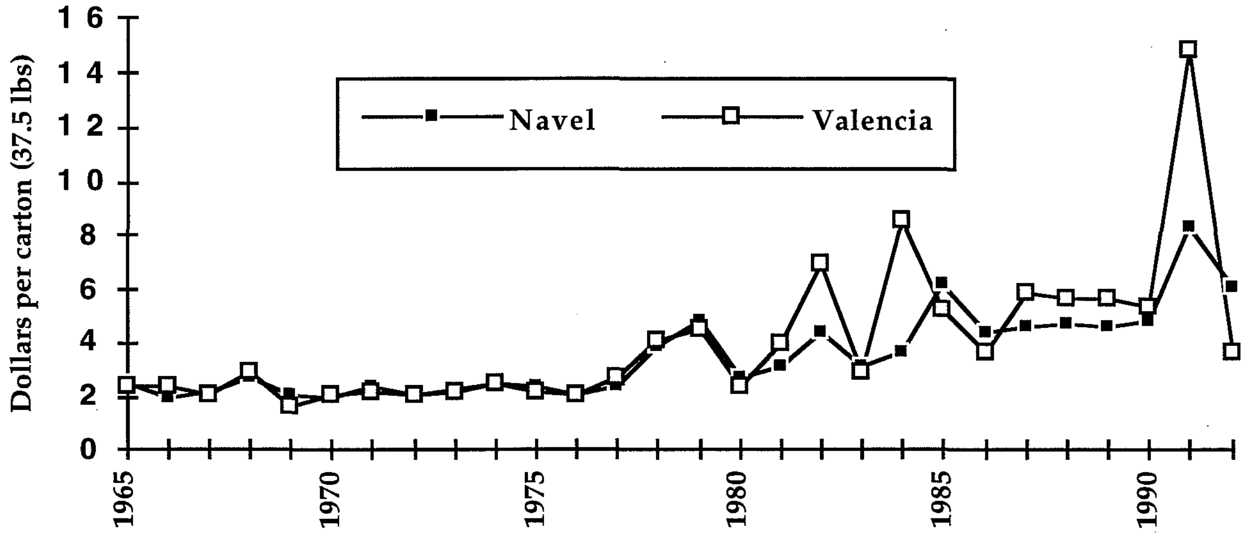
From 1965 to 1992, fresh on-tree Navel prices increased 4.4% and Valencia prices 5.1%. During this period the producer price index (PPI) increased 5.9% per year (Figure 2). Since the projected inflation of costs is 5.0% and the PPI has grown about 1% more than citrus prices, Navel and Valencia fresh on-tree prices are estimated to increase 4% per year over the next 15 years.

Table 13. Projected California Citrus Prices ($/Carton)

	Navel		Valencia	
Measure	Average	Std. Dev.	Average	Std. Dev.
1993-94 on-tree fresh price	$5.00	$1.87	$5.00	$2.51
1993-94 on-tree juice price	$0.00	$0.00	$0.00	$0.00
Annual price increase	4.0%	2.0%	4.0%	2.0%
Correlation with fresh yield	-0.60		-0.55	

Prices are projected from 1955-56 to 1991-92 data (California Agricultural Statistics Service).

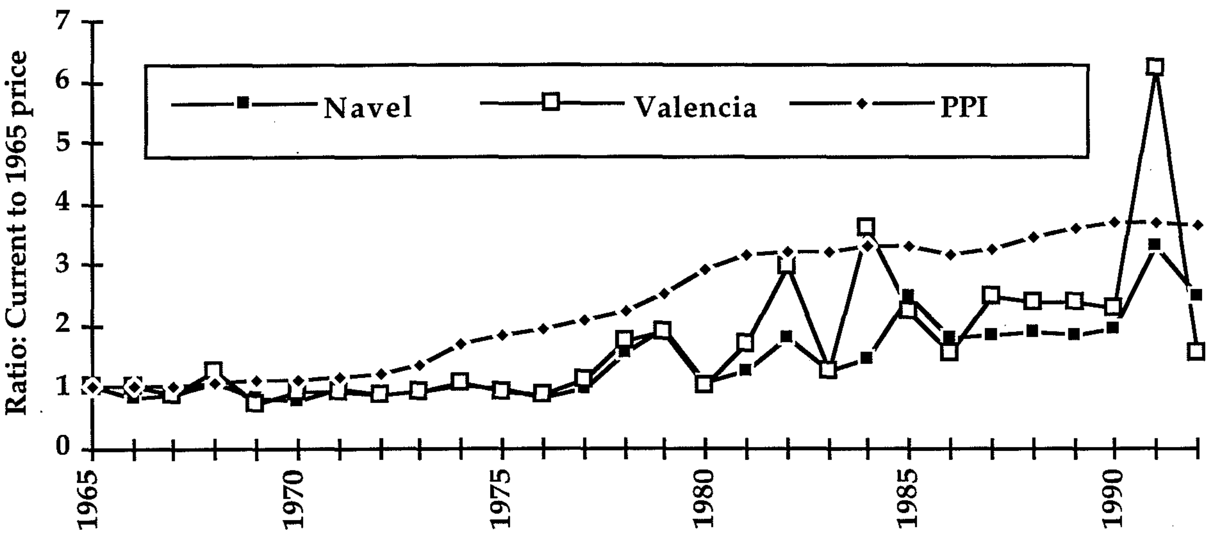
Figure 1. California On-Tree Prices of Citrus Marketed Fresh



Source: California Agricultural Statistics Service.

22 To show that similar prices imply similar costs for a competitive business such as producing oranges, suppose that from 1965 to 1980 it had cost much less to produce one variety, say Navel. Then with similar prices, higher profits with Navels would have induced growers to plant significantly more Navel trees. Then the higher Navel production would have entered the market and reduced Navel prices below Valencia prices. But the fact that Navel and Valencia prices continued to move together implies that the costs (and profits) of Navel and Valencia oranges also remained similar.

Figure 2. Inflation: California Citrus and Producer Price Index



The Producer Price Index (PPI) is for "total intermediate goods" (Council of Economic Advisors).

Severe Frosts and Citrus Prices

Severe frosts destroy oranges, lowering supplies and boosting prices. High citrus prices do occur when fresh yields are low. On average, when fresh yields fall by 10.0%, Navel prices rise by 6.0%, and Valencia prices rise by 5.5%. Previous economic studies have specified that benefits of wind machines include receiving higher prices during the coldest years. This study does not because there is evidence that wind machines offer little protection during severe freezes. The two coldest winters in recent decades were 1967-68 and 1990-91. The difference in losses with and without wind machines was slight during both years. For 1967-68, the difference in FCIC loss ratios (indemnities as a percent of liabilities) was a mere 4.9% for Navel and 2.9% for Valencia (Hasbargen *et al.*). During the 1990-91 freeze, the temperatures at ground level and 30 feet were about the same (O'Connell and Pehrson). This implies that wind machines did not increase orchard temperatures; the air they blew down was as cold as the air in the orchard. In 1990-91 there were some Valencia orchard yields of zero, also indicating that wind machines did not protect citrus fruit. As Carmen (1991) noted, the coldest periods tend to be advective (windy) freezes. The wind mixes the air at different altitudes and lessens the effectiveness of wind machines.

Further evidence that wind machines offer little protection during the coldest periods is the fact that differences in FCIC insurance premiums for orchards with and without wind machines are only about $30 per acre. The current FCIC deductible is 25%, so indemnities are only paid after severe frosts. The estimated before-tax benefits of wind machines are about $300 per acre. The difference in premiums for a 25% deductible is about 10% of the difference in expected losses with and without wind machines. Since premiums are based on historical losses, this implies that 90% of the benefits offered by wind machines are for the first 25% of fresh yield, and only 10% of the protection is for losses exceeding the 25% deductible.

Grade Effect

The quality premium used for this study is 2.0% of the citrus on-tree value. This is based largely on discussions with managers of Sunkist and Kaweah and on Hasbargen's 1978 and 1988 studies. For the 1988 study, wind machines were believed to increase the quality and price received by one to two percent. The managers of Sunkist and Kaweah believe that wind machines raise the value of fresh oranges by an average of two percent. Oranges may be downgraded from first to second grade because of brown marks on the peel caused by ice. Wind machines reduce the number of oranges downgraded. One manager stated, "You just need wind machines, the quality is much better." The other manager was more conservative, "two percent is a good estimate, but it's an upper bound."

WIND MACHINE FROST PROTECTION: EVIDENCE

This section provides background on how wind machine benefits (reported in the previous section) were derived. Wind machine frost protection depends on orchard and climate conditions. This protection is measured as the additional percent of yield which can be sold to the fresh market due to the wind machine. In this study, the estimated Additional Fresh yield is 6.0% of fresh yield for Navel and 7.0% for Valencia. This section explains why these values are the best estimates for San Joaquin Valley oranges by summarizing previous studies and then presenting results from a model applied to weather stations in Kern and Tulare Counties.

Hasbargen, 1978

Hasbargen estimated wind machine benefits by adding four variables additional percent fresh, additional percent first grade, crop yields in following years, and the effect of higher prices during years of heavy frost. His estimated sum of the first two variables are presented in Table 14. Hasbargen also added 2.0% for better yields following hard freezes (10% times the two coldest years), and 1.4% due to higher prices during the coldest years (20% higher prices during the two coldest years gives added losses of 6 and 8 percent those years).

Hasbargen concluded that wind machines raise net revenues by 12 to 20% per year. Hasbargen also compiled FCIC records of citrus frost protection with and without frost protection (Table 15). The high loss ratios he reported are due to several cold periods during these years and because orchards which were insured tended to be those most susceptible to frost damage. The difference in loss ratios with and without wind machines is between 5% and 6%.

Table 14. Differences in the percentage value lost due to frosts with water protection alone versus water plus wind machines

Frequency	A[1]	B[2]	C[3]	Others[4]	Suggested Range
1 year in 10	20	35-40	70	50	30-50
1 year in 10	15	25-30	50	40	20-40
2 years in 10	10	—	—	—	8-12
5 years in 10	0-5	8-12	5-10	0-10	5-10
1 year in 10	0	0	0	0	0
Weighted average	6.75				9.1-16.4

1) Citrus Specialist in the Agricultural Extension Service.
2) Top producer with 20 years experience managing his own and other groves with and without wind machines.
3) Quality conscious producer who was very pro-wind machines.
4) Based on more limited comments from others, including client management and a small packer-grower.

Source: Hasbargen (1978).

Table 15. FCIC Loss Ratios (Indemnities as a percent of Liabilities) With and Without Frost Protection, 1962-1976

	Navel		Valencia	
Year	Without	With	Without	With
1962	39.8	46.3	62.1	72.6
1963	0	0	2.1	0
1964	0.5	0	2.1	1.8
1965	11.7	8.5	6.8	3.7
1966	0.3	0	0	0
1967	65.7	60.8	79.7	77.0
1968	15.6	8.2	22.1	11.1
1969	12.9	4.2	10.4	4.3
1970	17.3	9.2	23.3	12.2
1971	8.4	4.7	11.3	4.4
1972	54.6	41.5	67.1	56.0
1973	0	0	0.6	0.1
1974	18.4	7.1	13.8	5.0
1975	14.9	3.9	5.3	1.3
1976	0.5	0	0.1	0.0
Average	16.7	11.3	19.1	13.2

Source: Hasbargen, (1978). The FCIC deductible was 10% of liability during this time (vs. 25% today).

Hasbargen, Eidman & Pehrson, 1988

These authors further evaluated FCIC insurance data (see Table 16). They observed that average actual loss differences of 6.2% and 6.9% are significantly below the suggested range of 9-16% from survey estimates. Also, the largest differences between the survey and FCIC loss data are in the heavy loss years. The insurance data indicate that wind machines gave little protection during these two years (1962 & 1967). The authors noted that those years were advective (windy) freezes.[23]

During the 1967-76 period, the FCIC did not insure the first 10% loss. This deductible, the authors believed, caused the insurance data to understate the true losses by at least one percent. The authors also noted that the higher grade of fresh oranges protected by wind machines might be expected to add one to two percent to the crop value. The authors did not add these two factors to the estimates of the extension citrus specialist. The authors concluded that the extension citrus specialist's estimate of 6.75% of crop saved was the most consistent with the insurance data. Their estimated percent value of production saved is:

Percent	*Reason*
6.75%	Additional percent of crop marketed as fresh.
2.0%	Higher yields following cold years (10 % for two coldest years)
0.7%	Higher prices during cold years (20 % higher 2 years)
=	
9.45%	Additional Value due to Wind Machines

Table 16. Difference in losses between "protected" and "unprotected" orange groves as determined by insurance adjusters, compared with survey estimates.

Description	Indemnity Payments as a Percent of Liability* Navels(%)	Valencias(%)	Loss Differences from June Survey (%)
10 yr. avg. - no frost protection	20.83	23.37	
10 yr. avg. - with frost protection	13.96	17.14	
Difference in losses	6.87	6.23	9.1-16.4
Differences in losses by years:			
Year of largest losses, 1967	4.9	2.9	30 - 50
Year of 2nd largest loss, 1972	13.1	11.1	20 - 40
3rd & 4th bad years, 1974 1970	9.7	10.0	8 - 12
Typical years	6.3	5.7	5 - 10
Best year	0	0	0

Source: Hasbargen *et al.*, 1988.

23 Wind machines blow the higher warmer air down into the cooler orchard level air. The larger the temperature difference (inversion), the more effective is the machine. An advective (windy) freeze eliminates the inversion and the effectiveness of wind machines.

Independent Private Study

A firm which manages citrus recently evaluated the profitability of wind machines and concluded that new wind machines, on average, generate a 23% return on investment. They estimated the benefits by comparing the net citrus revenues per acre for orchards with and without wind machines.

The average rate of return for average San Joaquin Valley citrus orchards is likely to be significantly less than 23% for two reasons. One, this firm's orchards are on the fringe of the San Joaquin Valley. The manager stated that their orchards face colder temperatures than most orchards in the Valley, so their wind machines offer greater protection. Also, this firm's estimated before-tax variable costs are $1,000 per wind machine ($100 per acre) per year. But as Table A2 in the Appendix reveals, annual variable costs for new propane wind machines exceed $1,400 per wind machine.

The firm's manager also asserted that during the 1990-91 freeze, wind machines led to more trees surviving and to higher yields the following year. He believed this was true even though temperatures at 40 feet and at orchard level were similar during the freeze. He said that although the wind machines did not increase the orchard temperatures, they created additional air movement which apparently raised yields the following year.

Weather Model

A weather model was developed as part of this study to better estimate the average level of frost protection at two representative sites where weather data is available. Citrus managers can use these two sets of results to approximate the results expected for their orchards.

A. Relationship between frost damage and weather.

Citrus frost damage depends on variety, yield, harvest dates, minimum temperature level, prices, and type of frost protection. These variables are included in the model. Frost damage is also influenced by other weather variables, such as wind, humidity, and duration of temperature, but these variables are not included in the model because their effects are captured in the minimum temperature variable.

Minimum temperature is included in the model, but its duration is not. Suppose the temperature drops below the critical level, say 24°F. Frost damage will be much higher if the temperature holds at 24°F for several hours than if it just reaches 24°F and quickly rises to above freezing. For 41 observations of cold nights at different weather stations, temperatures remained at the minimum for less than one hour in all but four observations, and less than two hours for all observations (Carmen).

The simple model below relates the key weather variable, minimum temperature, with frost damage. The relationship for a single day is presented in equation 1, and for a season in equation 2.

$$ELO_i = \sum_{j=1}^{J} ([D(T_{ij})][P(T_{ij})]S_i) \qquad (1)$$

$$ELO = \sum_{i=1}^{I} (ELO_i) \qquad (2)$$

where:

- i = 1, ..., 137 first possible cold night to the last (November 1 to March 15).
- ELO_i = Expected percent yield loss due to frost *without* wind machines for one day.
- ELO = Percent yield loss for the cold season.
- T_{ij} = Minimum temperature j on day i.
- $D(T_{ij})$ = Percentage damage given minimum temperature j on day i.
- $P(T_{ij})$ = Probability the minimum temperature is j on day i.
- S_i = Percent unharvested on day i.

S_i is the percent of oranges exposed to the cold; it equals 100% minus the percent harvested minus the share on the tree already frost damaged. The two common citrus varieties, Navel and Valencia, are considered separately. Valencia oranges are harvested from April through October, thus 100% of their potential fresh yield is exposed to winter frosts. The Navel harvest season extends from November to April, so the percent of yield susceptible to frost falls as winter harvesting progresses. The Navel harvest is estimated here using weekly fresh shipments.

The boundaries of the relationship between minimum temperature (T) and frost damage (D(T)) are defined as levels which freezing just begins and at which freeze damage is 100%. For Valencia oranges:

T_c = 27°F = Critical temperature, below which freeze damage begins, and

T_t = 20°F = Minimum temperature which would result in total loss of fresh sales.

For Navel oranges, T_c and T_t are one degree Fahrenheit lower (Carmen).

The temperature at which a "total loss" occurs is based on cold chamber experiments at the University of Florida. "On another trial, the chamber temperature was reduced to 20°F, all [citrus] fruits freezing within an hour" (Pehrson). "Undercooling occurs when the temperatures inside the fruit drop below the freezing point of the fruit without starting to freeze. Mature fruit usually undercools to temperatures of 22°F to 25°F without freezing...When fruits freeze, temperatures inside the fruit rise to the freezing point of the fruit and stay there, no matter how low the outside air temperature, until the fruit is completely frozen. There is very little undercooling when there is ice on the fruit." Temperatures at which freezing of oranges begins:

Green oranges	28.5 to 29.5°F
Half-ripe oranges	28.0 to 29.0°F
Ripe Oranges	27.0 to 28.0°F

When air temperatures fall rapidly, fruit on trees may be as much as 7°F warmer than the air. Also, a warm day helps protect oranges. Following warm days (60°F or higher), ripe oranges are threatened at 26°F, and following cold days (59°F or lower), ripe oranges are threatened at 27°F (Puffer and Turrell).

Note that the range of D(T) in equation 1 is 0 to 1 (0 to 100% damage). To simplify, the minimum temperature (T) was transformed to also be between 0 and 1 by letting $T_t = 20°F = 0$ and $T_c = 27°F = 1$. The other new T's equal $(T - T_t)/(T_c - T_t)$ which are (T - 19)/7 for Navel and (T - 20)/7 for Valencia.

The Florida experiments also indicate that as temperature falls below 27°F, freeze damage increases at an increasing rate, and suggests a relation between minimum temperature and frost damage. "With chamber temperatures at 26°F, 50% of the fruit was frozen after 11 hours. However the first fruit took 4 hours to freeze ... Another experiment lowered the temperature to 25°F with about 5% of the fruit freezing after 1/2 to 1 hour at this temperature. In 21/2 to 3 hours, nearly 50 percent of the fruit was frozen, 81/2 hours at 25 F, 80% were frozen. On another trial the chamber temperature was reduced to 20°F, all fruits freezing within an hour. During all these trials, most fruits undercooled before freezing." Alternative relations are plotted in Figure 3. Comparing these relations with the Florida chamber experiments led to the following function:

$$D(T) = 1 \qquad \text{if } T \leq T_t$$
$$D(T) = 0 \qquad \text{if } T \geq T_c$$
$$D(T) = (1-T)^{1.5} \qquad \text{if } T_t < T < T_c$$

B. Citrus Frost Damage With Wind Machines.

The model to estimate yield loss with wind machines is identical to that in equations 1 and 2, except for the inclusion of a factor indicating that orchard temperature is raised by the wind machine. The percent loss per day with a wind machine is ELW_i in equation 3 and equation 4 shows the season's percent loss is the sum of losses for all days.

$$ELW_i = \sum_{j=1}^{J}([D(T_{ij} + W)][P(T_{ij})]S_i) \qquad (3)$$

$$ELW = \sum_{i=1}^{I}(ELW_i) \qquad (4)$$

W equals the increase in orchard temperature due to the wind machine, which is the temperature difference between the orchard altitude and the wind machine altitude (inversion) times the percent of the inversion that the wind machine modifies. According to University of California biometeorologist Richard Synder, who has measured the inversion in orchard temperatures for several years, the average temperature difference between 2 and 10 meters of altitude in the San Joaquin Valley is 4°F.

Synder also measured the modification several nights in the San Joaquin Valley and discovered a range from a very small percent to 100%, with an average of approximately 50%. These results show that previous estimates have tended to underestimate the percent of the temperature difference which is modified by wind machines.[24]

Robert Brewer measured the difference in the temperatures of Tulare county orchards with and without wind machines to be approximately 2°F (Table 17). Brewer's observations are consistent with Snyder's measurements. Wind machines increase the temperature of San Joaquin Valley orchards by an estimated 2°F, half the inversion strength of 4°F.

C. Water as Frost Protection.

Applying water offers significant frost protection. Water releases heat as it cools. Therefore, an orchard should be thoroughly irrigated before a freeze. Wet soil absorbs more heat during the day and releases more warmth at night and releases heat for a much longer time. Wet soil releases about two and one-half times as much heat as a dry soil (Sentinal Frost Protection). However, water may worsen frost damage if not applied wisely. If a freeze is expected, applying water to orchard soil will protect against frost damage. But all the water should be absorbed into the soil; standing water will turn to ice and be a cooling hazard when it melts. Also, water should never be applied over an orange tree. The weight of

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24 Gerber estimated it to have a maximum of 35% while the University of California Cooperative Extension (1982) estimated it to be 1/4 of the inversion.

Figure3. Alternative Relationships Between Minimum Temperature and Citrus Frost Damage

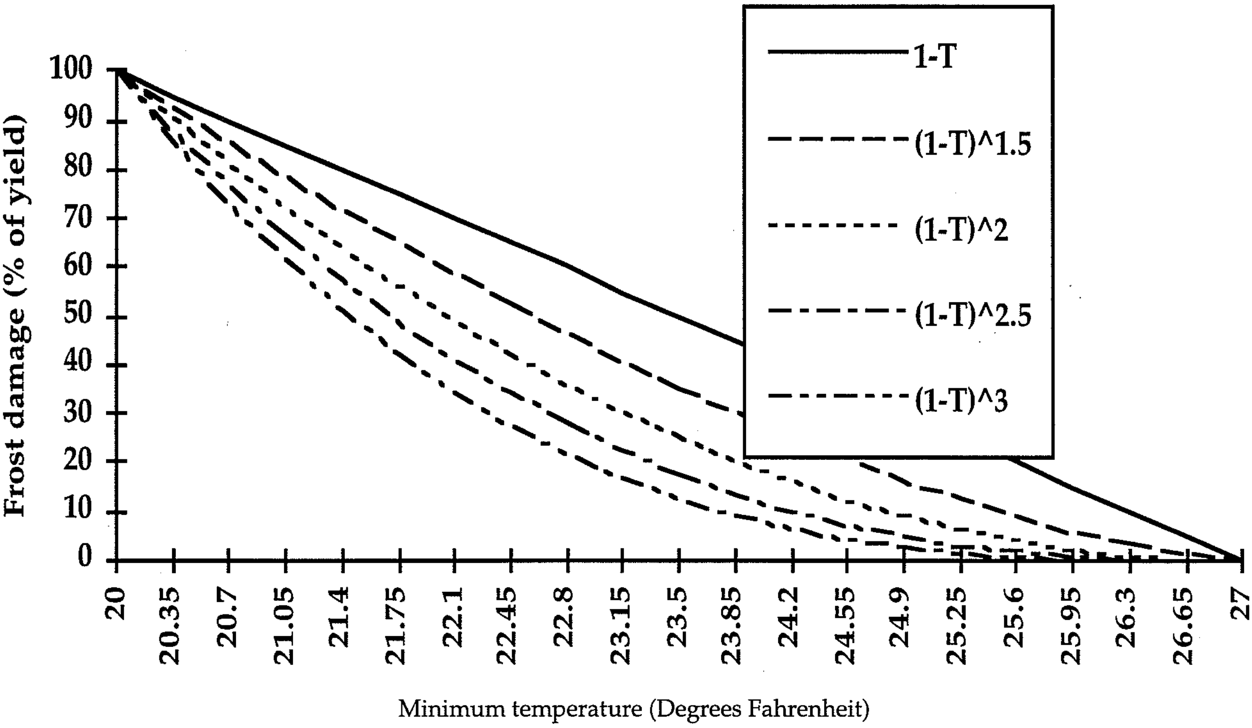

Table 17. Temperature response to application of 473 l/min/ha (50 gal/min/ac) of 18 C irrigation water with and without a wind machine. The values represent ranges and means for 13 cold nights extending over 3 seasons.

	Without Wind Machine		With Wind Machine	
Water Applied	Range	Mean	Range	Mean
None			1.5 to 2.5°F	2.0°F
1 furrow (center)	1.5 to 2.5°F	1.8°F	2.5 to 4.5°F	3.5°F
2 furrows (underskirts)	2.0 to 3.5°F	2.5°F	4.5 to 5.5°F	4.9°F
Low Head Sprinklers	-0.5 to 4.5°F	4.0°F	-1.5 to 6.0°F	5.5°F

Site was Ivanhoe in Tulare County, California. On all but one night the dew points were above 0°C.

Source: Brewer.

the resulting ice may break branches and, when the ice eventually melts, the cooling effect may freeze oranges. Applying water through a sprinkler system increases orchard temperature by at least 2°F or as much as wind machines. Evidence includes field observations by Brewer and by Evans and private insurance rates which are identical for frost protection from either water sprinklers or wind machines.

Brewer's experiment in Tulare county found that applying surface water raised orchard temperatures by 2°F and applying water through low head sprinklers increased temperatures by 4°F, as shown in Table 17. "Heating by undertree sprinklers depends on mixing heat into the layer of air that includes the trees by convection. It is very dependent on the strength of the air temperature inversion above the canopy which limits the height of the heated volume. The level of heating is also dependent on the amount of water applied. A 1°F to as much as 3°F temperature increase up to 12 feet in height can be expected under most radiative frost situations. The temperature of the applied water is quite significant in determining the protection level, and preheating the water may be an option when adequate water supplies are limiting." Evans added that "undertree sprinkling is now common in Washington state. Ambient (orchard level) air temperature increases of about 2°F are common although increases up to 4°F have been found under very strong inversion conditions." He found that "the maximum estimated increase in orchard temperature was about 1.7°C (3°F) under Central Washington conditions. The concurrent use of a wind machine has been found to add about an equal amount of temperature rise as was contributed by the undertree system, but this needs further validation." One alternative would be to heat the water (e.g., oil-fired flow through heaters, using warm ground-water or by solar heating of ponds) before distribution to the field.

Primary factors influencing the success of undertree sprinkling systems are, in approximate order of importance (Evans):

1. height and strength of temperature inversion,
2. amount and temperature of applied water, and
3. wind speed (wind removes heat).

But as Synder noted, Washington state data were obtained with deciduous fruit which is not directly comparable to citrus. Also, some California growers have observed that applying water does not raise the orchard temperature to the extent that wind machines do.

The rate and temperature of water being applied influence the amount of change in orchard temperature. Less water means less effect. Washington growers generally apply water for frost protection through impact sprinklers while San Joaquin Valley growers apply through microsprinklers. Washington growers apply 40 to 55 gallons per minute (Evans). Note in Table 17 that Brewer applied 50 gallons per minute. The rates are the same, suggesting that 2°F is a reasonable estimate for surface water and that sprinklers warm orchards even more. The temperature of the water Brewer applied was 18°C (64°F). For the coldest days, the temperature of the applied water could be substantially less than 64°F, resulting in less than a 2°F increase in orchard temperature.

Therefore, the weather model here assumes th applying surface water raises the orchar temperature by an estimated 1°F. Water appliec through sprinklers appears to add at least 2°F to the orchard temperature, the same effect as wind machines.

D. Humidity Level.

"Dew point" is the temperature, for a given pressure, to which air must be cooled before it condenses. High dew point conditions slow the loss of heat. A low dew point temperature occurs during dry conditions. With a low dew point, the orchard temperature cools more rapidly.

Southern San Joaquin Valley winter nights are often quite foggy. This implies a high dew point and weak inversion. But the fog is unpredictable from night to night and spotty from area to area. Many nights in many areas are not foggy.

Dew point is not included in the model because estimates of the inversion in Table 17 and by Synder already have taken into account the dew point and humidity levels of the San Joaquin Valley during winter nights.

E. Results: Lindcove Weather Station

Temperatures at Lincove are representative of the slightly warmer parts of the citrus region in the San Joaquin Valley. The model was applied to Lindcove daily minimum temperature data from August 1981 to September 1993. November 1 to March 15 is defined to be the cold season, so November 1 is day 1 and March 15 is day 137. For most days there are 12 observations, one each for the 12 years from 1981 to 1993, but some days have missing observations.

For most days, none of the years had temperatures below 27°F, so estimated damage due to cold for these days is zero. But consider Christmas day, which has recorded low temperatures at which cold damage occurs. For Christmas, day 55, the low temperatures are:

1981	1982	1983	1984	1985	1986
50	28	42	34	32	44
1987	**1988**	**1989**	**1990**	**1991**	**1992**
26	36	NA	24	33	34

For two years, 1987 and 1990, the low temperature is below the critical temperature of 27°F.

The probability of observing a particular low temperature equals the number of times that low temperature occurred divided by the number of observations (11). The low temperature is 24°F one year and 26°F another year. The probability that the low temperature equals 24°F is: P(T) = Nj/N or P(T = 24°F) = 1/11 = 9.09%. Similarly, P(T = 26°F) = 1/11 = 9.09%.

The relation of damage to low temperature is D(T) = $(1 - T)^{1.5}$. Recall that T is transformed to T_c =27°F = 1 and T_t = 20°F = 0. Thus,

D(T = 24°F) = D(T = 0.571)= 28.1% damage
D(T = 26°F) = D(T = 0.857)= 5.4% damage

The expected damage for Christmas day is
S(for all T below 27°F) P(T)*D(T)

P(T=24) * D(T=24) = 9.09% * 28.10%	= 2.56%
P(T=26) * D(T=26) = 9.09% * 5.41%	= 0.50%
Sum of expected damage	= 3.06%

The model shows that on Christmas day, the expected percent of oranges frozen is 3.06% of the unharvested oranges. Having applied this method to each day before Christmas led to 17% loss due to frost as of Christmas day. Multiplying the remaining 83% by the 100% unharvested and by the 3.06% damage equals an expected loss of 2.54% on Christmas day. The expected percent loss was similarly calculated for each day of the cold season. For most days, the expected loss is zero since most days did not have low temperatures below 27°F.

The next step is to estimate losses expected with wind machines. Wind machines raise orchard temperatures by an estimated 2°F. So 2°F was added to the actual minimum temperatures and the model was rerun. The result for Lindcove is that wind machines increase the percent of Valencia yield marketed fresh by 13.3% (see Table 18).

During cold periods, citrus growers apply water to as many trees as the water supply allows. Applying surface water raises orchard temperature by an estimated 1°F. To estimate the percent of fresh market yields lost due to frost while using surface water but without a wind machine, 1°F was added to the actual low temperatures and the model was rerun. Also, to estimate frost damage protection while using water and wind machines, 3°F was added to the actual low temperature before running the model. In this case, wind machines protected 7.7% of Valencia yields.

The results presented thus far equally weight the Arctic 1990-91 season which has been reported as the coldest period this century. Thus, equally weighting 1990-91 in the 12 years of temperature data overestimates the true expected losses. Evaluating several decades of weather data would lead to estimates closer to the true values. Since the 1990-91 season was so unusual and because only 12 years' data are available for Lindcove, additional fresh market yields were estimated again while excluding 1990-91 (Table 19). The results with and without 1990-91 are in stark contrast. Combining the two sets of outcomes and weighting the results without 1990 by 2/3 leads to 6.5% additional fresh sales without the application of water.

F. Results: Lamont Weather Station

The weather model was also used to evaluate Lamont weather data. For the coldest days, the lowest temperature for Lamont is 1 to 3°F colder than for Lindcove. As expected, the weather model estimates a higher level of frost damage and finds that wind machines protect a higher percentage of yield. Model results show that wind machines increase the percent of citrus marketed as fresh by approximately 30% both with and without the application of water. Although these results based on just 12 years of temperature data may overstate the level of protection offered by wind machines, it is likely that a significant level of protection is offered. This means

Table 18. Lindcove Weather Station, Tulare County: Estimated Losses Due to Frost, 1981-93 — Valencia

	Wind Machine		
	Without	With	Difference
No Water Application			
Percent Loss	19.8	6.5	13.3
With Application of Water			
Percent Loss	11.1	3.4	7.7

Table 19. Lindcove Weather Station, Tulare County: Estimated Losses Due to Frost, 1981-93 (Excluding 1990-91) — Valencia

	Wind Machine		
	Without	With	Difference
No Water Application			
Percent Loss	3	0	3
With Application of Water			
Percent Loss	1	0	1

that wind machines are likely to be profitable in cold areas such as Lamont.

G. Relation Between Previous Studies and the Weather Model

Hasbargen concluded in 1978 that wind machines increase grower yields by 9.1% to 16.4%. His 1988 study estimated yield improvements to be 9.45% with wind machines. These are percentages of total yield. Both are based on grower interviews and FCIC insurance loss ratios with and without wind machines. Both estimate that wind machines increase the percent of crop marketed as fresh by 6.75% and they add additional yield benefits for higher quality, better yields in following years, and higher prices during severe frosts.

This study estimates that wind machines, on average, increase the value of Navel yields by 8.0% (6.0% additional fresh + 2.0 higher fresh price) and the value of Valencia yields by 9% (7.0% + 2.0%). The intent of the weather model was to estimate the average frost protection and the protection for each site where historical minimum temperature data is available. The model gives plausible estimates of protection for different minimum temperatures.

Both private and federal frost insurance is available for citrus in California. The programs are similar, but there are some significant differences. As a result, growers need to assess the benefits and costs for each before deciding whether or not to insure. This section begins with an introduction to the general concepts of crop insurance.

Some growers have considered using frost insurance in place of wind machines to protect citrus revenues. This sophisticated approach to risk management acknowledges that farmers are in business to produce profits, not just fruit. Insurance is a way to directly replace revenues lost due to frost damage, whereas using wind machines is an indirect approach that requires producing, harvesting and marketing oranges. Normally, insurance is not a "profitable" investment because indemnities received by farmers must total less than the insurance premiums paid or the insurance companies would go out of business. However, crop insurance is subsidized by the government, thus farmers pay only part of the total cost. As a result, crop insurance, unlike normal insurance, could in theory be a profitable investment for farmers; more revenues could be received in insurance indemnities than are paid out in premiums over time. The normal benefit of insurance, a reduction of risk, is also received by farmers with crop insurance. Thus, crop insurance may be a very useful risk management tool for growers. This issue is addressed below in evaluations of private and Federal Crop Insurance Corporation policies.

Private Insurance Lowers Risk and Expected Returns

Frost insurance is considered here assuming that growers maximize risk-adjusted profits, which are profits minus a risk premium. The risk premium is a measure of each grower's attitudes concerning the tradeoff between risk and return.[25] Risk is the degree of variability in revenues due to frost damage. The risk premium may be different for each grower because each person has a unique situation and attitude toward risk.

The risk premium depends on the probability and amount of possible losses and on a grower's aversion to these possible losses. The risk premium is higher when profits vary more widely and when growers more strongly prefer stable incomes. Growers who receive all or most of their income from one crop face significant risk, thus they may be more likely to insure. Growers who are diversified into other crops and businesses are generally less willing to insure; they face less income risk because citrus losses may be offset by higher profits in other crops or businesses.

Frost insurance is one tool to lower the risk of significant drops in revenues caused by yield losses. Insurance reduces the variation of income of insured growers over time by paying them indemnities during years in which yields are significantly reduced. While frost insurance does not protect against low prices, it does raise income during years of severe frost and does guarantee a certain level of income should the entire crop freeze.

Virtually all investments involve a tradeoff between risk and return; higher risk is associated with higher expected return, and lower risk implies lower average profits. Private insurance is no different. An insured grower's profits are lower, on average, by an amount up to the level of insurance premiums paid. To survive economically, insurance companies set premiums to cover all indemnities they expect to pay plus their operating costs and a profit margin. For growers to make "profits" on private insurance, indemnities received must be higher than premiums paid. On the whole, this could only occur if insurers' profits were negative. The fact that, on average, insurance companies do cover their operating costs and do earn profits requires that growers, on average, earn lower profits by insuring. Nevertheless, insurance is worthwhile for growers if the lower profits are outweighed by the reduction in risk.

For an insurance company, *premium collected = indemnity paid + insurer's costs + insurer's profits*. The insurer's costs and profits are positive; hence the premium rate is higher than the indemnity rate. The government subsidy of crop insurance could possibly outweigh enough of an insurer's costs and profits so that average indemnities equaled or exceeded premiums. This makes the insurer's situation:

Premium + Federal Subsidy = Indemnity +
Insurer's Costs + Profits

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25 For example, suppose a grower could choose between receiving a certain $80 per acre or an alternative with a 50% chance of receiving $0 and a 50% chance of receivng $200. Growers maximize expected profits minus a risk premium [$E(\pi)$ - RP]. In this example, profits are $20 higher for the risky case. A grower will choose the certain $80 if his or her risk premium exceeds $20. Growers more willing to bear risk in return for higher expected profits may choose the uncertain option.

If Subsidy > Insurer's Costs and Profits,
then Premium < Indemnity

In this case, crop insurance would actually be a profitable investment for growers in that they would receive more in indemnity payments over time than they would pay out in premiums.

The remainder of this section estimates the effects of federal and private citrus frost insurance on growers' risk and returns based on the experience of recent decades.

Federal Crop Insurance Corporation

The FCIC is an agency of the US Department of Agriculture. The FCIC either directly insures citrus growers or reinsures: subsidizes private insurance companies and fixes their premiums. Eighty percent of California citrus insured by the FCIC is reinsured. The companies which reinsure are required to charge the same rates so they compete on service.

For citrus, the FCIC classifies California into five risk classes by geographic area, with orchards in class one being the least susceptible to frost damage and orchards in class five the most susceptible. The FCIC subsidizes 30% of the premium for the two highest risk classes and 20% for risk classes one through three. This means growers pay only 70-80% of the actual premium costs for their crop insurance.

When insuring through the FCIC, growers choose:

- to use their own or the county ten year average yield,
- which varieties to insure (in practice, a grower must insure all the acreage of a variety within a county),
- their desired coverage level (50, 65, or 75% of the 10 year average fresh yield),
- and their price election (California growers nearly always choose the maximum offered).

The FCIC determines the premium rate by calculating the historical indemnity rate (by variety, county, risk class, and protection level), adds one percent, and subtracts the subsidy. This is illustrated in the hypothetical example below for a 20% subsidy.

Historic Average Ratio: Indemnity/Liability		10.0%
Catastrophic Load	+	1.0%
Sum	=	11.0%
Subsidy lowers rate by 20%	x	80%
FCIC subsidized rate	=	8.9%

In this example, the historical indemnity rate is 10.0% yet the premium is only 8.9%. This means that, over time, growers are expected to receive profits of $1.10 for every $100 of insurance. Thus, orchards with average or higher risk of frost damage (compared to the orchards previously insured by FCIC) will make money by insuring. Only orchards with below-average risk will pay more in premiums than they receive in indemnities. Also, insurance is more likely to be profitable for orchards in the highest risk classes which receive a 30% subsidy.

The risk classes are set by geographic area. Once an orchard is planted, the grower has no influence over its risk class. Frost damage may vary widely within a risk class. Within any class, the more susceptible to frost an orchard is, the more profitable it is to insure.

Growers with high yields are penalized in that growers with low yields may use the county average and thus receive larger indemnities than if they had insured based on their actual yields. This raises the premium rates for all growers. This partially

Table 20. FCIC and Private Citrus Frost Insurance: A Comparison

	Private	FCIC
Average Premium Rate	5.0 %	4.5 %
Deductible (% of liability)	10 % -15 %	25 %
Coverage Limit	$2,000	Yield * FCIC price (is less than $2,000)
Advance Sign-up	21 days	12 months
Paperwork	Less	More

Source: Insurance representatives who issue private and FCIC policies.

26 Insurance representatives report that over the past 10 years, about 2.5% of Tulare citrus was insured through the FCIC (1,479 acres insured/60,000 acres of citrus) and less than 1% of Kern citrus was insured with the FCIC.

explains why California citrus growers favor private policies over FCIC insurance. Approximately ten times more growers insure privately than through the FCIC.[26] Table 20 presents additional reasons for citrus growers' preferences for private insurance.

A. Coverage Levels

FCIC insurance coverage (liability) levels are presented in Table 21. The liability for private insurance is calculated the same way, although the price level may be higher. The maximum quantity of fruit which can be insured is 75% of the previous 10-year average fresh yield.[27] The coverage amount is the quantity of insured fruit times the FCIC price.

Frost insurance premiums equal the premium rate times the coverage (liability) amounts.[28] Future indemnities equal the future indemnity rate times the coverage amount. The indemnity rate is the dollars received per $100 of liability. Insurance is profitable for a grower if the indemnity rate exceeds the premium rate. While the premium rate is known, the future indemnity rate in unknown as it depends on future temperatures and other conditions.

This study evaluates the profitability of frost insurance for orange growers by estimating the future indemnity rate two ways. One uses historical premiums and indemnities. The other is based on current premiums and historical county yields.

B. Method 1: Actual FCIC Indemnities and Premiums.

Comparing actual indemnities received and premiums paid by orange growers over several years provides a direct estimate of the profitability of insurance. FCIC indemnities are presented because private indemnities were not available. The profitability of insurance is the difference between premiums and liabilities.

For all crops insured from 1981 to 1990, California farmers received $1.45 in indemnities from FCIC supported policies for every $1.00 in premiums (American Association of Crop Insurers). Most (68%) of these claims were paid to growers for excess moisture. In general, the FCIC subsidies enabled California farmers to increase their average profits with FCIC insurance.

Citrus growers, however, did not make money during this period by insuring through the FCIC. The 1980s were relatively warm, and growers suffered less frost damage compared to other decades. From 1981 to 1990, California citrus growers received $0.49 in indemnities for every $1.00 in premiums (American Association of Crop Insurers). The 1990-91 freeze raised the ten year average ratio to $0.57 in indemnities for every $1.00 in premiums. Even accounting for the 1990-91 freeze, the average insured grower would have lost $0.43 for every dollar paid in FCIC premiums.

A shortcoming of using only FCIC actual indemnities and premiums is that orchards which are insured generally are those most susceptible to frost damage. Thus, the historical indemnity rate is higher than it would be had all growers insured. It is difficult for the FCIC or any insurer to know any single grower's risk of frost damage. The FCIC attempts to charge higher premiums to higher risk growers by classifying all orchards into one of five risk classes and including an experience factor. The experience factor is supposed to indicate whether a particular grower has an unusually good or bad record of collecting indemnities. But in practice, most orchards are in risk classes two and three. Also, the experience factor is set to 1.0 for nearly all growers, regardless of actual experience or protection practices.

Due to these shortcomings and the relatively small insurance data set available, the indemnity rate was estimated by using historical county yields and simulating the indemnities that would have been received had all growers insured. This method is

Table 21. FCIC Citrus Frost Insurance: San Joaquin Valley, 1993-94 Coverage Amounts

	Total Yield	Fresh Yield	Fresh Yield	Coverage Level	Unit Guarantee	Price	Coverage Amount
Variety	crt/ac	(%)	crt/ac	(%)	cartons/ac	$/crt	$/ac
Navel	714	77	550	75	413	4.00	1,652
Valencia	730	65	475	75	356	4.50	1,602

Sources: Yields: Navel and Valencia Orange Administrative Committees. Coverage Level: Available levels are 50, 65, and 75%. Price is the maximum price allowed by the FCIC.

27 For example, suppose current yield of Valencia is 850 cartons per acre, the ten year average is 800, historic fresh shipments are 50% of yield and the grower chooses the 75% insurance option. Insurance indemnities would be collected if fresh shipments of Valencias fell below 300 cartons per acre (800 cartons/acre *50% fresh *75% coverage).

28 The coverage amount is the dollar value of the insured fruit.

based on data from 1955 to 1992, so both warm and cold decades are included. Also, county yields include the yields of all growers, not just the growers most susceptible to frost. Using county data over the extended period is believed to give more representative results.[29] Therefore, the next section presents this method for private and federal insurance.

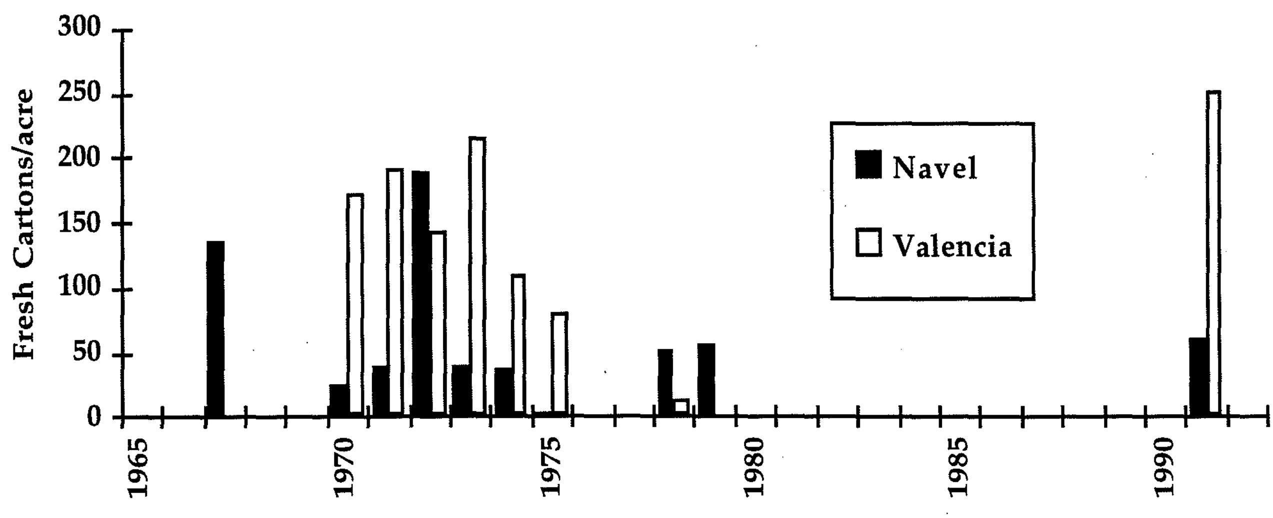
C. Method 2: Simulated FCIC and Private Indemnities Based on Historical County Yields.
A more realistic indemnity rate was estimated by using fresh market yields of Kern and Tulare counties from 1955-56 to 1991-92. First, the quantity of insured fruit was estimated by computing the 10-year average of fresh yields and multiplying it by the coverage level of 75% for FCIC and 85% or 90% for private policies. Next, the quantity of indemnities was estimated. It equals the quantity insured minus actual fresh yield.[30] Finally, the average indemnity rate per acre is the total quantity of indemnities divided by the total quantity of insured fruit.

The results of the simulation analysis are presented in Figure 4 for Kern County and 5 for Tulare County. The figures show the estimated quantity of indemnities (expressed in terms of cartons per acre) that growers would have received if they had been insured in each year. For both counties, there were no losses severe enough to trigger insurance indemnities during the 1980's, but growers would have received indemnities in several years during the 1970's, especially in Kern County. Also, the freeze of 1990-91 resulted in the biggest losses in several decades.

Private vs. FCIC Citrus Frost Insurance

In this section the relative risks and returns of FCIC and private frost insurance policies are compared. To do so, indemnities for FCIC and private policies were simulated just as described above. Identical yields and orange price levels are used for both types of insurance policy. However, differences in the two types of policy must be considered when making comparisons. In particular, the lower deductible for private policies means that more indemnities will be received by growers over time using private, compared to FCIC insurance.

Figure 4. Kern County Citrus, Quantity of Indemnities per Year with FCIC Insurance

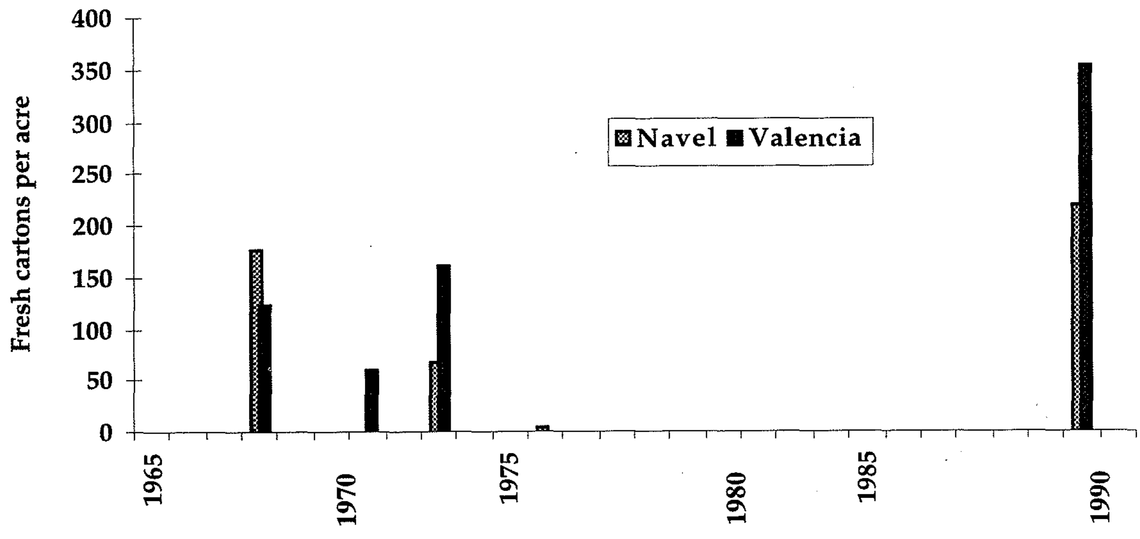


In Figures 4 and 5, the FCIC indemnities are simulated from county yields.

29 A limitation of using county data is that yields of any single grower may vary more than the county average. Generally, the more acreage a grower has, the more the grower's yields will rise and fall with the county average and the more similar will be the indemnity rates.

30 For example, if the insurance liability is 300 cartons per acre and the actual fresh yield is 240 cartons, the indemnity amount received by the grower is 60 cartons per acre times the contract price.

Figure 5. Tulare County Citrus, Quantity of Indemnities per Year with FCIC Insurance



The frost insurance policies of two private companies located in Fresno are analyzed as examples: L. J. Linder, Inc. and Rural Community Insurance Services (formerly Crop Hail Management). For both insurers, the premium rate for Navel and Valencia oranges with frost protection is 5.0% of the liability. For both firms, growers qualify for this lower premium rate if they use either wind machines or microsprinklers. All acreage of a variety within a county must be insured. The two insurers have different schedules of indemnity rates. The deductible is the first 10% of yield losses for Linder and the first 15% for Rural Community. The indemnity for Linder is 10% less than actual frost damage from 10 to 70% of average yields and 1.5% indemnity for every 1% frost loss over 70% of average yields. The indemnity schedule for Rural Community increases from a 5% indemnity for a 15% frost loss up to 100% indemnity for a 70% loss.

To judge the value of each type of insurance policy, a simulation was developed to estimate the total revenues per acre that a grower would receive each year from the sale of undamaged oranges plus all insurance indemnities from damaged fruit. These simulated on-tree revenues are presented in Figure 6 for Kern County and Figure 7 for Tulare County. Three insurance alternatives are considered: having no insurance, FCIC policies, and private policies. For the case of no insurance, total revenues per acre equal the county fresh yield times the on-tree fresh price. The FCIC and private policy revenues are computed by subtracting the insurance premium and adding any indemnity received to fruit sales revenues. For both types of insurance, the coverage level is 75% of the 10-year average fresh yield times the fresh price. The premium is the 1993-94 rate times the coverage amount.

The results in Figures 6 and 7 illustrate the higher revenues received when investing in private policies. Private insurance premiums are slightly higher than FCIC premiums, but the indemnities paid by private policies are significantly above those paid by the FCIC. Thus, total revenues received by growers are highest in most cases when using private insurance. Figures 6 and 7 also illustrate that even with insurance, citrus growers face significant variation in revenues from year to year. This is due to yield and price changes from year to year.

The estimated risk and returns of FCIC and private frost insurance policies are summarized in Table 22. Risk is measured by the standard deviation of annual revenues over the data period. Revenues per acre equal on-tree sales revenues, minus the insurance premium paid, plus any insurance indemnities received.

As shown in Table 22, expected revenues are higher when using private insurance than FCIC frost insurance in both counties and for both varieties of orange. This is consistent with Figures 6 and 7 and with citrus growers' expressed preferences for private versus FCIC frost insurance. The FCIC only insures frost damage which exceeds 25% of the 10-year average of fresh yields. Private policies begin paying once frost damage exceeds 10 or 15% of average fresh yield and Rural Community pays 100% of liability once damage reaches 70% of the amount insured. A lower deductible and higher payment rates for all levels of damage lead private insurers to pay a higher level of indemnities.

In general, the more an orchard is susceptible to frost, the more favorable are private insurance policies. For example, Tulare County Navel yields suffered relatively few freeze losses, so total revenues with FCIC and private policies are similar. In contrast, Kern County Valencia yields varied greatly, and growers with private policies received over $100 per acre more revenues than did growers with FCIC insurance.

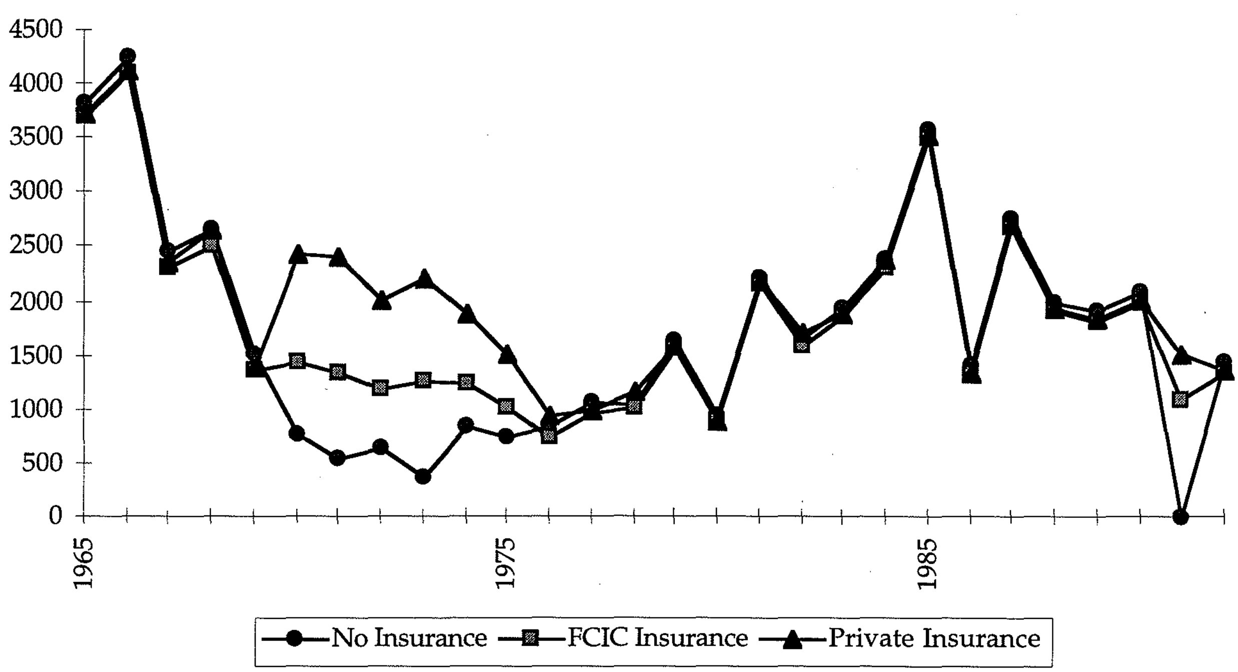
Also, some private insurers pay greater indemnities than others. All companies which reinsure are required by the FCIC to charge the same premium rate and offer the same protection. This is not so with private policies. Although the two insurers in this study both charged the same premium rate, Rural Insurance's indemnity schedule causes it to pay more often for frost losses than does L. J. Linder.

For private insurance, growers using microsprinklers qualify for the same lower rate they pay if they have wind machines. The use of surface irrigation, however, does not qualify for the lower premium rate. Therefore, unless a lower premium rate can be negotiated, it is less cost-effective to insure orchards protected by surface irrigation.

Total revenues received by growers are generally more stable when using private policies rather than FCIC policies. Private policies lower the variance in income more because they pay indemnities for milder freezes; FCIC insurance only raises the income of insured growers during years with freeze losses greater than 25% of average yields.

Finally, frost insurance does not appear to be a "profitable" investment for orange growers. This conclusion is based on simulation results which show that total indemnities received by growers are less than total insurance premiums paid over time. However, frost insurance does reduce risk in that revenues are made more stable over time. For growers wanting to reduce risk, private frost insurance is superior to FCIC frost insurance because private policies lead to higher revenues and lower variation in revenue levels over time than does FCIC insurance.

Figure 6. Kern County Valencia Revenues



Figures 6 and 7, revenues equal on-tree values, minus the insurance premium paid, plus indemnities received. Insurance indemnities for each policy are simulated from historical county yields. The premium is the 1993-94 rate. Values for all years are converted to 1994 dollars.

Figure 7. Tulare County Valencia Revenues

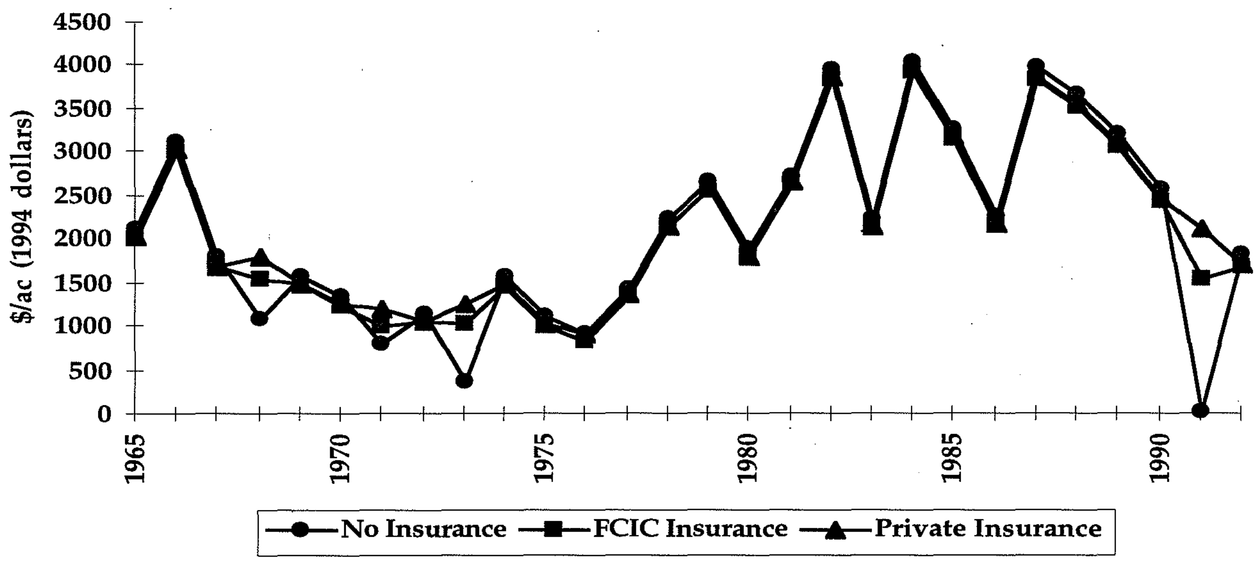


Table 22. Insurance Risk and Returns: Estimated Average and Variation of Revenues per Acre for Alternative Insurance Policies

	FCIC	Rural Community	Linder
		NAVEL	
Kern			
Expected Revenues	$1,642	$1,765	$1,627
Std. Dev.	674	622	674
Tulare			
Expected Revenues	1,981	2,008	1,956
Std. Dev.	620	622	596
		VALENCIA	
Kern			
Expected Revenues	$1,796	$2,028	$1,912
Std. Dev.	864	806	819
Tulare			
Expected Revenues	2,116	2,227	2,181
Std. Dev.	951	896	921

Revenues per acre equal on-tree revenues minus insurance premiums plus insurance indemnities.
Expected revenues are average revenues for the data period. Std. Dev. is the standard deviation of total revenues.

SUMMARY OF RESULTS

This study evaluates the effects of wind machines and frost insurance on San Joaquin Valley citrus growers' expected revenues and risk. The current cost-effectiveness of each frost risk management tool is estimated using actual cost data and simulated benefits. The results are representative of those a typical grower would get in a similar analysis. The methods are presented in a straightforward manner so that growers can follow them when making their own decisions regarding whether to invest in either of these risk tools.

The costs of wind machines and insurance are estimated here by projecting from historical data collected by surveying people in the business. The costs for wind machines are the after-tax fixed and variable costs of owning and operating the equipment. Insurance costs are the premium rate times the coverage amount.

The benefits of wind machines and insurance are more difficult to estimate than are costs. This study estimated the average level of benefits and offers guidelines for how the benefits vary by citrus variety, winter temperatures, and yield. Therefore, alternative methods are used to evaluate the average and range of benefits across different conditions.

The benefits of wind machines — the additional net revenues received by growers — are evaluated based on previous studies and conversations with citrus growers, managers, and Cooperative Extension Farm Advisors. Also, a weather model based on Florida cold chamber experiments is used to simulate average protection and the level of protection for two sites where temperature data is available. Still lacking is long-term comparable field trials with and without wind machines.

The financial benefits of insurance — the indemnities received minus premiums paid — are evaluated with two methods. The first analysis, based on FCIC historical premiums and indemnities, probably understates the future indemnity rate because data are available only for the 1980s, a decade slightly warmer than normal. Thus, the second method, which simulates indemnities based on historical Kern and Tulare County fresh yields, provides a valid comparison between federal and private insurance policies because identical methods and yields are applied to each policy. The non-financial benefit of insurance — risk reduction — is shown to exist as well.

Wind Machine Results

New wind machines are not "profitable", on average, but might be for colder areas. Holding wind and other variables constant, a colder area within the citrus belt can expect greater frost protection from wind machines. Therefore, this study estimates break-even frost protection levels for each type of wind machine. Citrus managers can estimate the actual frost protection of wind machines for each of their orchards and compare this estimate with the breakeven protection level reported in Table 1. If the actual frost protection is greater than the breakeven value, then the wind machine is profitable.

New 125 hp diesel and propane wind machines are profitable for an average orchard if they increase fresh Navel yields by 8.1% and fresh Valencia yields by 9.7%. This is equivalent to stating that new propane wind machines pay for themselves if they lead to an additional 45 cartons per acre being sold in the fresh market each year for Navel and 46 cartons per acre for Valencia. In this study, it was estimated that the probability of profits occurring was about 19% for new propane wind machines used to protect navel oranges and about 30% for Valencias.

Thus, for average San Joaquin Valley orchards, new wind machines are not profitable. New propane wind machines lower annual profits by $47 per acre for Navel orchards and $52 per acre for Valencia orchards. Existing electric machines are not profitable, but existing diesel machines *are* profitable about 65% of the time.

Citrus growers lose profits by continuing to operate existing electric wind machines supplied by Southern California Edison. The annual cost of operating a 100 horsepower electric wind machine supplied by SCE is $60 per acre per year higher than the annual costs of a new diesel or propane wind machine. For orchards in which wind machines give high levels of protection, growers would raise profits $60 per acre by replacing SCE electric machines with new diesel or propane machines. For all other orchards, growers would maximize profits by selling SCE electric machines and not replacing them. In every case, citrus growers would increase profits by liquidating existing electric wind machines supplied by SCE.

In locations where wind machines offer high levels of protection, growers would maximize profits by continuing to operate electric machines supplied by PG&E. For all other sites, growers increase profits by selling electric wind machines supplied by PG&E and not replacing them.

New diesel and propane machines currently have similar annual costs. However, there are additional risks with propane machines. Propane fuel is not always available in the winter and its price varies more than diesel prices. Yet, these risks for propane machines could be more than offset by potential hikes in the price of diesel fuel.

Wind machines reduce the uncertainty and variability of fresh citrus yields. More stable yields and revenues especially benefit undiversified and highly indebted growers. If expected returns from wind machines are negative for any site, this amount can be viewed as the "risk premium" growers must pay for more stable yields and revenues.

Insurance Results

Grower profits, on average, are lower when insuring than when not insuring. In return for the premiums paid, insurance lowers the risk of revenue losses due to frost. For growers willing to bear any risk to earn higher expected profits, insurance is not a viable option. However, for highly risk averse growers, the costs of insurance may be worthwhile because insurance reduces their risk exposure.

Grower profits are lower when insuring because insurance companies set premiums to cover expected indemnities plus their costs. Also, orchards which generally receive the most frost damage are more often insured. However, insurers are not able to adequately set premiums in proportion to risk. This raises the rates for all insured growers.

Private frost insurance is superior to federal frost insurance. A simulation based on county yields showed that private insurance leads to higher profits and greater risk protection. This held for Navel and Valencia varieties and Kern and Tulare counties. This result is consistent with growers' preferences. Only 1% to 2% of San Joaquin Valley citrus orchards have federal frost insurance

The profitability of insurance varies with the weather. Relatively fewer indemnities were paid to growers in the 1980s when winters were slightly warmer than in previous decades. Federal citrus frost insurance traditionally has not been profitable for growers and this was particularly true during the 1980s. From 1980-81 to 1989-90, for every $1 in premiums citrus growers paid for federal insurance, growers received $0.49 in indemnities. The 1990-91 freeze raised the ratio by only 8%, bringing the ten year FCIC ratio to $0.57 in indemnities per $1 in premiums. These low indemnity rates support the finding that even with the federal subsidy, growers with federal insurance receive few indemnities relative to the premiums they pay. Generally, the higher the expected level of frost damage, the more favorable are private policies.

General Conclusions

While wind machines protect against low levels of frost damage, frost insurance safeguards incomes against losses from catastrophic freezes. Thus, the decision to insure is largely independent of the decision to install wind machines, and vice versa. The Federal Crop Insurance Corporation and private insurance companies set higher premium rates for orchards without frost protection. The rate differential is based on previous indemnities paid for frost damage with and without frost protection. The FCIC and private insurers set premium rates to earn about the same profit level for policies covering orchards with and without frost protection. As a result, insurance lowers growers' profits about the same regardless of frost protection. Equivalently, if a grower believes the lower risks faced when insured offset the lower expected returns, the grower should insure all orchards, with and without wind machines.

Applying water offers significant frost protection. Microsprinklers offer similar amounts of protection as do wind machines. Both raise orchard temperatures about 2°F and more for strong inversions. Both wind machines and microsprinklers qualify as frost protection for private insurance. Also, field experiments have measured a difference in orchard temperatures with and without the application of water. Adding surface water also warms orchards, but not as much as microsprinklers.

Kern County citrus yields vary more than Tulare County yields and Valencia yields vary more than Navel yields. Also, Valencia yields are more susceptible to frost. This indicates that frost protection, either wind machines or sprinklers, or frost insurance should be considered for oranges produced in Kern County. The least susceptible production appears to be Navel oranges in Tulare County, especially in warmer areas such as Lindcove.

Given the results presented here, new wind machines are not cost-effective, on average. Yet, wind machines may be profitable for some orchards in colder sites. Crop insurance clearly offers benefits for oranges in Kern County, but may not be "profitable" in Tulare County. In all cases, insurance reduces risk, which is a desirable feature that may justify the cost to San Joaquin Valley citrus growers.

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APPENDIX

Table A1	New Diesel Wind Machines 125 hp - Annual Ownership and Operating Costs New Diesel Wind Machines 125 hp, Navel - Benefits,Additional Value of Navel Production New Diesel Wind Machines 125 hp, Valencia - Benefits, Additional Value of Valencia Production
Table A2	New Propane Wind Machines 125 hp, Annual Ownership and Operating Costs New Propane Wind Machines 125 hp, Navel - Benefits, Additional Value of Navel Production New Propane Wind Machines 125 hp, Valencia - Benefits, Additional Value of Valencia Production
Table A3	Existing Electric Wind Machines 100 hp, Pacific Gas & Electric (PG&E), Annual Ownership and Operating Costs Existing Electric Wind Machines 100 hp, Navel - Benefits, Additional Value of Production Existing Electric Wind Machines 100 hp, Valencia - Benefits - Additional Value of Production
Table A4	Existing Electric Wind Machines 100 hp, Southern California Edison (SCE) - Annual Ownership and Operating Costs Existing Electric Wind Machines 100 hp, Navel - Benefits, Additional Value of Production Existing Electric Wind Machines 100 hp , Valencia - Benefits, Additional Value of Production
Table A5	Existing Diesel Wind Machines 125 hp, Annual Ownership and Operating Costs Existing Diesel Wind Machines 125 hp, Navel - Benefits, Additional Value of Navel Production Existing Diesel Wind Machines 125 hp, Valencia - Benefits, Additional Value of Valencia Production
Table A6	Existing Propane Wind Machines 125 hp, Annual Ownership and Operating Costs Existing Propane Wind Machines 125 hp, Navel - Benefits, Additional Value of Navel Production Existing Propane Wind Machines 125 hp, Valencia - Benefits, Additional Value of Valencia Production

Table A1. New Diesel Wind Machines 125 hp - Annual Ownership and Operating Costs

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ownership Costs ($):															
Purchase & Installation	19,000														
Downpayment	4,000														
Unpaid Balance	15,000														
Annual Loan Payment	3,757	3,757	3,757	3,757	3,757										
Interest Payment	757	757	757	757	757										
Principle Payment	3,000	3,000	3,000	3,000	3,000										
Property Taxes	192	179	166	154	144	134	124	116	107	100	93	86	80	75	70
Insurance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Total Ownership costs	7,979	3,967	3,956	3,946	3,937	172	164	158	152	146	142	138	134	131	129
Operating Costs:															
Diesel Fuel	570	610	653	698	747	799	855	915	979	1,048	1,121	1,200	1,284	1,374	1470
Labor	304	319	335	352	370	388	407	428	449	472	495	520	546	573	602
Repairs	0	0	100	15	110	116	122	128	134	141	148	155	163	171	180
Maintenance	75	79	83	87	91	96	101	106	111	116	122	128	135	141	148
Total Operating Costs	949	1,008	1,170	1,242	1,318	1,399	1,485	1,576	1,673	1,777	1,886	2,003	2,127	2,259	2,400
Total Costs	8,928	4,975	5,126	5,188	5,255	1,571	1,649	1,734	1,825	1,923	2,028	2,141	2,262	2,391	2,529
Deductible expenses:															
Depreciation	2,714	2,714	2,714	2,714	2,714	2,714	2,714	0	0	0	0	0	0	0	0
Interest	757	757	757	757	757	0	0	0	0	0	0	0	0	0	0
Property Taxes	192	179	166	154	144	134	124	116	107	100	93	86	80	75	70
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Operating Costs	949	1,008	1,170	1,242	1,318	1,399	1,485	1,576	1,673	1,777	1,886	2,003	2,127	2,259	2,400
Total Deductions	4,642	4,689	4,841	4,902	4,969	4,285	4,364	1,734	1,825	1,923	2,028	2,141	2,262	2,391	2,529
Tax Saving	1,857	1,876	1,936	1,961	1,988	1,714	1,745	694	730	769	811	856	905	956	1,011
Salvage Value															7,500
Depreciated Value															0

Table A1 *(Continues - p.2)*

	Annual Ownership and Operating Costs														
	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital Gain/loss															7,500
Tax on gain/write-off															3,000
Total After-tax costs:	7,071	3,099	3,190	3,227	3,267	-143	-96	1,040	1,095	1,154	1,217	1,285	1,357	1,434	–2,983
Discount factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present value	6,547	2,657	2,532	2,372	2,224	-90	-56	562	548	534	522	510	499	488	–940
Net Present Value	18,909														
Equivalent Annual Annuity	2,209														
Acres per wind machine	10														
Equiv. Annuity ($/acre/yr)	221														

Interest Rate	8.00%
Diesel Fuel	
Price ($/gal.)	0.95
Fuel Usage (gal./hour)	6
Time Operated (hours/year)	100
Annual Diesel Fuel Costs	$570
Property Tax Value (new)	$16,000
Property Tax Rate	1.20%
Depreciation Rate	7.00%
Corporate Inc. Tax Rate	40.00%
Inflation (projected)	
Diesel Fuel (%)	7.00%
Labor (%)	5.00%
Repairs (%)	5.00%
Maintenance (%)	5.00%

Table A1. *(Continues - p. 3)*

New Diesel Wind Machines 125 hp, Navel - Benefits: Additional Value of Navel Production ($/Acre)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	714	721	728	736	743	750	758	766	773	781	789	797	805	813	821
Percent Fresh (%)	77	77	77	77	77	77	77	77	77	77%	77	77	77	77	77
Fresh Yield	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Additional Fresh (%)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Add'l Quant (cartons/acre)	33	33	34	34	34	35	35	35	36	36	36	37	37	38	38
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	165	173	182	191	201	211	222	233	244	257	270	283	298	313	328
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Add'l Rev. ($/acre/year)	55	58	61	64	67	70	74	78	81	86	90	94	99	104	109
Sum Add'l Rev. ($/acre/yr)	220	231	243	255	268	281	295	310	326	342	360	378	397	417	438
After Tax Rev. ($/acre/yr)	132	139	146	153	161	169	177	186	196	205	216	227	238	250	263
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	317
Present Value per period ($)	122	119	116	112	109	106	103	101	98	95	93	90	88	85	83
Present Value ($)	1,520														
Equiv. Annuity ($/acre/yr)	178														
Add'l Rev. (aft-tax,$/acre/yr)	178														
Cost (after-tax, $/acre/yr)	221														
Profit (after-tax, $/acre/yr)	**($43)**														
Breakeven Levels															
Additional Fresh	8.00%														
Yield (cartons/acre)	685														
Total yield	890														
On-tree Fresh Price ($/carton)	6.20														

Annual Yield Increase	1.00%
Annual Fresh Price Increase	4.00%

Table A1 . *(Continues - p. 4)*

New Diesel Wind Machines 125 hp, Valencia - Benefits: Additional Value of Valencia Production ($/Acre)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	730	737	745	752	760	767	775	783	790	798	806	814	823	831	839
Percent Fresh (%)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Fresh Yield	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Additional Fresh (%)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Add'l Quant (cartons/acre)	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	166	174	183	192	202	212	223	234	246	259	272	285	300	315	331
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Add'l Rev. ($/acre/year)	47	50	52	55	58	61	64	67	70	74	78	81	86	90	94
Sum Add'l Rev. ($/acre/yr)	214	224	236	247	260	273	287	301	316	332	349	367	385	405	425
After Tax Rev. ($/acre/yr)	128	135	141	148	156	164	172	181	190	199	209	220	231	243	255
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value per period ($)	119	115	112	109	106	103	100	98	95	92	90	87	85	83	80
Present Value ($)	1,475														
Equiv. Annuity ($/acre/yr)	172														
Add'l Rev. (aft-tax,$/acre/yr)	172														
Cost (after-tax, $/acre/yr)	221														
Profit (after-tax, $/acre/yr)	**($49)**														
Breakeven Levels															
Additional Fresh	9.50%														
Yield (cartons/acre)	608														
Total Yield	935														
On-tree Fresh Price ($/carton)	6.40														

Annual Yield Increase	1.00%
Annual Fresh Price Increase	4.00%

Table A2. New Propane Wind Machines 125 hp - Annual Ownership and Operating Costs

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ownership Costs ($):															
Purchase & Installation	15,000														
Downpayment	3,000														
Unpaid Balance	12,000														
Annual Loan Payment	3,005	3,005	3,005	3,005	3,005										
Interest Payment	605	605	605	605	605										
Principle Payment	2,400	2,400	2,400	2,400	2,400										
Property Taxes	160	149	139	129	120	111	104	96	90	83	78	72	67	62	58
Insurance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Total Ownership costs	6,196	3,186	3,177	3,169	3,162	150	144	139	134	130	126	123	121	119	117
Operating Costs:															
Propane Gas	1,105	1,160	1,218	1,279	1,343	1,410	1,481	1,555	1,633	1,714	1,800	1,890	1,984	2,084	2,188
Propane Tank Rental	80	84	88	93	97	102	107	113	118	124	130	137	144	151	158
Labor	185	194	204	214	225	236	248	260	273	287	301	316	332	349	366
Repairs	0	0	100	105	110	116	122	128	134	141	148	155	163	171	180
Maintenance	75	79	83	87	91	96	101	106	111	116	122	128	135	141	148
Total Operating Costs	1,445	1,517	1,693	1,778	1,867	1,960	2,058	2,161	2,269	2,382	2,501	2,627	2,758	2,896	3,041
Total Costs	7,641	4,703	4,870	4,947	5,028	2,110	2,202	2,299	2,403	2,512	2,628	2,750	2,879	3,015	3,158
Deductible expenses:															
Depreciation	2,143	2,143	2,143	2,143	2,143	2,143	2,143	0	0	0	0	0	0	0	0
Interest	605	605	605	605	605	0	0	0	0	0	0	0	0	0	0
Property Taxes	160	149	139	129	120	111	104	96	90	83	78	72	67	62	58
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Operating Costs	1,445	1,517	1,693	1,778	1,867	1,960	2,058	2,161	2,269	2,382	2,501	2,627	2,758	2,896	3,041
Total Deductions	4,384	4,446	4,613	4,690	4,771	4,253	4,345	2,299	2,403	2,512	2,628	2,750	2,879	3,015	3,158
Tax Savings	1,753	1,778	1,845	1,876	1,909	1,701	1,738	920	961	1,005	1,051	1,100	1,152	1,206	1,263
Salvage Value															7,500

Table A2 *(Continues - p. 2)*

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Depreciated Value															0
Capital Gain/loss															7,500
Tax on gain/write-off															3,000
Total After-tax costs:	5,887	2,925	3,025	3,071	3,120	409	464	1,380	1,442	1,507	1,577	1,650	1,727	1,809	-2,605
Discount factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present value	5,451	2,508	2,401	2,257	2,123	258	271	745	721	698	676	655	635	616	-821

Net Present Value	19,195
Equivalent Annual Annuity	2,243
Acres per wind machine	10
Equiv. Annuity ($/acre/yr)	224
Interest Rate	8.00%
Propane Fuel	
Price ($/gal.)	0.85
Fuel Usage (gal./hour)	13
Time Operated (hours/year)	100
Annual Propane Fuel Costs	$1,105
Property Tax Value (new)	$13,350
Property Tax Rate	1.20%
Depreciation Rate	7.00%
Corporate Inc. Tax Rate	40.00%
Inflation (projected)	
Propane Fuel (%)	5.00%
Propane Tank (%)	5.00%
Labor (%)	5.00%
Repairs (%)	5.00%
Maintenance (%)	5.00%

Table A2. *(Continues - p. 3)*

New Propane Wind Machines 125 hp - Navel - Benefits: Additional Value of Navel Production ($/Acre)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	714	721	728	736	743	750	758	766	773	781	789	797	805	813	821
Percent Fresh (%)	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Fresh Yield	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Additional Fresh (%)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Add'l Quant (cartons/acre)	33	33	34	34	34	35	35	35	36	36	36	37	37	38	38
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	165	173	182	191	201	211	222	233	244	257	270	283	298	313	328
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Add'l Rev. ($/acre/year)	55	58	61	64	67	70	74	78	81	86	90	94	99	104	109
Sum Add'l Rev. ($/acre/yr)	220	231	243	255	268	281	295	310	326	342	360	378	397	417	438
After Tax Rev. ($/acre/yr)	132	139	146	153	161	169	177	186	196	205	216	227	238	250	263
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value per period ($)	122	119	116	112	109	106	103	101	98	95	93	90	88	85	83
Present Value ($)	1,520														
Equiv. Annuity ($/acre/yr)	178														
Add'l Rev. (aft-tax,$/acre/yr)	178														
Cost (after-tax, $/acre/yr)	224														
Profit (after-tax, $/acre/yr)	**($47)**														
Breakeven Levels															
Additional Fresh	8.10%														
Yield (cartons/acre)	693														
Total Yield	900														
On-tree Fresh Price ($/carton)	6.30														

Annual Yield Increase	1.00%
Annual Fresh Price Increase	4.00%

Table A2. *(Continues - p. 4)*

New Propane Wind Machines 125 hp - Valencia - Benefits: Additional Value of Valencia Production ($/Acre)															
	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	730	737	745	752	760	767	775	783	790	798	806	814	823	831	839
Percent Fresh (%)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Fresh Yield	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Additional Fresh (%)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Add'l Quant (cartons/acre)	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	166	174	183	192	202	212	223	234	246	259	272	285	300	315	331
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Add'l Rev. ($/acre/year)	47	50	52	55	58	61	64	67	70	74	78	81	86	90	94
Sum Add'l Rev. ($/acre/yr)	214	224	236	247	260	273	287	301	316	332	349	367	385	405	425
After Tax Rev. ($/acre/yr)	128	135	141	148	156	164	172	181	190	199	209	220	231	243	255
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value per period ($)	119	115	112	109	106	103	100	98	95	92	90	87	85	83	80
Present Value ($)	1,475														
Equiv. Annuity ($/acre/yr)	172														
Add'l Rev. (aft-tax,$/acre/yr)	172														
Cost (after-tax, $/acre/yr)	224														
Profit (after-tax, $/acre/yr)	**($52)**														
Breakeven Levels															
Additional Fresh	9.70%														
Yield (cartons/acre)	618														
Total Yield	950														
On-tree Fresh Price ($/carton)	6.50														

Annual Yield Increase	1.00%
Annual Fresh Price Increase	4.00%

Table A3. - Existing Electric Wind Machines 100 hp - Annual Ownersyhip and Operating Costs - Pacific Gas & Electric (PG&E)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ownership Costs ($):															
Salvage Value	4,000														
Downpayment	4,000														
Unpaid Balance	0														
Annual Loan Payment	0	0	0	0	0										
Interest Payment	0	0	0	0	0										
Principle Payment	0	0	0	0	0										
Property Taxes	48	45	42	39	36	33	31	29	27	25	23	22	20	19	17
Standby Electricity	1,157	1,240	1,329	1,425	1,527	1,637	1,755	1,882	2,017	2,162	2,318	2,485	2,664	2,855	3,061
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Total Ownership costs	5,235	1,316	1,404	1,498	1,600	1,709	1,826	1,953	2,088	2,234	2,390	2,558	2,738	2,931	3,138
Operating Costs:															
Electricity	447	480	514	551	591	633	679	728	780	836	896	961	1,030	1,104	1,184
Labor	135	142	149	156	164	172	181	190	199	209	220	231	242	255	267
Repairs	250	263	276	289	304	319	335	352	369	388	407	428	449	471	495
Maintenance	75	79	83	87	91	96	101	106	111	116	122	128	135	141	148
Total Operating Costs	907	963	1,021	1,084	1,150	1,220	1,295	1,375	1,460	1,550	1,646	1,748	1,856	1,972	2,095
Total Costs	6,142	2,278	2,425	2,582	2,750	2,929	3,122	3,328	3,548	3,784	4,036	4,305	4,594	4,903	5,233
Deductible expenses:															
Depreciation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Interest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Taxes	48	45	42	39	36	33	31	29	27	25	23	22	20	19	17
Standby Electricity	1,157	1,240	1,329	1,425	1,527	1,637	1,755	1,882	2,017	2,162	2,318	2,485	2,664	2,855	3,061
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Operating Costs	907	963	1,021	1,084	1,150	1,220	1,295	1,375	1,460	1,550	1,646	1,748	1,856	1,972	2,095
Total Deductions	2,142	2,278	2,425	2,582	2,750	2,929	3,122	3,328	3,548	3,784	4,036	4,305	4,594	4,903	5,233
Tax Savings	857	911	970	1,033	1,100	1,172	1,249	1,331	1,419	1,513	1,614	1,722	1,838	1,961	2,093
Salvage Value															1,000
Depreciated Value															0
Capital Gain/loss															1,000
Tax on gain/write-off															400

Table A3. *(Continues - p. 2)*

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total After-tax costs:	5,285	1,367	1,455	1,549	1,650	1,758	1,873	1,997	2,129	2,270	2,421	2,583	2,756	2,942	2,540
Discount factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present value	4,894	1,172	1,155	1,139	1,123	1,108	1,093	1,079	1,065	1,052	1,039	1,026	1,014	1,001	801

Net Present Value	19,757	
Equivalent Annual Annuity	2,308	
Acres per wind machine	10	
Equiv. Annuity ($/acre/yr)	231	
Interest Rate	8.00%	
Electricity		PG & E AG 4-B-W
Customer Charge ($/month)	16.00	Rates effective July 1, 1993 through December 31, 1994.
Meter Charge ($/month)	6.00	Rates not published as of December 1993.
Sum ($/month)	22.00	Rates quoted by Dan Goozman, PG&E.
Number Months	12	
Total Customer Charge	$264.00	
Demand Charge ($/kW/month)	$1.75	
kW/100 hp Wind machine	85	
Number Months/ Season	6	
Total Service Charge	$893	
Total Fixed Electricity	$1,157	
Variable		
Energy Charge ($/kWh)	0.05964	
kW/hr	75	
Hours Operated/ Season	100	
Total Variable Electricity	$447	
Total Electricity Costs	1,604	
Property Tax Rate	1.20%	Kern County Assessor (1.0 % county + 0.2 % school)
Depreciation Rate	7.00%	
Corporate Inc. Tax Rate	40.00%	
Inflation		
Electricity Standby (%)	7.20%	*Increasing Agricultural Electricity Rates: Economic Implications and*
Electricity Variable (%)	7.20%	*Alternatives*, Draft Report, California Energy Commission, April 1992.
Labor (%)	5.00%	"Since 1979 the average electricity costs to agricultural class customers (adjusted
Repairs (%)	5.00%	for inflation) increased by 36 percent for PG & E and 16 percent for SCE.
Miscellaneous (%)	5.00%	An Additional 14 percent is forecasted by 1998."
		14% over 6 years is 2.2% annual increase above inflation.

Table A3. *(Continues - p. 3)*

	Existing Electric Wind Machines 100 hp PG&E - Navel - Benefits - Additional Value of Production ($/Acre)														
	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Total Yield (cartons/acre)	714	721	728	736	743	750	758	766	773	781	789	797	805	813	821
Percent Fresh(%)	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Fresh Yield (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Additional Fresh (%)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Add'l Quant (cartons/acre)	33	33	34	34	34	35	35	35	36	36	36	37	37	38	38
On-tree Fresh Price ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Revenues ($/acre/yr)	165	173	182	191	201	211	222	233	244	257	270	283	298	313	328
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Add'l Revenues ($/acre/yr)	55	58	61	64	67	70	74	78	81	86	90	94	99	104	109
Sum Add'l Rev. ($/acre/yr)	220	231	243	255	268	281	295	310	326	342	360	378	397	417	438
After-Tax Rev. ($/acre/yr)	132	139	146	153	161	169	177	186	196	205	216	227	238	250	263
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value ($/acre/yr)	122	119	116	112	109	106	103	101	98	95	93	90	88	85	83
Present Value ($)	1,520														
Annual Annuity ($/ac/yr)	178														
Add'l Revenue ($/acre/yr)	178														
Cost ($/acre/yr)	231														
Profit ($/acre/yr)	**($53)**														
Breakeven Levels															
Additional Fresh (percent)	8.40%														
Yield (cartons/acre)	716														
Total Yield	930														
Price Fresh On-tree ($/carton)	6.50														
Annual Yield Increase (%)	1.00%														
Annual Fresh Price Increase	4.00%														

Table A3. *(Continues - p. 4)*

Existing Electric Wind Machines 100 hp, PG&E - Valencia - Benefits: Additional Value of Production ($/Acre)															
	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Total Yield (cartons/acre)	730	737	745	752	760	767	775	783	790	798	806	814	823	831	839
Percent Fresh (%)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Fresh Yield (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Additional Fresh (%)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Add'l Quant (cartons/acre)	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38
On-tree Fresh Price ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Revenues ($/acre/yr)	166	174	183	192	202	212	223	234	246	259	272	285	300	315	331
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Add'l Revenues ($/acre/yr)	47	50	52	55	58	61	64	67	70	74	78	81	86	90	94
Sum Add'l Rev. ($/acre/yr)	214	224	236	247	260	273	287	301	316	332	349	367	385	405	425
After-Tax Rev. ($/acre/yr)	128	135	141	148	156	164	172	181	190	199	209	220	231	243	255
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value ($/acre/yr)	119	115	112	109	106	103	100	98	95	92	90	87	85	83	80
Present Value ($)	1,475														
Annual Annuity ($/ac/yr)	172														
Add'l Revenue ($/acre/yr)	172														
Cost ($/acre/yr)	231														
Profit ($/acre/yr)	**($58)**														
Breakeven Levels															
Additional Fresh (percent)	0.10														
Yield (cartons/acre)	637														
Total Yield	980														
Price Fresh On-tree ($/carton)	6.50														
Annual Yield Increase (%)	1.00%														
Annual Fresh Price Increase	4.00%														

Table A4 - Existing Electric Wind Machines 100 hp -Annual Ownership and Operating Costs, Southern California Edison (SCE)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ownership Costs ($):															
Salvage Value	4,000														
Downpayment	4,000														
Unpaid Balance	0														
Annual Loan Payment	0	0	0	0	0										
Interest Payment	0	0	0	0	0										
Principle Payment	0	0	0	0	0										
Property Taxes	48	45	42	39	36	33	31	29	27	25	23	22	20	19	17
Standby Electricity	1,457	1,562	1,675	1,795	1,925	2,063	2,212	2,371	2,542	2,725	2,921	3,131	3,357	3,598	3,857
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Total Ownership costs	5,535	1,638	1,749	1,869	1,997	2,135	2,283	2,442	2,613	2,796	2,993	3,204	3,431	3,674	3,934
Operating Costs:															
Electricity	742	796	853	914	980	1,051	1,126	1,207	1,294	1,388	1,488	1,595	1,709	1,833	1,964
Labor	135	142	149	156	164	172	181	190	199	209	220	231	242	255	267
Repairs	250	263	276	289	304	319	335	352	369	388	407	428	449	471	495
Maintenance	75	79	83	87	91	96	101	106	111	116	122	128	135	141	148
Total Operating Costs	1,202	1,279	1,360	1,447	1,539	1,638	1,743	1,855	1,974	2,101	2,237	2,381	2,536	2,700	2,875
Total Costs	6,738	2,917	3,109	3,316	3,536	3,773	4,026	4,297	4,587	4,898	5,230	5,586	5,966	6,374	6,810
Deductible expenses:															
Depreciation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Interest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Taxes	48	45	42	39	36	33	31	29	27	25	23	22	20	19	17
Standby Electricity	1,457	1,562	1,675	1,795	1,925	2,063	2,212	2,371	2,542	2,725	2,921	3,131	3,357	3,598	3,857
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Operating Costs	1,202	1,279	1,360	1,447	1,539	1,638	1,743	1,855	1,974	2,101	2,237	2,381	2,536	2,700	2,875
Total Deductions	2,738	2,917	3,109	3,316	3,536	3,773	4,026	4,297	4,587	4,898	5,230	5,586	5,966	6,374	6,810
Tax Savings	1,095	1,167	1,244	1,326	1,415	1,509	1,610	1,719	1,835	1,959	2,092	2,234	2,386	2,549	2,724
Salvage Value															1,000
Depreciated Value															0
Capital Gain/loss															1,000
Tax on gain/write-off															400

Table A4. *(Continues - p. 2)*

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total After-tax costs:	5,643	1,750	1,866	1,989	2,122	2,264	2,416	2,578	2,752	2,939	3,138	3,351	3,580	3,824	3,486
Discount factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present value	5,225	1,501	1,481	1,462	1,444	1,426	1,409	1,393	1,377	1,361	1,346	1,331	1,316	1,302	1,099
Net Present Value	24,473														
Equivalent Annual Annuity	2,859														
Acres per wind machine	10														
Equiv. Annuity ($/acre/yr)	286														

Interest Rate	8.00%	
Electricity		Southern California Edison (SCE)
Customer Charge ($/month)	15.20	Schedule PA-1
Meter Charge ($/month)	0.00	Rates in effect winter 1993-94
Sum ($/month)	15.20	
Number Months	12	
Total Customer Charge	$182.40	
Demand Charge ($/kW/month)	$1.25	
kW/100 hp Wind machine	85	
Number Months/ Season	12	
Total Service Charge	$1,275	
Total Fixed Electricity	$1,457	
Variable		
Energy Charge ($/kWh)	0.09896	
kW/hr	75	
Hours Operated/ Season	100	
Total Variable Electricity	$742	
Total Electricity Costs	2,200	
Property Tax Rate	1.20%	Kern County Assessor (1.0 % county + 0.2 % school)
Depreciation Rate	7.00%	
Corporate Inc. Tax Rate	40.00%	
Inflation		
Electricity Standby (%)	7.20%	*Increasing Agricultural Electricity Rates: Economic Implications and*
Electricity Variable (%)	7.20%	*Alternatives*, Draft Report, California Energy Commission, April 1992.
Labor (%)	5.00%	"Since 1979 the average electricity costs to agricultural class customers (adjusted
Repairs (%)	5.00%	for inflation) increased by 36 percent for PG & E and 16 percent for SCE.
Miscellaneous (%)	5.00%	An Additional 14 percent is forecasted by 1998."
		14% over 6 years is 2.2% annual increase above inflation.

Table A4 *(Continues - p. 3)*

Existing Electric Wind Machines 100 hp - SCE - Navel - Benefits: Additional Value of Production ($/Acre)															
	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Total Yield (cartons/acre)	714	721	728	736	743	750	758	766	773	781	789	797	805	813	821
Percent Fresh (%)	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Fresh Yield (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Additional Fresh (%)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Add'l Quant (cartons/acre)	33	33	34	34	34	35	35	35	36	36	36	37	37	38	38
On-tree Fresh Price ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Revenues ($/acre/yr)	165	173	182	191	201	211	222	233	244	257	270	283	298	313	328
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Add'l Revenues ($/acre/yr)	55	58	61	64	67	70	74	78	81	86	90	94	99	104	109
Sum Add'l Rev. ($/acre/yr)	220	231	243	255	268	281	295	310	326	342	360	378	397	417	438
After-Tax Rev. ($/acre/yr)	132	139	146	153	161	169	177	186	196	205	216	227	238	250	263
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value ($/acre/yr)	122	119	116	112	109	106	103	101	98	95	93	90	88	85	83
Present Value ($)	1,520														
Annual Annuity ($/ac/yr)	178														
Add'l Revenue ($/acre/yr)	178														
Cost ($/acre/yr)	286														
Profit ($/acre/yr)	**($108)**														
Breakeven Levels															
Additional Fresh (percent)	0.109														
Yield (cartons/acre)	886														
Total Yield	1,150														
Price Fresh On-tree ($/carton)	8.00														
Annual Yield Increase (%)	1.00%														
Annual Fresh Price Increase	4.00%														

Table A4 *(Continues - p. 4)*

	Existing Electric Wind Machines 100 hp - 100 hp - SCE - Valencia -Benefits: Additional Value of Production ($/Acre)														
	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Total Yield (cartons/acre)	730	737	745	752	760	767	775	783	790	798	806	814	823	831	839
Percent Fresh (%)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Fresh Yield (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Additional Fresh (%)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Add'l Quant (cartons/acre)	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38
On-tree Fresh Price ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Revenues ($/acre/yr)	166	174	183	192	202	212	223	234	246	259	272	285	300	315	331
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Add'l Revenues ($/acre/yr)	47	50	52	55	58	61	64	67	70	74	78	81	86	90	94
Sum Add'l Rev. ($/acre/yr)	214	224	236	247	260	273	287	301	316	332	349	367	385	405	425
After-Tax Rev. ($/acre/yr)	128	135	141	148	156	164	172	181	190	199	209	220	231	243	255
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value ($/acre/yr)	119	115	112	109	106	103	100	98	95	92	90	87	85	83	80
Present Value ($)	1,475														
Annual Annuity ($/ac/yr)	172														
Add'l Revenue ($/acre/yr)	172														
Cost ($/acre/yr)	286														
Profit ($/acre/yr)	**($114)**														
Breakeven Levels															
Additional Fresh (percent)	0.13														
Yield (cartons/acre)	793														
Total Yield	1,220														
Price Fresh On-tree ($/carton)	8.30														
Annual Yield Increase (%)	1.00%														
Annual Fresh Price Increase	4.00%														

Table A5 - Existing Diesel Wind Machines - 125 hp -Annual Ownership and Operating Costs

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ownership Costs ($):															
Purchase & Installation	5,000														
Downpayment	5,000														
Unpaid Balance	0														
Annual Loan Payment	0	0	0	0	0										
Interest Payment	0	0	0	0	0										
Principle Payment	0	0	0	0	0										
Property Taxes	48	45	42	39	36	33	31	29	27	25	23	22	20	19	17
Insurance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Total Ownership costs	5,078	76	75	73	72	72	71	71	71	72	72	73	74	75	77
Operating Costs:															
Diesel Fuel	570	610	653	698	747	799	855	915	979	1,048	1,121	1,200	1,284	1,374	1,470
Labor	304	319	335	352	370	388	407	428	449	472	495	520	546	573	602
Repairs	250	263	276	289	304	319	335	352	369	388	407	428	449	471	495
Maintenance	75	79	83	87	91	96	101	106	111	116	122	128	135	141	148
Total Operating Costs	1,199	1,270	1,346	1,426	1,512	1,602	1,698	1,800	1,909	2,024	2,146	2,276	2,413	2,560	2,715
Total Costs	6,277	1,346	1,421	1,500	1,584	1,674	1,770	1,871	1,980	2,095	2,218	2,348	2,487	2,635	2,792
Deductible expenses:															
Depreciation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Interest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Taxes	48	45	42	39	36	33	31	29	27	25	23	22	20	19	17
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Operating Costs	1,199	1,270	1,346	1,426	1,512	1,602	1,698	1,800	1,909	2,024	2,146	2,276	2,413	2,560	2,715
Total Deductions	1,277	1,346	1,421	1,500	1,584	1,674	1,770	1,871	1,980	2,095	2,218	2,348	2,487	2,635	2,792
Tax Savings	511	539	568	600	634	670	708	749	792	838	887	939	995	1,054	1,117
Salvage Value															2,000
Depreciated Value															0

Table A5. *(Continues - p. 2)*

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital Gain/loss															2,000
Tax on gain/write-off															800
Total After-tax costs:	5,766	808	852	900	950	1,004	1,062	1,123	1,188	1,257	1,331	1,409	1,492	1,581	475
Discount factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present value	5,339	693	677	661	647	633	620	607	594	582	571	560	549	538	150
Net Present Value	13,419														
Equivalent Annual Annuity	1,568														
Acres per wind machine	10														
Equiv. Annuity ($/acre/yr)	157														
Interest Rate	8.00%														
Diesel Fuel															
Price ($/gal.)	0.95														
Fuel Usage (gal./hour)	6														
Time Operated (hours/year)	100														
Annual Diesel Fuel Costs	$570														
Property Tax Value	$4,000														
Property Tax Rate	1.20%														
Depreciation Rate	7.00%														
Corporate Inc. Tax Rate	40.00%														
Inflation (projected)															
Diesel Fuel (%)	7.00%														
Labor (%)	5.00%														
Repairs (%)	5.00%														
Maintenance (%)	5.00%														

Table A5. *(Continues - p. 3)*

Existing Diesel Wind Machines 125 hp - Navel -Benefits: Additional Value of Navel Production ($/Acre)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	714	721	728	736	743	750	758	766	773	781	789	797	805	813	821
Percent Fresh (%)	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Fresh Yield	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Additional Fresh (%)	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Add'l Quant (cartons/acre)	33	33	34	34	34	35	35	35	36	36	36	37	37	38	38
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	165	173	182	191	201	211	222	233	244	257	270	283	298	313	328
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Add'l Rev. ($/acre/year)	55	58	61	64	67	70	74	78	81	86	90	94	99	104	109
Sum Add'l Rev. ($/acre/yr)	220	231	243	255	268	281	295	310	326	342	360	378	397	417	438
After Tax Rev. ($/acre/yr)	132	139	146	153	161	169	177	186	196	205	216	227	238	250	263
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value per period ($)	122	119	116	112	109	106	103	101	98	95	93	90	88	85	83
Present Value ($)	1,520														
Equiv. Annuity ($/acre/yr)	178														
Add'l Rev. (aft-tax,$/acre/yr)	178														
Cost (after-tax, $/acre/yr)	157														
Profit (after-tax, $/acre/yr)	**$21**														
Breakeven Levels															
Additional Fresh	5.10%														
Yield (cartons/acre)	485														
Total Yield	630														
On-tree Fresh Price ($/carton)	4.40														

Annual Yield Increase	1.00%
Annual Fresh Price Increase	4.00%

Table A5 (Continues - p. 4)

Existing Diesel Wind Machines 125 hp - Valencia -Benefits: Additional Value of Valencia Production ($/Acre)															
	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	730	737	745	752	760	767	775	783	790	798	806	814	823	831	839
Percent Fresh (%)	65	65	65	65	65	65	65	65	65	65	65%	65	65	65	65
Fresh Yield	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Additional Fresh (%)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Add'l Quant (cartons/acre)	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	166	174	183	192	202	212	223	234	246	259	272	285	300	315	331
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Add'l Rev. ($/acre/year)	47	50	52	55	58	61	64	67	70	74	78	81	86	90	94
Sum Add'l Rev. ($/acre/yr)	214	224	236	247	260	273	287	301	316	332	349	367	385	405	425
After Tax Rev. ($/acre/yr)	128	135	141	148	156	164	172	181	190	199	209	220	231	243	255
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value per period ($)	119	115	112	109	106	103	100	98	95	92	90	87	85	83	80
Present Value ($)	1,475														
Equiv. Annuity ($/acre/yr)	172														
Add'l Rev. (aft-tax,$/acre/yr)	172														
Cost (after-tax, $/acre/yr)	157														
Profit (after-tax, $/acre/yr)	**$16**														
Breakeven Levels															
Additional Fresh	6.20%														
Yield (cartons/acre)	429														
Total Yield	660														
On-tree Fresh Price ($/carton)	4.60														
Annual Yield Increase (%)	1.00%														
Annual Fresh Price Increase	4.00%														

Table A6. - Existing Propane Wind Machines - 125 hp - Annual Ownership and Operating Costs

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ownership Costs ($):															
Purchase & Installation	5,000														
Downpayment	5,000														
Unpaid Balance	0														
Annual Loan Payment	0	0	0	0	0										
Interest Payment	0	0	0	0	0										
Principle Payment	0	0	0	0	0										
Property Taxes	48	45	42	39	36	33	31	29	27	25	23	22	20	19	17
Insurance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Total Ownership costs	5,078	76	75	73	72	72	71	71	71	72	72	73	74	75	77
Operating Costs:															
Propane Gas	1,105	1,160	1,218	1,279	1,343	1,410	1,481	1,555	1,633	1,714	1,800	1,890	1,984	2,084	2,188
Labor	185	194	204	214	225	236	248	260	273	287	301	316	332	349	366
Repairs	250	263	276	289	304	319	335	352	369	388	407	428	449	471	495
Maintenance	75	79	83	87	91	96	101	106	111	116	122	128	135	141	148
Total Operating Costs	1,615	1,696	1,781	1,870	1,963	2,061	2,164	2,272	2,386	2,505	2,631	2,762	2,900	3,045	3,198
Total Costs	6,693	1,772	1,855	1,943	2,035	2,133	2,236	2,344	2,457	2,577	2,703	2,835	2,974	3,121	3,274
Deductible expenses:															
Depreciation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Interest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Property Taxes	48	45	42	39	36	33	31	29	27	25	23	22	20	19	17
Management	30	32	33	35	36	38	40	42	44	47	49	51	54	57	59
Operating Costs	1,615	1,696	1,781	1,870	1,963	2,061	2,164	2,272	2,386	2,505	2,631	2,762	2,900	3,045	3,198
Total Deductions	1,693	1,772	1,855	1,943	2,035	2,133	2,236	2,344	2,457	2,577	2,703	2,835	2,974	3,121	3,274
Tax Savings	677	709	742	777	814	853	894	937	983	1,031	1,081	1,134	1,190	1,248	1,310
Salvage Value															2,000
Depreciated Value															0

Table A6. *(Continues - p. 2)*

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Capital Gain/loss															2,000
Tax on gain/write-off															800
Total After-tax costs:	6,016	1,063	1,113	1,166	1,221	1,280	1,341	1,406	1,474	1,546	1,622	1,701	1,785	1,872	765
Discount factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present value	5,570	911	884	857	831	806	783	760	738	716	696	676	656	637	241
Net Present Value	15,761														
Equivalent Annual Annuity	1,841														
Acres per wind machine	10														
Equiv. Annuity ($/acre/yr)	184														
Interest Rate	8.00%														
Diesel Fuel															
Price ($/gal.)	0.85														
Fuel Usage (gal./hour)	13														
Time Operated (hours/year)	100														
Annual Diesel Fuel Costs	$1,105														
Property Tax Value	$4,000														
Property Tax Rate	1.20%														
Depreciation Rate	7.00%														
Corporate Inc. Tax Rate	40.00%														
Inflation (projected)															
Propane Fuel (%)	5.00%														
Labor (%)	5.00%														
Repairs (%)	5.00%														
Maintenance (%)	5.00%														

Table A6 *(Continues - p. 3)*

Existing Diesel Wind Machines 125 hp - Navel -Benefits: Additional Value of Navel Production ($/Acre)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	714	721	728	736	743	750	758	766	773	781	789	797	805	813	821
Percent Fresh (%)	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
Fresh Yield	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Additional Fresh (%)	6.00	6.00	6.00	6.00	6.00	6.00%	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Add'l Quant (cartons/acre)	33	33	34	34	34	35	35	35	36	36	36	37	37	38	38
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	165	173	182	191	201	211	222	233	244	257	270	283	298	313	328
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	550	555	561	566	572	578	584	589	595	601	607	613	620	626	632
Add'l Rev. ($/acre/year)	55	58	61	64	67	70	74	78	81	86	90	94	99	104	109
Sum Add'l Rev. ($/acre/yr)	220	231	243	255	268	281	295	310	326	342	360	378	397	417	438
After Tax Rev. ($/acre/yr)	132	139	146	153	161	169	177	186	196	205	216	227	238	250	263
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value per period ($)	122	119	116	112	109	106	103	101	98	95	93	90	88	85	83
Present Value ($)	1,520														
Equiv. Annuity ($/acre/yr)	178														
Add'l Rev. (aft-tax,$/acre/yr)	178														
Cost (after-tax, $/acre/yr)	184														
Profit (after-tax, $/acre/yr)	**($7)**														
Breakeven Levels															
Additional Fresh	5.10%														
Yield (cartons/acre)	485														
Total Yiled	630														
On-tree Fresh Price ($/carton)	4.40														
Annual Yield Increase	1.00%														
Annual Fresh Price Increase	4.00%														

Table A6. *(Continues - p. 4)*

Existing Propane Wind Machines 125 hp - Valencia -Benefits: Additional Value of Valencia Production ($/Acre)

	Year														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Quantity Fresh															
Yield (cartons/acre)	730	737	745	752	760	767	775	783	790	798	806	814	823	831	839
Percent Fresh (%)	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Fresh Yield	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Additional Fresh (%)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Add'l Quant (cartons/acre)	33	34	34	34	35	35	35	36	36	36	37	37	37	38	38
Price Fresh ($/carton)	5.00	5.20	5.41	5.62	5.85	6.08	6.33	6.58	6.84	7.12	7.40	7.70	8.01	8.33	8.66
Add'l Rev. ($/acre/year)	166	174	183	192	202	212	223	234	246	259	272	285	300	315	331
Quality of Fresh															
Quality Premium (%)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Quant Fresh (cartons/acre)	475	479	484	489	494	499	504	509	514	519	524	529	535	540	545
Add'l Rev. ($/acre/year)	47	50	52	55	58	61	64	67	70	74	78	81	86	90	94
Sum Add'l Rev. ($/acre/yr)	214	224	236	247	260	273	287	301	316	332	349	367	385	405	425
After Tax Rev. ($/acre/yr)	128	135	141	148	156	164	172	181	190	199	209	220	231	243	255
Discount Factor	1.08	1.17	1.26	1.36	1.47	1.59	1.71	1.85	2.00	2.16	2.33	2.52	2.72	2.94	3.17
Present Value per period ($)	119	115	112	109	106	103	100	98	95	92	90	87	85	83	80
Present Value ($)	1,475														
Equiv. Annuity ($/acre/yr)	172														
Add'l Rev. (aft-tax,$/acre/yr)	172														
Cost (after-tax, $/acre/yr)	184														
Profit (after-tax, $/acre/yr)	**($12)**														
Breakeven Levels															
Additional Fresh	6.20%														
Yield (cartons/acre)	429														
Total Yield	660														
On-tree Fresh Price ($/carton)	4.60														

Annual Yield Increase (%)	1.00%
Annual Fresh Price Increase	4.00%

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