recommendations became available they were incorporated into the project. These new monitoring techniques and recommendations came from "satellite" projects listed later and reported on separately.

Evaluation: Evaluation of these two farming systems was carried out using data collected throughout each season and final evaluations just prior to harvest. In 1999 and 2000, P-1 grade sheets were used in the evaluation. In 2001 and 2002 California Dried Fruit Association of California (DFA of California) evaluated samples submitted from each orchard. This information was used in final evaluations. In 2003 and 2004, these systems were evaluated based on field evaluations and samples collected at harvest by field scouts and farm advisors. Changes in the evaluation procedure during the course of this project were required for economic reasons.

Education/outreach: A major effort was devoted to the production of the "Integrated Prune Farming Practices Decision Guide". This publication is now in its second edition and will soon have a third edition with sections on orchard floor management and mitigating pesticide runoff added to it. In 2003 the material in this guide was presented to clientele at six, one day, "Prune Pest and Orchard Management Short Course" meetings. The six meetings were held around the state (Gridley, Yuba City, Woodland, Orland, Red Bluff and at the UC Kearney Agricultural Center in Parlier). Registrants received the Decision Guide binder, UCIPM Tree Fruit Pest Identification Monitoring Cards, a hand lens, a CD database for recording field monitoring information and lunch. Meeting and binder costs were not fully recovered from registration with the balance paid by the California Dried Plum Board's ESPS grant. The meetings were well attended with a total of 180 people in attendance at the six meetings. The meetings were a combination of classroom lectures and field demonstrations. A meeting evaluation was conducted and participants gave the meetings very favorable comments.
The "Integrated Prune Farming Practices Decision Guide" binder is available for sale at Cooperative Extension offices that have major prune responsibility and were made available for sale at prune meetings held in 2004 where this project was a topic on the agenda. Currently there are over 220 copies of the binder in circulation.

Other meetings: In 2004, 14 meetings relative to this project were held and attended by 424 people. In Sutter County the following meetings were held: Statewide Dried Plum Day, March 3rd; Spring Field Day, April 29th; Fall Field Day, September 23rd; Sutter County Agricultural Commissioners Meeting, December 7th and 9th; Winter Field Meeting, December 14th. Other meetings across the state included: Glenn County's Spring Prune Meeting on May 18th; Madera County's Prune Day on May 19th; Merced County's Prune meeting on May 19th; Tulare County's Prune meeting on May 20th; Tehama County's Prune Day on February 26th; Sacramento County's meeting on the Dormant Spray Decision Guide on January 29th and two meetings one on March 9th and the other on April 16th for the California Dried Plum Board.

Funding: It was recognized that the California Dried Plum Board could not support this project to the extent needed to attract rapid, wide adoption of "reduced risk" practices by clientele. To this end, additional grant support from other agencies was sought to expand the project beyond the capabilities of the California Dried Plum Board. However, securing other grant funding has been contingent upon prune industry support provided by the California Dried Plum Board.

Satellite projects: "Reduced risk" concepts needed to be researched before being demonstrated or adopted on a wide scale. "Satellite projects", supported by IPFP to evaluate single aspects of "reduced risk", were established in one or more areas. "Satellite projects" were "stand alone" projects. Their objectives were designed to address single researchable questions for ultimate utility within IPFP. For example: evaluating aphid control with soft chemicals. "Satellite projects" are reported separately.

In 2004, IPFP supported the following "satellite projects":

1) Fall aphid control with low or below label rates of certain insecticides applied by air blast sprayer – Butte County.
2) Fall aphid control with low or below label rates of certain insecticides applied by hand gun – Sutter County.
3) Phytotoxicity of dormant oil sprays applied at different timings – Sutter County.
4) Fall aphid control with low or below label rates of certain insecticides applied by air blast sprayer – Glenn County.
5) Spring aphid control with oil – Butte County.
6) Determining the allowable time interval between leaf removal and taking pressure chamber readings before readings become unreliable – Butte County.
7) Production and dissemination of the second edition of the "Integrated Prune Farming Practices Decision Guide".

In 2003, IPFP supported the following "satellite projects":

8) Fall prune-tree defoliation for aphid control – Butte County.
9) Determining the allowable time interval between leaf removal and taking pressure chamber readings before readings become unreliable – Butte County.
10) Use of pheromone traps to measure oblique-banded leaf roller (OBLR) populations and predict fruit damage – Butte County.
11) Predicting hail damage – Tehama County.
12) Evaluating Imidan and fall "dormant" applications for aphid control – Butte and Sutter Counties.
13) Cost comparison of "reduced risk" or "conventional" approaches to pest monitoring and control – Statewide.
14) Production and dissemination of the "Integrated Prune Farming Practices Decision Guide" – Statewide.

In 2002, the project supported the following "satellite projects":

1) Controlling mealy plum and leaf curl plum aphids using reduced rates of diazinon and Asana with oil, in a dormant spray – Butte and Sutter Counties.
2) Controlling mealy plum and leaf curl plum aphids by using zinc to induce early fall defoliation – Butte and Sutter Counties.
3) Using pheromone traps to predict oblique banded leaf roller populations and fruit damage – Butte and Sutter Counties.
4) Using water traps to catch fall returning aphids to determine exactly when they return to lay their over-wintering eggs - Statewide.

In 2001, the project supported the following "satellite projects":

1) Controlling mealy plum and leaf curl plum aphids using reduced rates of diazinon and Asana with oil, in a dormant spray – Butte and Sutter Counties.

2) Controlling mealy plum and leaf curl plum aphids by using zinc to induce early fall defoliation – Butte and Sutter Counties.
3) Adjustments to the pressure chamber use protocol - Statewide
4) Using pheromone traps to predict oblique banded leaf roller populations and fruit damage - Statewide.
5) Literature and research review of prune aphid control using oils over the past ten years - Statewide.
6) Using water traps to catch fall returning aphids to determine exactly when they return to lay their over-wintering eggs - Statewide.

In 2000, the project supported the following “satellite projects” on:

1) Biological control of mealy plum aphids using *Harmonia axyridis* lady beetles - Statewide.
2) Pesticide efficacy trial using two types of oil and one type of pesticide for aphid control - Butte, Sutter, Glenn and Tehama Counties.
3) Alternate year dormant insecticide program evaluation- Tulare County.
4) A new aphid infestation-predicting model - Statewide.

In 1999, material efficacy “satellite projects” were conducted statewide for control of prune aphids using soft materials including a number of novel products not yet registered.

Prior to 1999, the project supported “satellite projects” on:

1) An alternate year dormant spray program to cut pesticide use in half - Tulare County.
2) A predictive model for forecasting scab off-grade at harvest – Butte and Tehama Counties.
3) Aphid control using soft chemicals – Statewide.
4) “Mow and throw” technique for weed control by either using cover crop residue following mowing or rice straw (ag-waste) as mulch for weed control down the tree row – Butte County.

IMPLEMENTATION – Industry Survey Results

The degree industry implements orchard monitoring in the cultural decision process measures the Integrated Prune Farming Practices (IPFP) project success – demonstrating the importance of monitoring when making pest management or cultural decisions is the cornerstone of the IPFP project. Although we have no objective baseline data when IPFP began in 1999, the basis for initiating such a program was the common knowledge that dried plum growers’ pest and cultural management decision process was indeed subjective often resulting in excess treatment. This created a growing concern for both economic and environmental consequences. For example, economic or treatment threshold levels that should “trigger” a decision process were essentially non-existent resulting in practices often being applied by: calendar, because the neighbor does it or, simply due to tradition. At the onset of IPFP, such management strategies, combined with burgeoning dried plum supplies, had reduced profitability margins. In order to have dried plums return an acceptable level of profit, new monitoring-based management strategies for careful and efficient use of inputs such as pesticides, water, and fertilizers to reduce costs and environmental contamination, were required. Through education/demonstration of appropriate pest, nutrition, and tree-water status monitoring, IPFP has replaced many conventional treatment strategies and provided grower access to an economically viable, environmentally sensitive decision process. Was the project successful?

In winter of 2003/2004, the Dried Plum Board in cooperation with the U.C.'s Sustainable Agriculture Research and Education Program (SAREP), prepared and sent a survey to all dried plum growers (1114) in California, to determine the extent monitoring practices developed and promoted within the IPFP program were used in the 2002 season – presumably as a result of extensive educational and demonstration efforts. Here we provide that survey's results (36% response) germane to IPFP program objectives.

Outreach efforts of IPFP resulted in approximately 71% of dried plum growers being aware of the IPFP project, according to survey results. Further, approximately 54% had attended field days within the previous 4 years; essentially all of these targeted IPFP concepts, especially monitoring.

Orchard monitoring: Orchard monitoring is the key component of the IPFP project and is essential to economic and efficient use of IPFP demonstrated inputs.

General:

	Yes	Sometimes	No
Is the orchard monitored 2-3 times per month during the active season?	67.9%		32.1%

Pest Management:

	Yes	Sometimes	No
Do you monitor dormant spurs for Aphid eggs and scales? (3.9% didn't recall)	39.5%		56.6%
Do you monitor for prune rust? (2.2% didn't recall)	76.7%		21.1%
Did you monitor in spring for live aphids?	65.6%		34.4%
Did you monitor beneficials?	58.4%		41.6%
Did you monitor spider mites?	76.7%		23.3%

Nutrition:

	Yes	Sometimes	No
Did you use leaf-tissue analyses?	61.0%		39.0%
Did you use well water analysis?	22.8%		77.2%

Irrigation:

Did you use the pressure chamber measurements (monitor) for irrigation scheduling? (.6% didn't recall)	5.9%	93.5%
Did you measure soil moisture for irrigation?	48.0%	52.0%

Monitoring-based practices: There were decisions made based upon monitoring. Below are changed practices we believe resulted from monitoring techniques developed and demonstrated within IPFP:

Nutrition:	Yes	No
Adjusted N fertilization based upon water analyses.	50.8%	49.2%

Irrigation scheduling:

Used the pressure chamber to schedule irrigations.	5.9%	94.1%

Pest Management: A substantial portion of orchard monitoring was devoted to pest management and the subsequent management decision process. Because one option, when using monitoring for pest control decisions is "no treatment", which was not recorded in the survey, the dormant and in-season insecticide/fungicide pest management changes could not be determined with the following exception.

	Yes	No
Used a miticide spray (3% didn't recall)	25.5%	58.4%

We believe, due to extent pest monitoring was conducted in dried plum orchards (~68% of grower respondents), and that 53.7% of those that monitored sometimes or always recorded their findings (according to that same survey), the findings were used to make more sensible pest control decisions by a significant number of dried plum growers.

RESULTS

Objective 1. Develop economic thresholds, monitoring techniques and implement alternative pest control strategies that reduce use of "conventional" biocides.

1. Dormant Treatment Decision Guide

Situation: Prune growers have had no way of knowing if they needed to apply a dormant insecticide and oil spray. The dormant spray has been in wide use because growers have been taught for many years that this is the most efficacious spray they can apply. It: 1) kills a number of pest including San Jose scale (SJS), peach twig borer (PTB), European red mite (ERM), mealy plum aphid (MPA) and leaf curl plum aphid (LCPA), and 2) is least harmful to beneficials. Also many prune growers apply a dormant spray because there is no good "reduced risk" alternative to high populations of MPA and LCPA. Recently the dormant spray has been implicated in polluting natural resources. These findings suggested that the dormant insecticide spray is being over used. A monitoring technique was needed to help growers decide if they required a dormant insecticide treatment.

Evaluation: During the course of this project various techniques were attempted to monitor and predict whether MPA and/or LCPA might occur in an orchard in the spring. Although some techniques were encouraging the "test of time" showed none of the techniques to be totally reliable. The techniques evaluated included: 1) A correlation between fall aphid abundance with spring aphid abundance. After three years of research a correlation of only 46 percent (significant at the 99 percent level of confidence) was the best that could be achieved. 2) A correlation between appearance of aphids in the fall and appearance of aphids in the spring. This correlation proved to be 80 percent accurate (significant at the 99 percent confidence level) in predicting whether or not orchards will have aphids in the spring. These results were encouraging but not being able to predict an aphid population 20 percent of the time was not satisfactory. In order to try and make the correlation more accurate a model developed by Tim Prather, a U.C. IPM advisor, called the "Prather Model" was developed. 3) The "Prather Model" considered geographic regions and tried to account for the aphids flying to and from their alternate hosts in the late summer/early fall. It also assumed that if an orchard had a high population of aphids in the spring, the grower would spray for them and there would be less of a population that could return in the fall resulting in fewer aphids the following spring. The "Prather Model" failed to have a significant correlation between predicted percent of trees to have aphids in the spring and the actual percent of trees to have aphids. 4) When spring aphid counts in one year were compared to spring aphid counts in the next it was found that there was 76 percent correlation (significant at the 99 percent confidence level) in predicting level of aphid infestation. This suggested that aphids return to the same orchards at approximately the same population levels.

Based on the monitoring techniques that had fairly high correlations (techniques 2 and 4) two treatment guides were developed and used through 2003 (Tables 1 and 2). Table 1 was for orchards that had been receiving annual dormant insecticide sprays. The aphid treatment threshold would be reached if: 1) one tree out of 40 trees monitored in the fall had prune aphids; or 2) orchard history indicates at least one tree had aphids last season despite application of a dormant insecticide and oil; or 3) at least one aphid egg was found in a dormant spur sample. Table 2 was for orchards that have not been receiving dormant insecticide sprays. The aphid treatment threshold was based on orchard history. If 10% or more of the trees had aphids during the last growing season, then a dormant treatment for aphids would be recommended.

A sequential sampling dormant spur monitoring technique involving sampling spurs in the winter for the presence of SJS or EFL crawlers is the other part of the “Dormant Treatment Decision Guides”. This monitoring technique was evaluated for three years before implementation. A statistician developed the sequential sampling procedure from the data collected from those three years. The treatment threshold is based on the number of fruit spurs that can have scale before scale become present on the fruit. It is believe that the presence of scale on the fruit is an early sign of a growing scale population that might eventually damage the trees. The monitoring technique involves the collection of 100 spurs in the winter, examining 20 of them at a time for presence of SJS and EFL. If, after evaluating the 20 spurs, a decision cannot be made, another 20 were evaluated and so on until all one hundred have been evaluated. In most cases the decision could be made after only looking at the first 20 spurs. The sequential sampling treatment threshold was based on 10 percent of the spurs out of 100 having live scale (see Tables 1 and 2).

Table 1. "Dormant Treatment Decision Guide" used until 2004 for orchards that had been receiving dormant sprays.

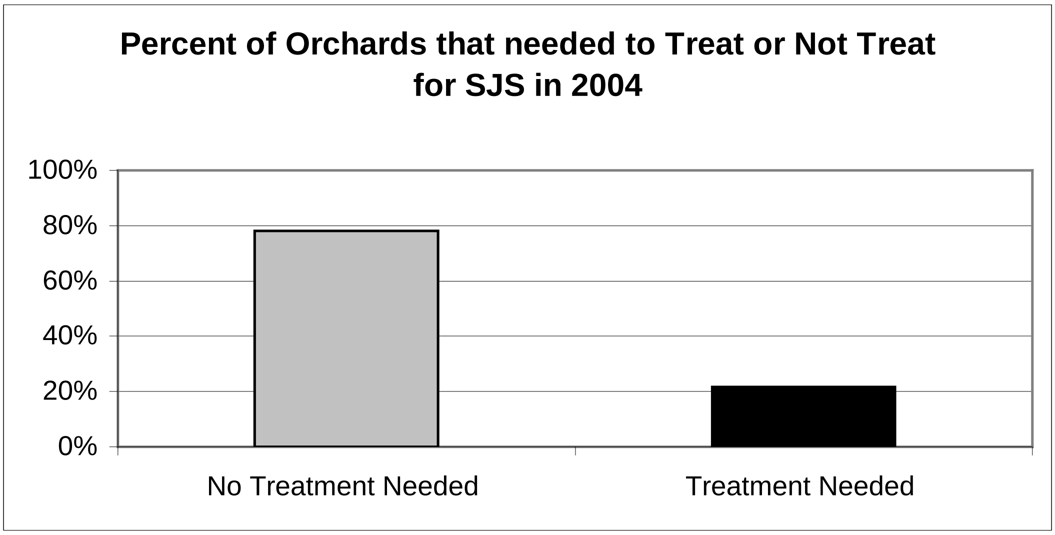
Dormant Treatment Decision Guide For Orchards That Have Been Receiving Dormant Insecticide Sprays in The Past			
Aphids present using methods 1, 2 or 3 (Y,N)	**Scale above Threshold**	**Reduced Risk Treatment Reccomendation**	**Conventional Treatment Recommendation**
N	N	Nothing	Nothing
N	Y	Dormant Oil	Dormant Insecticide + Oil
Y	N	Oil at Green Tip or Growing season Insecticide or Growing season Oil*	Dormant Insecticide + Oil
Y	Y		Dormant Insecticide + Oil
* Oil alone is not effective for Leaf Curl Plum Aphid once the leaves are			
1) One tree out of the 40 trees monitored in the fall has prune aphids.			
2) Orchard history indicates at least one tree had aphids last season			
3) One or more aphid eggs are found in the dormant spur samples.			

Table 2. "Dormant Treatment Decision Guide" used until 2004 for orchards that had not been receiving dormant sprays.

Dormant Treatment Decision Guide for Orchards That Have Not Been Receiving Dormant Insecticide Sprays in The Past				
Orchard History Indicates:		Scale above Threshold	Reduced Risk Treatment Recomendation	Conventional Treatment Recommendation
Below 10% of Trees Infested w/aphids	Above 10% of Trees Infested w/aphids			
x		N	Nothing	Nothing
x		Y	Dormant Oil	Dormant Insecticide + Oil
	x	N	Oil at Green Tip or Growing season Insecticide or Growing season Oil*	Dormant Insecticide + Oil
	x	Y		Dormant Insecticide + Oil
*Oil alone is not effective for Leaf Curl Plum Aphid once the leaves are curled.				

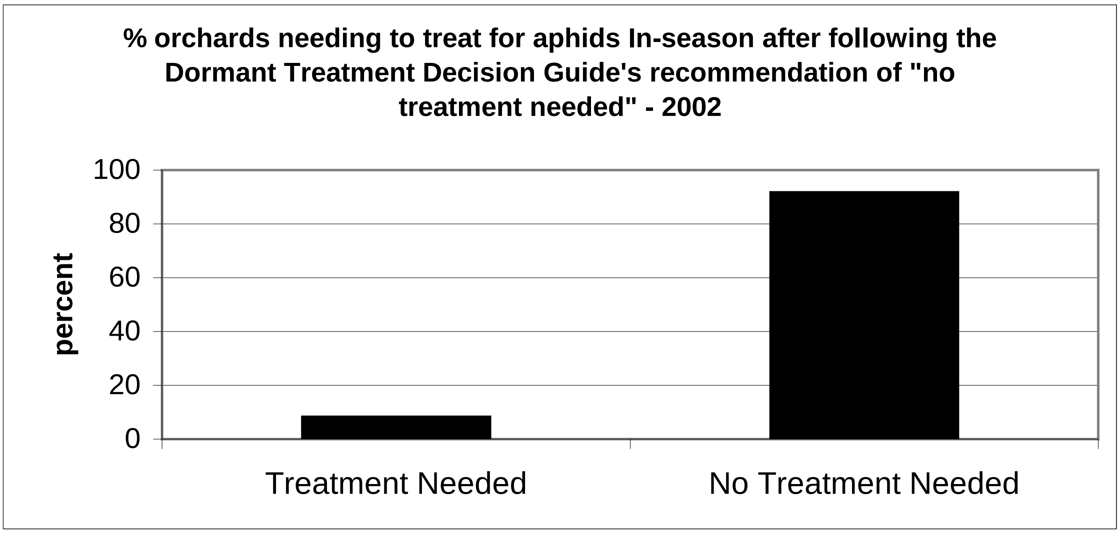
Results: 1) By following these guides very few orchards needed to treat for SJS (Figure 1) and no orchard had an outbreak of SJS during the course of the project.

Figure 1. The percent of orchards that needed to be treated for SJS during the course of the project.



2) In 2002 the two guides failed to accurately predict the need to control aphids in many cases. Two orchards needed to treat for aphids in the spring that were not recommended to do so in the dormant season. Both orchards had not been applying dormant sprays and had no aphid history over the past three years but, never the less, aphids became a problem. Other growers that had no history of aphids in their orchards were also beginning to report aphid problems. Also, the use of these guides did not predict aphid outbreaks or the need to treat in any orchard that had previously used a dormant pesticide treatment (Figure 2).

Figure 2. In 2002 nearly 10 percent of the orchards had to treat for aphids after being advised there was no aphid problem.



As a result of problems predicting aphid outbreaks, for the 2003/04 dormant period, all cooperating growers were advised to control aphids in the dormant period or with oil during the bloom period unless they had long term history of knowing that their orchard was not frequented by aphids. This program was totally successful in 2004.

Conclusions: The Dormant Treatment Decision Guide for orchards that have been receiving dormant insecticide sprays in the past was not reliable in forecasting aphid outbreaks; there is no good way of knowing long term history of aphid populations in those orchards. The Guide for orchards that had not been receiving dormant insecticide sprays in the past was fairly reliable but there were still problems with two orchards that required aphid control after predicting aphids would not be a problem. The SJS part of both guides was reliable and useful.

As a result of problems predicting aphid outbreaks a revised guide for all orchards was developed and presented in Table 3. The recommendation to treat for aphids in November is based on reliable "satellite project" information developed in 2003/04 and is suggested to mitigate the problem of dormant spray runoff into surface waterways.

Table 3. The "Dormant Treatment Decision Guide" developed in 2004.

"Dormant" Treatment Decision Guide for Prune Orchards				
Aphid Pressure Unknown Due to Past Dormant Sprays?[1]	**Long Term Orchard History or Spur Sample Indicates Aphids? (No or Yes)**	**Scale Above Threshold**	**"Reduced Risk" Treatment Options**	**"Conventional" Treatment**
Yes		**No**	Low rates of insecticides without oil in Nov. **OR** 2X oil* (once at green tip and 10 days later). **OR**	Insecticide + oil
Yes		**Yes**	Low rates of insecticides + oil	Insecticide + oil
	No	**No**	Nothing	Insecticide + oil
	No	**Yes**	Oil (low pop[2]) **OR** Insecticide + oil (high pop[2])	Insecticide + oil
	Yes	**No**	Low rates of insecticides without oil in Nov. **OR** 2X oil* (once at green tip and 10 days later). **OR**	Insecticide + oil
	Yes	**Yes**	Low rates of insecticides + oil	Insecticide + oil
*** Oil alone is not effective for leaf curl plum aphid once the leaves are curled and will only suppress mealy plum aphid populations**				

[1] To help determine the history of aphids in a dormant treated orchard:

1) Carefully observe trees throughout the orchard during growing season for the presence of any aphids. OR
2) Leave a few edge rows untreated and observe trees during the growing season for the presence of aphids.

[2] Low scale populations are when 10 – 15 percent of the spurs have live scale.
High scale population is when more than 15 percent of the spurs have live scale.

2. Pheromone Traps to Aid with Treatment Decisions

Situation: Pheromone traps have long been available but are generally underutilized by prune growers who make treatment decisions. Pheromone traps most commonly are used to help determine treatment timing by calculating degree-days from a biofix and, in the case of SJS traps, are also used to assess the presence of beneficial insects. Rarely have they been shown to be useful or have they been used to help determine if a treatment was needed. Information of this type could be useful to prune growers who may need to treat for PTB, OBLR or SJS.

A. San Jose Scale (SJS)

Evaluation: By monitoring SJS pheromone traps in spring, the quantity of beneficial insects (*Encarsia (Prospatella)* and *Aphytis melinus)*, as well as SJS males, was documented in each orchard each year since 1999. For each “conventional”, “reduced risk” and “check” orchard one SJS scale trap was used and 1000 fruit were examined in July and near harvest for evidence of SJS crawlers.

Results: Figure 3 shows the average numbers of male SJS and parasites caught in the “conventional”, “reduced risk” and “check” orchards during the course of this project. No significant differences in pheromone trap catches were ever found for male SJS between the “conventional”, “reduced risk”, and “check” orchards. Significant differences in beneficial insects did occur in some years. *Encarsia (Prospatella)* was caught in significantly larger numbers in “reduced risk” and “check” orchards than in “conventional” orchards in 2000 and in 1999 there were significantly more parasites of both species in the “check” orchards than in the “conventional” orchards. No live or parasitized SJS were found on fruit during pre-harvest fruit evaluation in 2004, 2003, 2002 or 2001. However, a few live SJS was found on fruit in the 2000 and 1999 crops. The average number of live and parasitized SJS found on fruit during this project is shown in Table 4.

Figure 3. Mean number of male SJS and SJS parasitoids caught each year during the project.

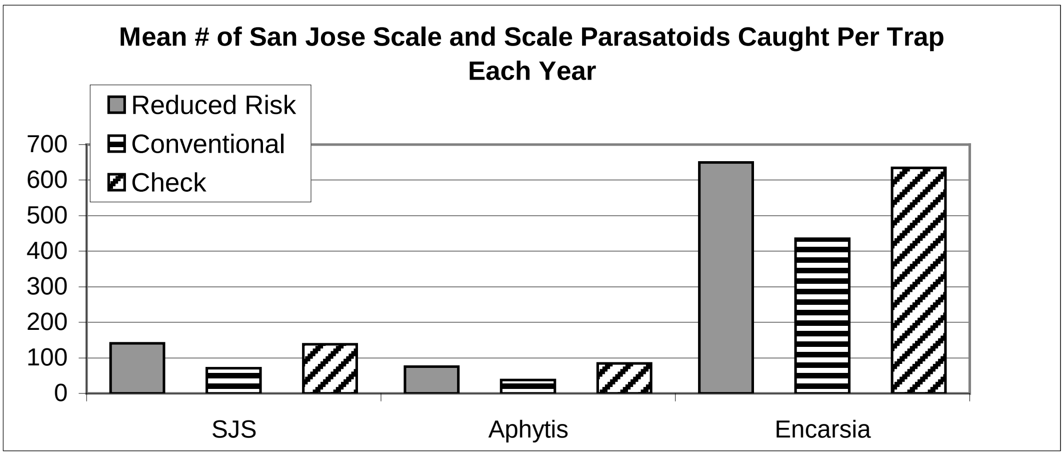


Table 4. Average number of live or parasitized SJS found on fruit each year of the project.

TREATMENT	% Fruit w/Live SJS	% Fruit w/ Parasitized Scale
"REDUCED RISK"	3	1
"CONVENTIONAL"	7	0
CHECK	.5	.5

Conclusion: Presence of more parasitoids in "reduced risk" and "check" orchards, where dormant insecticides had not been applied indicates the dormant insecticide with oil treatment suppressed populations of these beneficial insects. Clearly parasites can keep SJS in check after a few years of no dormant insecticide applications. The data suggest that average SJS traps catching less than 150 male scales during the late winter-spring are low populations and should not require treatment since SJS crawler presence was not significant on the fruit. Although there was a few SJS on the fruit the first two years of the project, albeit it was minor and of no economic consequence, in the last four years no SJS was found on the fruit. No SJS buildup was seen on the trees branches in any of the orchards during the course of this project.

Using SJS traps occasionally (not necessarily every year) can gave a good indication of SJS and scale parasite populations in the orchard and should be a practice growers should follow.

B. Peach Twig Borer (PTB)

Situation: Although research conducted during this project revealed a high correlation between total PTB trap catch in an orchard and damaged fruit at harvest and a high correlation between live PTB larva and PTB damage during the season PCAs and growers said that they would not use either of these techniques of determining the need for a PTB treatment. The techniques were too costly and time consuming. A new, less time consuming, PTB monitoring technique had to be discovered.

Currently PCAs and growers do use PTB pheromone traps to obtain a biofix and then base their spray timing on degree-day accumulation. Project leaders took advantage of this and, over the past three years, developed and evaluated a one-time fruit monitoring technique that could tell the PCA if a PTB treatment was actually needed.

Evaluation: PTB pheromone traps were used to obtain a biofix and 400 degree-days after biofix, 1200 fruit were evaluated in each "conventional", "reduced risk" and "check" orchard for the presence of PTB larva or PTB damage. Based on this fruit evaluation, a treatment decision was made based on a threshold of 1 percent of fruit having larva and/or larva damage. However, after the 2002 season the threshold of 1 percent was found to be too conservative and was changed to 2 percent. This treatment, if needed, would lessen the chance of more worm or brown rot damage associated with worms later in the season. Alternatively, if the orchard history indicated that last year's crop had significant worm damage then, two-bloom time *B.t.* sprays (one at "popcorn" bloom and again ten days later) would be recommended. For each site, 1000 fruit were examined in July and near harvest for evidence of PTB larvae or damage in order to validate this monitoring technique.

Results: When the treatment threshold for PTB was set at one percent of the fruit containing PTB larva and/or PTB damage at 400 degree-days from biofix only one of the project orchards reached that level and was recommended for treatment. Of those orchards that did not reach the treatment thresholds only one orchard had any PTB larva and/or PTB fruit damage with 1.3 percent damage being detected in July and at harvest only one orchard, a different one, had any PTB larva and/or PTB fruit damage with 1.4 percent damage being detected. None of these orchards were treated and there was no significant difference in PTB damaged fruit between the “conventional” and “reduced risk” plots at harvest.

The one project orchard that was recommended for treatment had a previous history of having over four percent of the fruit damaged due to PTB larvae. The grower followed the projects recommendation of applying two bloom-time B.t. sprays (one at popcorn and again ten days later). Since the 400 degree-day fruit evaluation revealed 2.29 percent PTB damage in the “check” orchard, an additional PTB spray was recommended. This strategy was completely successful. The “conventional” and “reduced risk” plots had very low levels of PTB damage in the July and harvest evaluations while the “untreated check” had considerably more damage (Table 5). The Dried Fruit Associations grade sheet revealed no PTB damage in the “conventional” or reduced risk” orchards but the untreated “check” orchard had 1.3 percent PTB damage (Table 5). However, statistically there were no significant differences in the PTB damage between the three orchard programs.

Table 5. Control strategies and incidence of PTB damage in the only orchard during the course of this project that indicated a need for a 400 degree-day PTB treatment.

% Fruit with PTB Damage (Butte County Orchard) 2001			
Evaluation Timing	**"Reduced Risk" Bt + Inseason Insecticide**	**"Conventional"Dormant Insecticide + Inseason Insecticide**	**Untreated Check**
400 Degree-Days	0.8	0.3	2.9
July Evaluation	0.2	0.0	1.8
Harvest Evaluation	0.7	1.4	2.3
DFA Disease/Insect Offgrade	0	0	1.3

After the treatment threshold was changed to two percent of the fruit containing PTB larva and/or PTB damage at 400 degree-days from biofix none of the orchards in this project needed to apply a growing season PTB treatment for dried fruit. The July and harvest samples found that no project orchards had PTB larva and/or damage over 1 percent. There was no significant difference between the “conventional” and “reduced risk” plots in the amount of PTB damaged fruit found at harvest in 2003 (Table 6). There was very little PTB damage found in the reduced risk orchards in 2004 (data not shown).

Table 6. Mean percent fruit with PTB larvae and/or damage present (2003)

Treatment	400 Degree-Days	July	Harvest
Reduced Risk	0.02	0.17	0.06
Conventional	0	0.01	0.02

Conclusion: Fruit monitoring at 400 degree-days after PTB biofix using pheromone traps can be a useful tool in determining treatment necessity and timing. A 2 percent treatment threshold is very conservative based on the fact that there was nearly no visible damage to the fruit at harvest in any year of the project.

C. Oblique Banded Leaf Roller (OBLR):

Situation: Prior to the investigations undertaken in this project no method was known on how OBLR pheromone traps and fruit monitoring might be used to determine the need for an OBLR treatment.

Evaluation: Research using OBLR trap catches and fruit monitoring was conducted and evaluated each year just like the PTB research described above except a one-time sample could not be used because exact degree-days for evaluating the presence of OBLR or OBLR damage in prunes was not known. To determine best single evaluation timing for the presence of OBLR larva and/or damage 1200 fruit were monitored each week in each orchard for three weeks starting at 690 degree-days after biofix and for five weeks in 2003. At the best evaluation timing a treatment decision was made based on 1 percent (later raised to 2 percent) of fruit with OBLR larva or OBLR larval damage present. Alternatively, if the orchard history indicated that last year's crop had significant worm damage (more than 2 percent) then, two-bloom time *B.t.* sprays (one at popcorn and again ten days later) were recommended. For each site, 1000 fruit were examined in July and near harvest for evidence of OBLR larvae and/or damage in order to validate this monitoring technique.

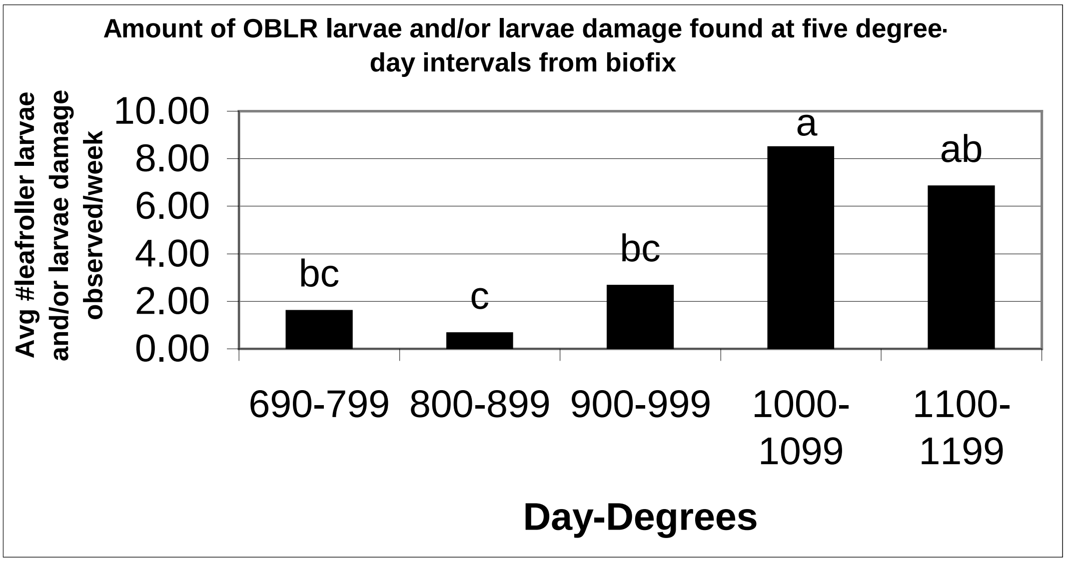
Results: When fruit was evaluated for three weeks beginning at 690 degree-days after biofix, none of the project orchards reached the 1 percent treatment threshold and none needed to apply a growing season OBLR treatment. However, in the July sample six orchards had OBLR larva and/or damage over 1 percent with 2.5 percent being the highest and at harvest five orchards had OBLR larva and/or damage of over 1 percent with 2.5 percent being the highest. However, there was no significant difference between the "conventional", "reduced risk" or "check" orchards in the amount of OBLR damaged fruit found at harvest. Tables 7 shows the average percent of fruit with OBLR damage or larva present from all project orchards.

Table 7. Mean percent fruit with OBLR damage present (690 Degree-Days + 2 weeks, July and Harvest Final Evaluations).

Treatment	690 Degree-Days + 2 weeks	July OBLR Damage	Harvest OBLR Damage
Reduced Risk	0.43	0.57	0.52
Conventional	0.31	0.32	0.42
CHECK	0.43	0.57	0.52

When fruit was evaluated for five weeks beginning at 690 day-degrees after biofix, 900-999 day-degrees from biofix, was found to be the best time to evaluate the presence of OBLR larva and/or damage (Figure 4). This timing was the beginning of the rise in the population.

Figure 4. Amount of OBLR larvae and/or larvae damage found at five degree-day intervals from biofix.



Using the 900-999 degree-day monitoring timing in 2003 and 2004 no treatments were recommended since no orchard exceeded 2 percent of the fruit with OBLR larva and/or damage. The July and harvest sample found that no orchards had OBLR larva and/or damage over 1 percent and there was no significant difference between the “conventional” and “reduced risk” orchards in the amount of OBLR damaged fruit found at harvest, July or at 900-999 DD (Table 8 and 9).

Table 8. Mean percent fruit with OBLR larvae and/or damage present (2003).

Treatment	936 DD	July	Harvest
Reduced Risk	0.77	0.20	0.14
Conventional	0.70	0.02	0.07

Table 9. Mean percent fruit with OBLR Larvae and/or damage present (2004).

Treatment	900-999 DD	July	Harvest
Reduced Risk	0.22	0.36	0

Conclusion: Fruit monitoring at 690 degree-days after biofix using pheromone traps was too early to get an accurate reading of OBLR damage. Fruit monitoring at 900-999 degree-days after biofix was the best time to evaluate for OBLR. This monitoring technique can be a useful tool in determining treatment necessity and timing. The 2 percent treatment threshold is considered conservative since worm damage at harvest was negligible.

3. Spring Prune Aphid Monitoring

Situation: Without a dormant insecticide and oil treatment it would be important to be able to assess aphid populations' during the growing season to determine if treatments would be needed.

Although it has been reported that MPA causes fruit cracking there is no documented evidence to support this. Knowing what damage these aphids cause would be important in determining the need for control measures.

Evaluation: Beginning in April, a random sample of 80 trees per project site was observed weekly to determine the presence of leaf curl plum aphids (LCPA) and mealy plum aphids (MPA). The treatment threshold was 10 percent or more of the trees having aphids in 1999 and 2000 but in 2001, the treatment threshold was changed based on research done by Dr. Nick Mills to more than 20 percent of the trees with significant aphid infestations. Significant was defined as trees with aphids covering 10 percent or more of the tree surface. Treatment recommendations ranged from an oil treatment to suppress MPA, to an insecticide treatment to eliminate MPA or LCPA.

A statistician developed a sequential sampling technique for prune aphids from project data. Sequential sampling allows for a small number of trees (20) to be sampled. From this small sample if the treatment threshold was reached and a decision to treat was made, then sampling could stop. If MPA and/or LCPA aphid levels were determined to be very low, sampling can also stop. If MPA and/or LCPA levels were moderate (more than very low, but not enough to call for a treatment) then additional trees (10) needed to be sampled until a decision could be made or 80 trees had been sampled.

After a few years of using the sequential sampling technique it was discovered that project scouts and PCAs were taking too long to complete the sequential aphid sampling. To correct this problem the sequential sampling technique was improved in 2003 and 2004 by introducing a timed search. The initial search was for 10 minutes, the approximate amount of time it should take to monitor 40 trees. If a decision couldn't be a made an additional five minutes would be spent looking at more trees. The total time allowed for monitoring was 20 minutes.

To determine to what extent aphids caused fruit cracking 40 fruit (from up to 25 trees) were examined in August from trees, which had been infested by MPA, and 40 fruit (from up to 25 trees) were examined from trees that had not been infested by MPA. For example: if only 10 trees in the orchard had aphids, then only 10 trees that did not have aphids would be evaluated.

Results: During the course of this project eight orchards were correctly identified as having growing season aphid populations that exceeded the projects treatment threshold. Treatment recommendations were made in all eight orchards. However aphid control was varied due to the course of action that each grower took. One orchard, with LCPA, was being farmed "organically" and a new organically approved insecticide that was used did not work. Another orchard had a MPA problem and an oil treatment gave satisfactory control. An oil treatment failed to control LCPA in a third orchard. Five other orchards also exceeded the growing season treatment threshold for aphids; however these growers chose not to follow the treatment recommendation.

Table 10 shows that the growing season aphid monitoring technique revealed an average of: 1) 30.8 percent of the orchards that had dormant insecticide treatments applied had a few aphids present in the spring, 2) 100 percent of the orchards that did not put on a dormant spray or a "reduced risk" treatment for aphids had a significant aphid problem in the spring and 3) 12.2 percent of the orchards that used a "reduced risk" technique to control aphids had a significant aphid problem and 62.8 percent had a few aphids present in the spring.

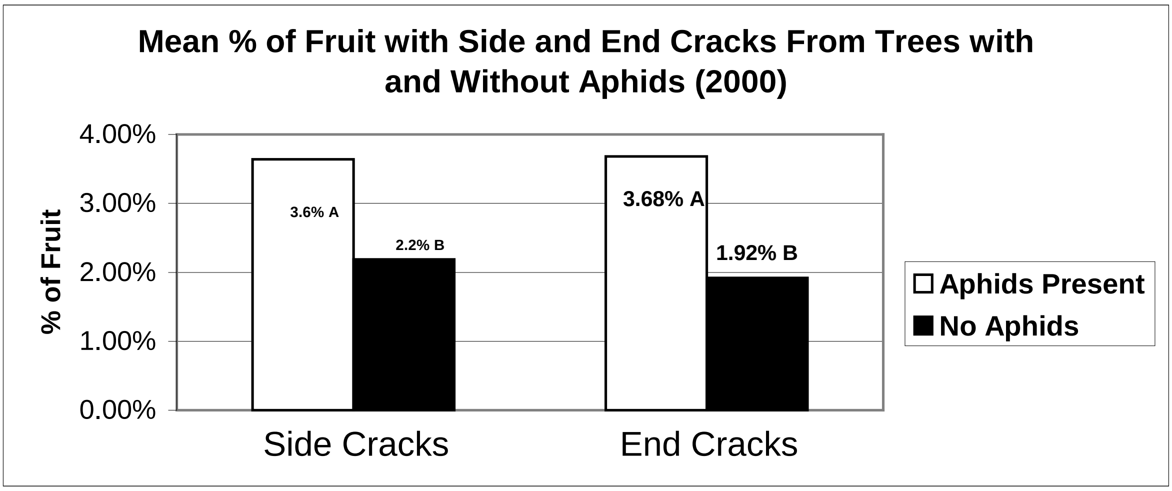
Table 10. Average incidence of aphids amongst cooperators.

Aphid control program	% of orchards with few aphids	% of orchards with significant aphids above treatment threshold
No program for aphids	0	100
"Reduced Risk" program for aphids	62.8	12.2
Applied traditional dormant spray	30.8	0

The timed search aphid sampling technique was compared to the sequential sampling method of looking at all 80 trees and produced the same results.

Although every year there was a numerical trend for more cracked fruit on trees that had aphids, 2000 was the only year that showed a statistically significant difference in the amount of fruit with side cracks and end cracks. Trees with MPA present had significantly higher levels of side cracks and end cracks on fruit than did trees without aphids. (Figure 5). This year was also the year with the highest MPA populations at project sites.

Figure 5. Cracked fruit associated with aphids.



Means not followed by a common letter are significantly different from each other at the 95 percent level of significance by to Duncan's Multiple Range Test for Mean Separation.

Conclusion: The new sequential sampling and timed search techniques for the presence of aphids gave a good indication of aphid population levels and when and if a treatment was needed. All of the orchards that did not apply a dormant, delayed dormant or bloom treatment for aphids in 2003 and 2004, had a treatable level during the growing season. Of the orchards that used the original "Dormant Treatment Decision Guide," 12.2 percent had a treatable level during the growing season. This prompted the 2004 revision of the "Dormant Treatment Decision Guide" as described earlier in this report (see page 14). The growing season treatment threshold (based on 20 percent of significantly infested trees) appears to be fairly accurate.

Even though there was not always a scientifically statistical difference, trees with MPA always had more cracked fruit than trees without MPA. Over the course of this project end cracks appeared to be associated with aphids more than side cracks.

4. Prune Rust Monitoring and Treatment Timing Recommendations:

Situation: Rust control is the most common pest treated during the growing season. Growers had no way of knowing if they needed to treat for rust or not. Most growers simply applied one or more protective wettable sulfur treatments in May, June and/or July.

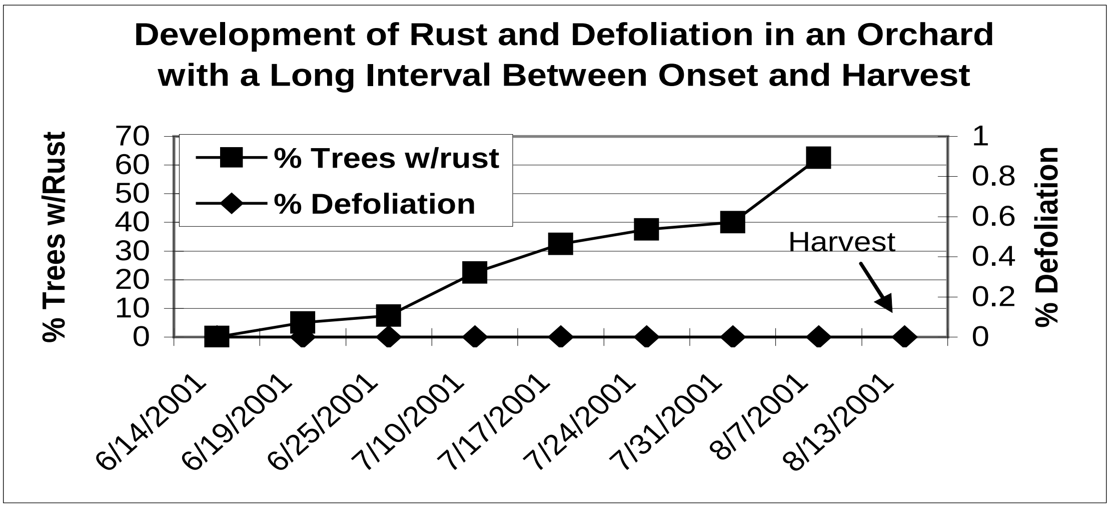
Previous research has shown that rust treatments applied close to the onset of rust infection were the most beneficial and provided protection for about two weeks. Teviotdale and

Sibbett demonstrated that post harvest defoliation from rust had no influence on subsequent fruit quality or productivity. In 1997 Olson, Krueger, and Teviotdale reported that the appearance of rust infection on leaves has no influence on fruit soluble solids, fruit dry away ratio or fruit size. However, fruit soluble solids, dry away ratio and/or fruit size can be affected if rust causes defoliation prior to harvest.

Evaluation: From this project a monitoring technique was developed to monitor the same 40 trees on each visit to each project site for the onset of prune rust infection. Monitoring for rust was initiated May 1st and continued every week in the Sacramento Valley and every other week in the San Joaquin Valley until mid-July if no rust was found. If rust was found, monitoring continued until approximately 4 weeks prior to harvest. The treatment threshold was the first sign of rust in the orchard. Once rust was detected, a treatment was recommended. After a rust treatment was applied, if continued monitoring indicated an increase in rust, additional treatments were recommended. In 2002 the monitoring switched to a random 40 tree search. This led to a broader search area and a faster detection method. Any tree defoliation that occurred prior to harvest in the project orchards was documented to help validate the treatment threshold and treatment cutoff timing.

Results: Prune rust was found in some of the project orchards every year. Growers that followed the projects recommendations and treated when rust first occurred had no defoliation prior to harvest. Slight defoliation only occurred in two years of the project and in only four orchards. The growers at these four orchards decided not to treat for rust even though they had reached the rust monitoring techniques treatment threshold. In 2000, 2001 and 2004 at untreated sites, no defoliation from rust occurred when rust was first detected 6, 7, and 6 weeks before harvest respectively. In 1999 only one orchard had 10 percent defoliation from rust and that was when rust was detected five weeks before harvest. In 2003, rust was found as early as eight weeks before harvest, resulting in minimal defoliation. The earliest prune rust occurred in an orchard was mid June, 2002, about eleven weeks prior to harvest and controlled with one treatment. No defoliation ever occurred when rust first appeared after July 15th. A graphic example of the prune rust data collected can be seen on Figure 6.

Figure 6. The percent of rust and defoliation found in one orchard during the course of a season.



Conclusion: The data suggests that rust monitoring and rust treatments can be terminated several weeks before harvest. Since 2003 rust treatments have not been recommended within six weeks prior to harvest.

This prune rust monitoring technique has worked well during the course of this project. The monitoring technique has the potential of greatly reducing rust treatments. Sixty-five percent of all orchards monitored in 2004 either had no rust or rust was found only after rust was no longer a problem (six weeks prior to harvest). The monitoring technique revealed that 76 percent of all orchards monitored in 2003, 84 percent of all orchards monitored in 2002 and 91 percent in 2001 had either no rust or rust was found only after rust was no longer a potential problem.

Monitoring for prune rust is a fairly simple technique. It takes one person less than 30 minutes to evaluate an orchard. Judging from the recent reduction in the amount of Sulfur used in prune production this or some other decision making technique is now being utilized by prune growers.

5. Presence–Absence Sequential Sampling for Web-spinning Mites:

Situation: Prunes are occasionally infested by web-spinning mites and require an in-season treatment. When this project started there were no established monitoring techniques or treatment threshold for web-spinning mites in prunes. When growers made treatment decisions it was generally based on visible damage or on calendar date. This was often too late, too early, or unneeded. The presence-absence web-spinning mite monitoring technique developed for almonds was tested and validated for use in prunes from 1999 through 2001.

Evaluation: In 1999, the presence-absence sequential sampling for web-spinning mites consisted of sampling 15 leaves from 10 trees per project site for the presence of web-spinning and beneficial mites/predators. Sampling began around June 1 and continued for 10 weeks. In 2000 the number of trees monitored dropped from 10 to 5 per project site due to the length of time it took to complete monitoring. The treatment threshold was established to be when over 53 percent of the leaves had web-spinning mites or eggs with mite predators present, or 32 percent of the leaves having web-spinning mites/eggs with no predators present. Sampling took 30 – 45 minutes (5 trees per site) and was done every other week until 20 percent of the leaves had mites. Once that level was reached sampling was done weekly. Pest control advisors were kept aware of the development of this mite monitoring technique.

Results: This monitoring technique was validated in prunes and clearly showed population levels of mites, predators and treatment thresholds. Even though PCAs agreed that the monitoring system was accurate and told them the information they needed to know they all agreed that they would never use it because it required too much time.

Conclusion: Although this monitoring technique takes too long for PCAs to implement the presence-absence monitoring technique for mites is a useful method of determining the need for treatment and reduces the likelihood of treating without justification. However, another mite monitoring system that that would be acceptable to PCAs had to be discovered and validated.

6. 10-Minute Search for Web-spinning Mites Technique

Situation: To replace the presence-absence mite sampling technique that PCAs would not use work was begun on a "10-minute search" monitoring technique in 2001 and 2002.

Evaluation: The "10-minute search" monitoring technique for web-spinning mites was compared to the presence-absence technique. Each monitoring technique was performed in the same area of the orchard. The "10-minute search" was conducted first so results would not be influenced by the results of the presence-absence technique. The "10 minute search" technique involved looking for symptoms of web-spinning mites, as well as, looking at individual leaves with a hand lens to evaluate mite predator and web-spinning mite populations. This would be done for approximately five minutes in two different locations in the orchard. After each five-minute search, web-spinning mite and mite predator levels were recorded. The following six categories for web-spinning mites and three categories for mite predators were used:

Web-spinning mite rating:

1. **None –** No mites present.

2. **Low** – An occasional web-spinning mite on occasional leaf. Web-spinning mites generally hard to find. Example: less than one web-spinning mite per leaf.

3. **Low-moderate** – Web-spinning mites easier to find, but no colonies of web-spinning mites, no webbing and few eggs. Example: two to four web-spinning mites per leaf.

4. **Moderate –** Some leaves with no web-spinning mites others with small colonies of web-spinning mites with eggs easy to find, but very little, if any, webbing.

5. **Moderate-high** – Web-spinning mites on most leaves, colonies with eggs and webbing on some leaves

6. **High** - Lots of web-spinning mites on most leaves. Colonies of web- spinning mites, eggs and webbing abundant.

Predator rating:

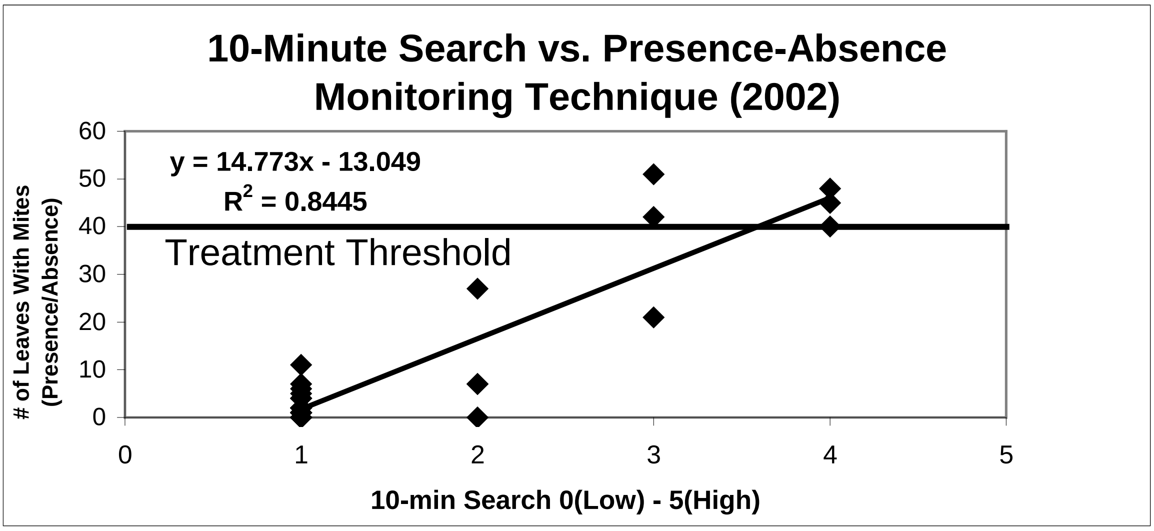
1. **Low** – Hard to find. Example: less than one predator per six leaves.

3. **Moderate** – Easier to find. Example: one predator per three leaves.

5. **High** – One or more predators per leaf.

Results: Results from this technique were compared with presence-absence technique and a strong correlation between the two was found. The "10-minute search" monitoring technique had an 84 percent correlation (significant at the 99 percent confidence level) with the presence-absence sampling technique in 2002 (Figure7).

Figure7. Correlation between "10 minute search" and presence/absence mite sampling.

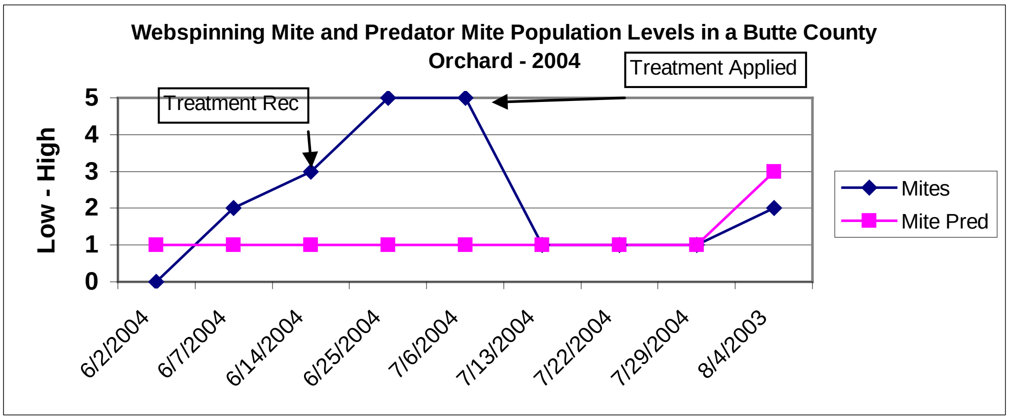


In 2004, 22 percent of the orchards reached a treatable level of web-spinning mites before mid July. Four orchards were treated shortly after the population reached the treatment threshold and lowered the population enough to avoid defoliation before harvest. The orchard that did not treat had a low incidence of defoliation prior to harvest.

Figure 8 is a summary of the data collected in one orchard and illustrates the type of information that this monitoring system can generate.

In 2003 and 2004, the "10-minute search" technique was the only mite monitoring technique that was used in this project.

Figure 8. Information gathered from using the "10 minute search" for mites in one orchard.



Conclusion: The "10-minute search" monitoring technique is an accurate time saving monitoring technique useful to determine weather or not a treatment is needed for web-spinning mites. With this technique the observer can see a problem coming and apply treatments in a timely fashion, often using low rates of miticides or oil. The "10-minute search" technique requires little training or experience to use. Pest control advisors should find this monitoring system acceptable since it takes little time to use.

7. Fruit Brown Rot Predictive Model (ONFIT – Over Night Freezing and Incubation Technique):

Situation: There is currently no way of knowing if fruit brown rot will occur or not. Consequently growers have been spraying pre-harvest for fruit brown rot based on a suspicion that it will occur. UC Plant Pathologist Themis Michalaides had created a technique to determine presence of fruit brown rot from latent infections that needs to be validated.

Evaluation: Evaluating the usefulness of ONFIT involves sterilizing and freezing a sample of green fruit from 23 project sites in late May-early June then allowing it to thaw to promote development of latent infections by *Monilinia fruticola* or *Monilinia laxa*. Levels of latent infection found using this ONFIT technique were correlated to levels of fruit brown rot infection that became visible at the project sites in the field from 1000 fruit samples evaluated in July and again at harvest. These results were compared to a predictive table provided by Dr. Michalaides (Table 11). This information was used to determine need to protect fruit from brown rot infection with a fungicide application.

Table 11. ONFIT brown rot predictive table.

% infected green fruit from ONFIT	% infected fruit (field)	% infected fruit (post harvest)
0	0	0
1	1	5
2	3	15
5	9	35
8	14	50

Results: The ONFIT technique was evaluated for four years but never during those four years was there enough brown rot in the field to validate the ONFIT technique. An example of the results obtained is presented in Table 12 which shows the results of our investigation in 2001. In this year the ONFIT procedure revealed that 12 sites (52 percent) had low levels of latent brown rot present. Results of the final field evaluations at harvest indicted that fruit brown rot was present in low levels at 10 sites (43 percent). Eight of the 10 sites that had brown rot at harvest were among the 12 predicted to have brown rot using the ONFIT procedure. In 2001, brown rot levels during July exceeded 1 percent infection in two sites, while at harvest only one site exceeded 1 percent infected fruit. ONFIT over estimated the harvest incidence of brown rot in 80 percent of the cases and underestimated the harvest incidence of brown rot in 20 percent of the cases.

Table 12. 2001 ONFIT results.

County and Site	ONFIT Prediction (% Brown Rot)	% Brown Rot Present in July	% Brown Rot Present at Harvest
Ag - Tulare	0	0.0	0.0
BR - Glenn	1	0.0	0.2
DB - Butte	2	0.3	0.2
Br - Madera	0	0.0	0.0
GC - Sutter	8	0.0	0.0
CSUC - Butte	0	0.3	0.0
DC - Butte	8	0.2	0.0
Fl - Tehama	1	0.0	0.0
EG - Fresno	0	0.0	0.0
BJ - Butte	2	0.5	1.5
JH - Sutter	0	0.0	0.0
JC - Butte	1	0.7	0.5
JT - Yolo	0	0.0	0.0
KJ - Yuba	5	7.0	0.2
LF - Glenn	1	0.2	0.2
MK - Yuba	6	0.7	0.0
AR - Tehama	0	0.0	0.0
MJ - Sutter	2	1.7	0.0
OO - Butte	0	0.0	0.3
RBF - Tehama	0	0.0	0.2
TR - Sutter	0	0.0	0.2
DV - Tulare	0	0.0	0.0
WG - Glenn	1	0.0	0.7

Conclusion: The ONFIT technique needs to be evaluated under more severe conditions before it can be relied upon. Under the current conditions of little or no fruit brown rot, the ONFIT test was 67 percent accurate in predicting whether or not the orchard would have some level of brown rot in 2001. Although this percent accuracy may seem low, it is surprisingly high for so little brown rot found at harvest. This monitoring technique could provide valuable guidance about the need for a fruit brown rot spray. More research and evaluation of the ONFIT during years of higher brown rot incidence will need to be conducted before any definite conclusions can be made. Due to the low incidence of brown rot no testing of ONFIT was done after 2001 in this project.

<u>Objective II. Evaluate more effective use of fertilizers and natural resources</u>

1. Using Tissue and Water Sample Analysis

Situation: Although leaf tissue analysis has been recommended for many years it is an underutilized tool in determining fertilization needs. Water analyses are also valuable in detecting nitrate nitrogen (NO_3^-N) in well water. Knowledge of NO_3^-N content of the water could be used by growers to supplement standard N fertilizer programs. For adoption of these monitoring tools, their utility needs to be documented and demonstrated to growers.

Evaluation: Each year plant nutrient levels of Nitrogen (N), Potassium (K), Zinc (Zn) and Boron (B) were obtained through tissue analysis. Plant tissue and water samples for each site were collected in July and submitted to a private analytical laboratory for analysis. Results from the samples were reported to growers for their consideration when making decisions on fertilizer applications in the "reduced risk" orchard sites. In 2002 water samples were only collected from wells that had high NO_3^-N in the past. In 2003 and 2004, no water samples were tested because no new orchards that irrigated with well water were added to the project.

Results: Results of water analyses are shown in Tables 13. Multiplying ppm of NO_3^-N by 2.72 results in pounds of Nitrogen per acre foot of irrigation water applied. Sites highlighted in Table 13 have a high amount of NO_3^-N in the water. Over the four years water samples were collected and analyzed the average pounds per year of Nitrogen per acre foot of irrigation water was 12.8 pounds.

Table 13. Water Analyses (1999-2002)

	2002		2001		2000		1999	
Site	**NO_3 N - ppm**	**Lbs N/acre ft water**	**NO_3 N - ppm**	**Lbs N/acre ft water**	**NO_3 N - ppm**	**Lbs N/acre ft water**	**NO_3 N - ppm**	**Lbs N/acre ft water**
Site 1			2.1	5.8	2.3	6.1	2.4	6.4
Site 2	7.7	20.94	7.2	19.5	10.1	27.4	10.1	27.5
Site 3	5.2	14.14	4.8	13.1	3.2	8.6	5.7	15.5
Site 4	5.4	14.69	8.0	21.8	5.2	14.2		
Site 5			1.7	4.6	1.7	4.5	6.1	16.5
Site 6			15.2	41.3	10.4	28.3	10.5	28.6
Site 7			25.2	68.5	3.4	9.1	5.9	16.0
Site 8	0.3	0.82	1.2	3.3	1.6	4.4	1.7	4.7
Site 9			9.6	26.1	8.5	23.1	8.2	22.2
Site 10			2.2	6.0	2.6	7.1	1.8	4.8
Site 11	3	8.16	0.8	2.2	2.7	7.4	2.1	5.7
Site 12	5.5	14.96	3.6	9.7	2.1	5.7	2.1	5.7
Site 13			3.9	10.6	8.3	22.6	5.2	14.1
Site 14			8.2	22.3	<.05	<.135	<.05	0
Site 15			2.7	7.3	<.05	<.135	0.1	0.2
Site 16					1.0	2.8	1.3	3.5
Site 17			0.7	1.9	1.5	4.2		
Site 18			0.2	0.5			<0.05	0
Site 19			10.8	29.4			11	30
Site 20					6.1	16.6	6	17

Although tissue analyses was conducted each year only the results for the past two years are shown in Table 14. Deficient levels of the nutrients are as follows: N – less than 2.2 percent, K – less than 1.3 percent, Zn – less than 18 ppm, and B – less than 30 ppm. B is also toxic if the levels in the tissue exceed 100 ppm.

In 2003, based on U.C. established critical mid-summer leaf tissue levels, 35 percent of the sites were considered deficient in N. No cooperator was deficient in K. Eighty-four percent of the cooperators were considered deficient in Zn. High levels of Zn found in two orchards were the result of Zn spray contamination. All cooperators orchards had adequate B levels.

In 2004, 67 percent of the sites that had leaf samples taken were deficient in N, 72 percent were deficient in Zn and none of the sites were deficient in K or B.

Table 14. 2003-2004 Tissue Analyses for Various Nutrients *

	2003				2004			
Site	N - %	K - %	Zn - ppm	B - ppm	N - %	K - %	Zn - ppm	B - ppm
1	2.4	2.35	**12**	51	2.39	2.68	18.00	66.00
2	**2.17**	2.77	**9**	48	2.37	2.42	**16.00**	61.00
3	2.25	1.85	70	54	**1.89**	1.85	**11.00**	46.00
4	2.23	1.47	18	37				
5	2.21	1.97	**15**	52	**1.94**	2.39	**15.00**	43.00
6	2.38	2.07	**16**	59	**1.88**	2.19	**13.00**	50.00
7	**1.83**	1.95	**14**	48	**1.68**	2.54	**13.00**	42.00
8	2.28	2.13	**15**	53	**1.44**	2.18	**15.00**	42.00
9	**2**	2.15	63	51	**1.54**	2.63	18.00	43.00
10	2.25	3.35	**11**	63	2.32	2.56	**16.00**	68.00
11	2.27	3.35	**11**	59	2.24	2.56	**16.00**	71.00
12	**1.86**	2.1	**15**	52	**2.01**	2.64	18.00	45.00
13	**1.89**	1.98	**15**	54	**1.87**	2.49	18.00	48.00
14	2.21	1.40				2.31		
15	2.48	1.37	**15**	54	**1.88**	1.68	**15.00**	45.00
16	**1.99**	1.88	**15**	49	**1.89**	1.65	**17.00**	47.00
17	2.49	2.42	**15**	58	**2.01**	2.63	**14.00**	49.00
18	2.58	2.24				1.68		
19	2.59	2.94				3.2		
20	2.54	1.56				3.72		
21	**1.8**	1.8	**10**	51	**1.81**	1.86	**13.00**	53.00
22	2.34	2.8	**13**	44	2.26	2.76	18.00	62.00
23	**2.15**	2.43	**17**	45	2.37	2.42	**16.00**	61.00

* **Bold** type indicates a deficiency

Conclusion: Considering that prune growers apply about two acre feet of irrigation water per acre each year the average N contribution from well water would be about 25 pounds of N per acre. Although this contribution is small the N levels found in the well water was considered when making fertilizer recommendations in the “reduced risk” orchard sites.

The percentage of orchards deficient in N, K, Zn and/or B in 2003 and 2004 was typical of what was found in other years of this project (Table 15). No grower was found to have high levels of N suggesting growers are not applying too much N. In fact the contrary appears to be the case. Growers may have reduced their fertilizer programs in recent years due to reduced payments and declining markets for prunes.

These tissue and water analysis have provided useful information and have proved to be very valuable tools when making fertilizer decisions.

Table 15. Percentages of orchards with various nutrient deficiencies over the six years of the project.

	Percent of orchards deficient in:			
Year	**N**	**K**	**Zn**	**B**
2004	67	0	72	0
2003	35	0	84	0
2002	20	0	26	0
2001	48	0	24	0
2000	5	5	47	0
1999	20	0	13	0

2. Early Leaf Analysis to Forecast the Need of Potassium (K) and/or Nitrogen (N) Fertilizer Applications:

Situation: Established guidelines for adequate leaf K levels in prunes are available using July leaf tissue samples. However, if a deficiency is present at that time, detrimental effects to production of the crop may have already occurred. If an early method of predicting nutrient deficiencies was available it would give growers an early opportunity to make corrective fertilizer applications that could benefit the trees before deficiency occurred later in the season.

Evaluation: In 2001, 2002 and 2003 the early leaf tissue sampling for K was compared to the July leaf samples at all project sites. In 2002 and 2003 N was also tested and compared along with K. The test involved the collection of 100 fully expanded, mature leaves from at least 25 healthy trees per orchard site in the first week of May and the first week of July and having them analyzed by a private analytical laboratory for K and N content. If a correlation between the two sampling dares could be made then early fertilizer recommendations could be made. Once in June, July and august trees in the "reduced risk" and "conventional" sites were visually monitored for the presence of K deficiency symptoms. In 2004 no test were conducted because the prune crop was too light to gain any meaningful information.

Results: Using May leaf K and N nutrient levels to predict a July leaf K and N nutrient levels was unsuccessful. Potassium and N levels in May would generally be predicted to be lower in July. This was not the case in many orchard sites. No correlation between these two leaf sampling times could be found for leaf K or N (Figure 9 and 10).

Figure 9. Correlation between May and July leaf Potassium.

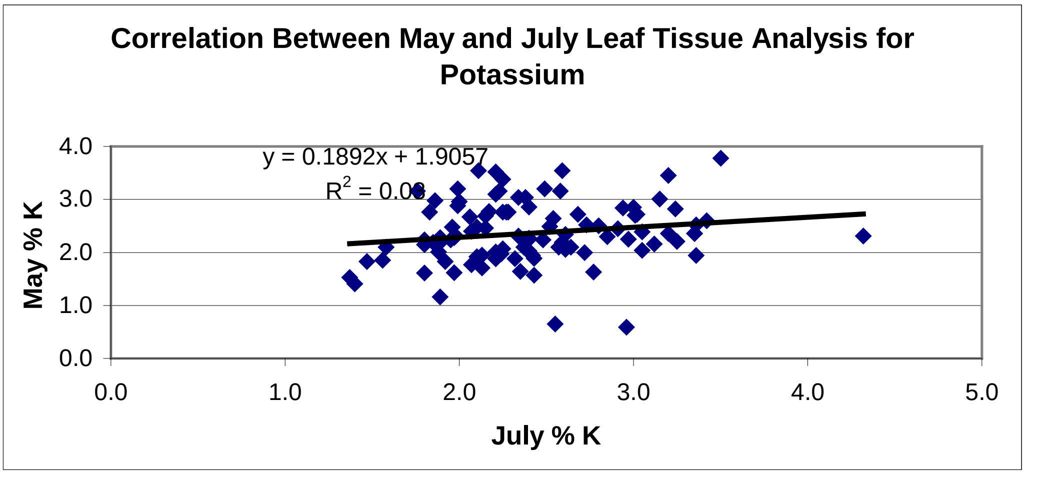
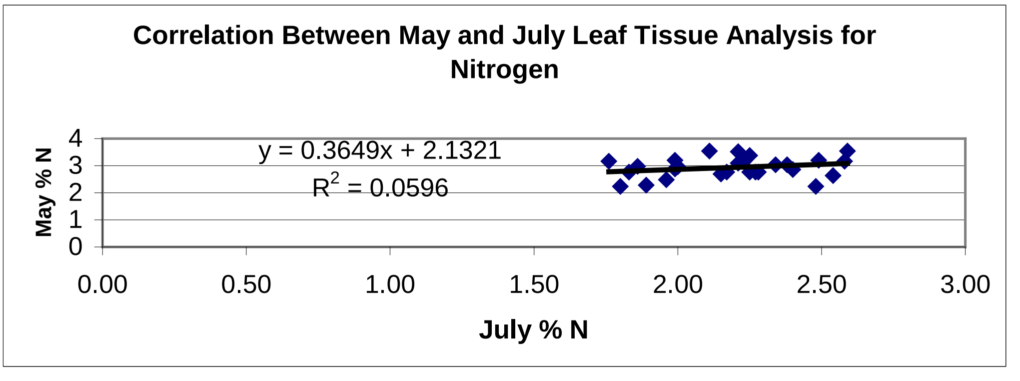


Figure 10. Correlation between May and July leaf Nitrogen.



Orchards that exceeded 2.3 percent leaf K in May generally did not have visual symptoms of K deficiency that year and generally had adequate K levels in the July tissue analysis. Orchards that were below 1.3 percent leaf K in May and were known not to have applied K for correction showed deficiency symptoms in July and August.

Conclusion: The poor correlations indicate that knowing the K and N status of prune trees in May has little relation to what the K or N status would be in July. This is undoubtedly due to: 1) the influence of any fertilizer applications that may have been recently made, 2) the influence of the crop load, 3) the influence of residual K and N in the soil. However, in general the following recommendations could be made based on the data collected: 1) K levels above 2.3 percent in May suggest that there will be no need for additional K applications that season and deficiency symptoms are highly unlikely and 2) May K levels at or below 1.3 percent suggest a likelihood of visual K symptoms and the need for K treatments. These guidelines are too broad to provide much utility. Other information such as irrigation schedule and quantity, soil type, soil K status, and crop load would be important factors needed to help get a better picture of the need for K applications in these orchards. This information is often difficult to obtain. May leaf sampling for Nitrogen status has little value except in the case where an orchard is near deficiency in May it would surely be deficient in July.

3. Irrigation Management:

Situation: Irrigation requirements of fully canopied orchards have been determined for stone fruits. It is generally assumed these requirements also apply to prunes. However, previous research on prunes has determined that reducing irrigation (typically 40%) in mid-season, allowing mild stress to occur has no economic effect on production and quality. Reducing irrigation saves money and water, reduces pesticide runoff and results in a lower dry away ratio. To expose growers to this new information and to gain adoption it needed to be demonstrated on a wide scale.

Evaluation: In order to achieve the goal of reduced irrigation and maximum economic productivity, a monitoring technique that determines tree-water status (midday stem water potential or SWP) was utilized. The monitoring technique was carried out on 5 – 10 trees every week from May through harvest in project orchards every year of the project.

The monitoring technique was conducted from 1:00 p.m. to 3 p.m. The midday SWP was determined by using a "pump up" pressure chamber. A plastic/foil envelope was used to cover a lower canopy leaf that was close to the trunk or a main scaffold. The bagged leaf remained on the tree for at least 10 minutes (result of 2001 "satellite project" results). The bagged leaf was then placed in the chamber with only the petiole sticking out. Air was forced into the chamber by pumping the device (similar to a tire pump) until water was forced out of the petiole. The amount of pressure that it took to force the water out of the leaf was measured in bars. The amount of bars it took to force the water out of the leaf was the tree's SWP. Irrigation was only recommended when SWP reached the target values as shown in Table 16.

Table 16. "Reduced risk" irrigation target values over the growing season for midday stem water potential (bars).

Period	Month						
	March	April	May	June	July	August	September
Early-	-6	-8	-9	-10	-12	-13	-14
Mid-	-7	-8	-9	-11	-12	-13	-15
Late-	-7	-9	-10	-11	-12	-14	-15

Results: Initially only five sites were able to have a comparison between "conventional" irrigation management and "reduced risk" irrigation management. At four of the sites (Aguire, CSUC, Giacolini, and Vossler) benefits of the "reduced risk" program in terms of reduced water use was realized (Figure 11). Some of these sites saved as much as 40 percent of their applied water as compared to the "conventional" program. Energy and economic savings with no impact on fruit production or fruit quality was also apparent at the end of the season. In the last four years all cooperating growers scheduled irrigations in all projects sites based on pressure chamber readings and following the "reduced risk" recommendation of irrigation scheduling. Monitored sites generally observed a good match between the observed and the target SWP. An example of these comparisons can be seen if Figure 24.

Figure 11. Midday stem water potential in comparison orchards

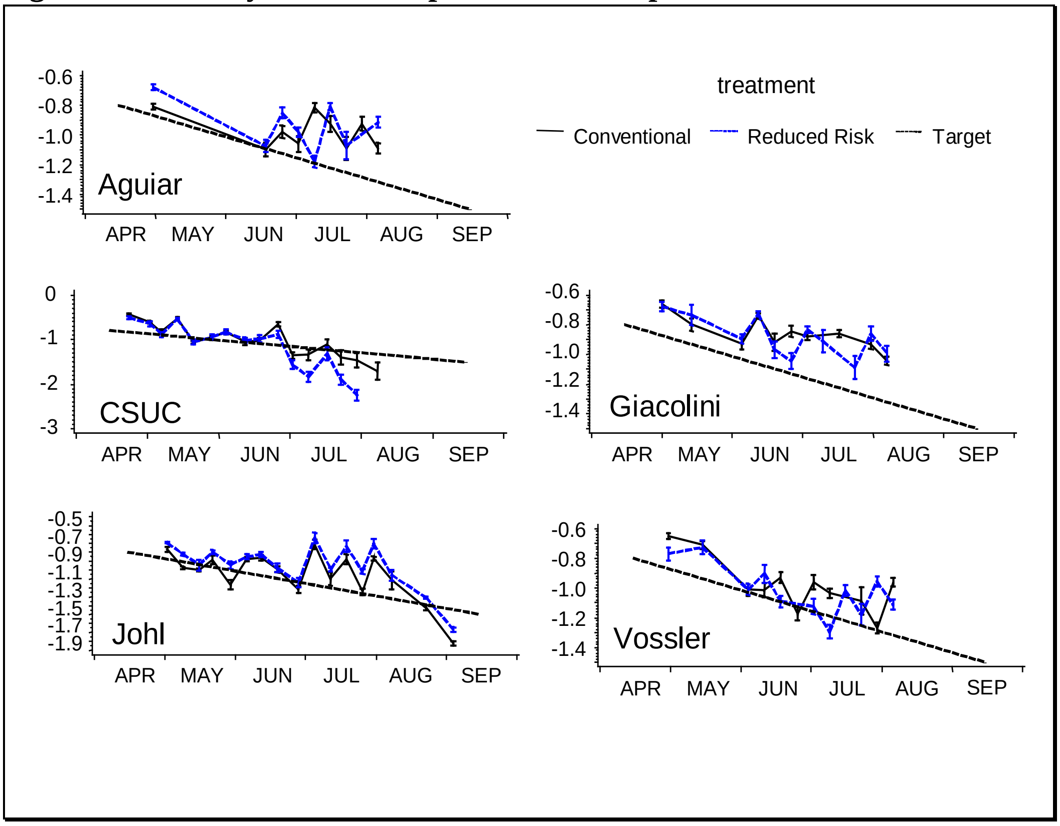
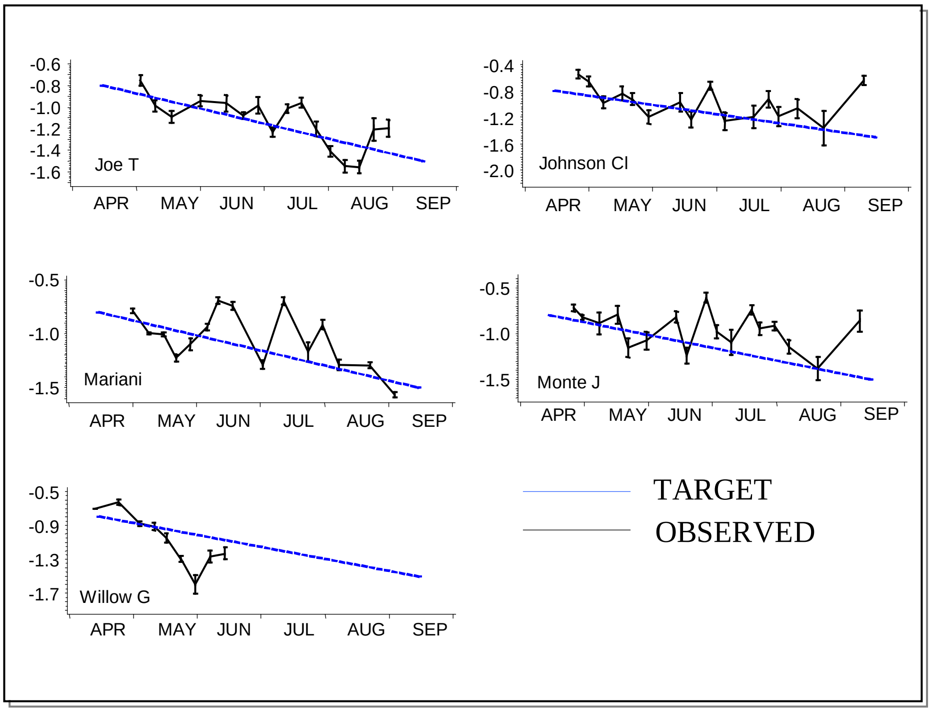


Figure 12. Observed midday stem water potential compared to target.



In 2004 project scouts scheduled irrigations with 15 out of the 23 growers in the project by measuring midday stem water potential using the pressure chamber and scheduling irrigations based on the "reduced risk" target values. No negative effects were observed or reported by scheduling irrigations in this manner.

Conclusion: All growers that followed the irrigation scheduling recommendations were satisfied. With a few years of experience, most growers were able to manage irrigation to achieve the targets recommended. In most cases this resulted in a substantial savings in energy and water use. Now that many growers have had positive experiences with this strategy some growers have started scheduling their own irrigations using this technique. Adoption is understandably slow in part due to the expense of the pressure chamber. A pump up pressure chamber cost more than $1300 and gas pressure chambers are nearly double that cost. As prune production becomes more economic greater adoption is anticipated.

4. Quality and Harvest Evaluation:

Situation: In order to evaluate the "reduced risk" program, fruit quality and harvest data was compared to sites farmed "conventionally" to see if there were any negative or positive effects on fruit quality and yield from using a "reduced risk" program.

Evaluation: In the first two years of the project, quality data were obtained from growers' P-1 grade sheets. However, these grade sheets were difficult to obtain from the grower, made harvesting for the grower more complicated and processors began charging growers for delivering small lots of fruit. Additionally, it was impossible to separate disease and insect damage since it was all lumped together on the P-1 grade sheets. In 2001 and 2002, the Dried Fruit Association of California (DFA) provided quality analysis from harvest samples that were submitted from each plot. This was an improvement but in 2003 DFA required a fee be paid for grading project samples. In 2003 and 2004, project scouts gathered fruit quality data in the field at harvest by examining 1000 fruit per site and recorded the number of fruit with scale (live or damage), cracks (side or end), worm damage, and brown rot . Three 100-fruit samples were also taken from each site and evaluated for dry away ratio, dry count per pound, soluble solids and fruit pressure. Beginning in 2001 the only yield data gathered was the average dried tons per acre production from the project orchards reported to project scouts by cooperating growers.

Results: Regardless of the method fruit quality was evaluated there was no significant differences between the means of any of the treatments ("reduced risk", "conventional", and/or "check") in soluble solids, dry away ratio, fruit pressure, presence of brown rot, presence of worm damage, or presence of fruit cracks in any year of the project except in 1999 where the "reduced risk" plots averaged slightly larger dried fruit. Fruit quality data for 2004 and 2003 is shown in Tables 17 and 18.

Table 17. Average fruit quality from all "reduced risk" sites in 2004.

Mean 2004 Dried Fruit Quality Data							
	Soluble Solids	Dry Away Ratio	Pressure (PSI)	% of Fruit with Brown Rot	% of Fruit with Worm Damage	% of Fruit with SJS Damage	% of Fruit with Cracks
Reduced Risk	23.95	2.90	4.22	0.44	0.44	0	0.28

Table 18. Average fruit quality from all "reduced risk" and "conventional" sites in 2003.

Mean 2003 Harvest and Quality Data								
	Soluble Solids	Dry Count/Lb	Dry Away Ratio	Pressure (PSI)	% of Fruit with Brown Rot	% of Fruit with Worm Damage	% of Fruit with SJS Damage	% of Fruit with Cracks
Conventional	22.17	68.41	3.14	3.92	0.24	0.09	0	1.93
Reduced Risk	21.69	65.66	2.99	3.64	0.69	0.20	0	1.66

Conclusion: Based on the data obtained from the 1999 through 2004 no adverse fruit quality or yield affects have been seen when using the "reduced risk" program.

Objective III. Encourage adoption of "reduced risk" practices through outreach and extension efforts.

Starting at petal fall, scouts and cooperating PCAs visited each orchard at least once a week until harvest. Orchard information such as insect counts, disease findings, etc. was reported to the grower at least once per week.

In 2004 a program was introduced to growers and PCAs in the Butte and Sutter County areas that offered to pay them for using the monitoring techniques researched and validated through this project. They were paid on a per acre basis, based on what monitoring techniques were actually followed. Funding was provided by the "State Water Resources Control Board" and "Cal-Fed". The goal was to allow people in the industry to try the various monitoring programs out and realize that there were no detrimental effects from using them. Over 1,200 acres were monitored using the IPFP program by five PCAs, four growers and one irrigation consultant. At the end of the season a survey was filled out by all who participated in the program. The survey asked how they thought each of the monitoring techniques they used worked for them. All of the participants had very positive responses to the questions.

Thirteen newsletters were published and distributed to all 1,400 prune growers and about 500 related industry members in California about the progress of the project.

Meetings to share information were numerous and well attended. During the six years of this project over 3,886 people attended 113 meetings focused on this project. In addition, the Tehama County advisor provided insect day degree accumulation to clientele via email on a regular basis. Advisors also wrote several newsletters. One advisor created a "loaner program" in which he loaned out pressure chambers so growers could become familiar with how they worked and how to schedule irrigations using stem water potential information.

Pest Control Advisor Involvement

During the course of this project approximately 15 Pest Control Advisors (PCAs) were asked to review and if possible try using monitoring techniques under evaluation during the 2000 and 2001 seasons. At meetings held in October 2000 and spring 2001, the Pac's and the project team met and discussed the monitoring techniques. Following are highlight points made at those meetings:

1) Many of the monitoring techniques took too long to implement. Many PCAs reported that they could not spend more than one-hour per week in an orchard. One PCA said he could not spend more than 30 minutes in an orchard. Suggestions made to speed up the monitoring procedure included: using a timed search rather than looking at a certain number of trees, look at one side of tree only rather than walking around tree, rather than recording data just keep a mental note of abundance of the pest being monitored.
2) Several PCAs reported that they use a more subjective monitoring technique. The quantitative monitoring under evaluation takes too long.
3) The PCAs all agreed that the treatment thresholds were about right and about the same that they have been using.
4) Most PCAs found that the dormant spur sampling technique was useful and even though it took some time, the winter is when they have more time and it required monitoring only once per season.
5) The PCAs found that the tree and fruit monitoring technique were useful but agreed that it took too long and too many trees had to be looked at before a decision could be made.
6) PCAs felt that the springtime aphid monitoring technique was useful but preferred quickly covering the entire orchard rather than the quantitative approach as stated in the monitoring technique.
7) PCAs found that the pheromone traps provided little if any useful information and recommended discontinuing their use.

Overall, the PCAs were pleased to be involved in the project. As stated in the highlighted points of the meeting, the PCAs favor more subjective methods of monitoring. However, for this project, quantitative methods must be used in order to determine what treatment thresholds and/or monitoring techniques are the most accurate. When the techniques and thresholds are finally presented to those involved in the prune industry, it is understood that many will use subjective techniques and shortcuts in order to save time and money.

Securing Additional Grant Support:

Additional grant support was solicited and secured from several sources. Listed below are the sources of each additional grant that was used to support this project:

CalEPA/DPR/PMA
UC/SAREP/BIFS
USDA/CSREES
USDA/NRCS
USEPA/Region 9
State Water Resources Control Board
Cal-Fed

Pesticide Use Reporting:

One of the main goals of the IPFP project was to reduce the amounts of pesticides applied. Shown below, in Table 17, are the pounds of active ingredient applied to prunes from 1997 to 2002 (2003 data is not currently available). Diazinon, oil and Sulfur show significant reductions beginning in 1999, the first year results from this research project were presented. Asana has only shown a slight reduction. This decrease is not because of the acreage reduction, but because growers are now using less material per acre (Figures 13 and 14).

The trend is clearly a reduced use of pesticides in prune production. To this end, project leaders believe that the project was a complete success.

Table 17. Total pound of pesticides used in prune production two years before and four years during the project.

Total Pounds of a.i. Applied						
	1997	**1998**	**1999**	**2000**	**2001**	**2002**
DIAZINON	57,335	57,139	40,068	48,877	28,587	38,585
ESFENVALERATE (Asana)	1,525	1,474	1,235	1,685	1,212	1,268
OIL	1,074,785	837,120	654,158	714,634	413,779	464,562
SULFUR	534,039	700,360	355,420	323,653	111,945	205,670

Figure 13. Total pounds of Asana, diazinon and oil used in prune production two years before and four years during the project.

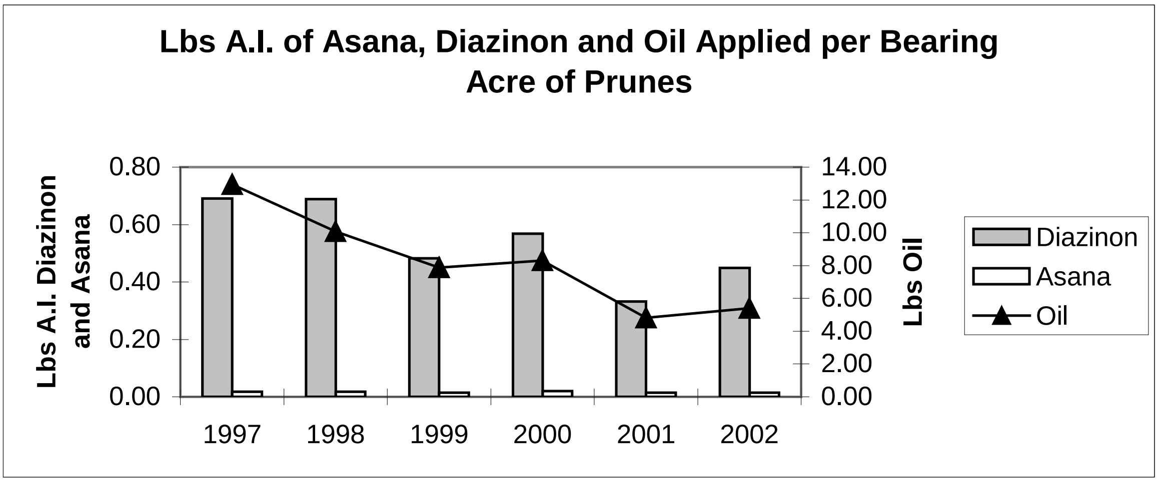
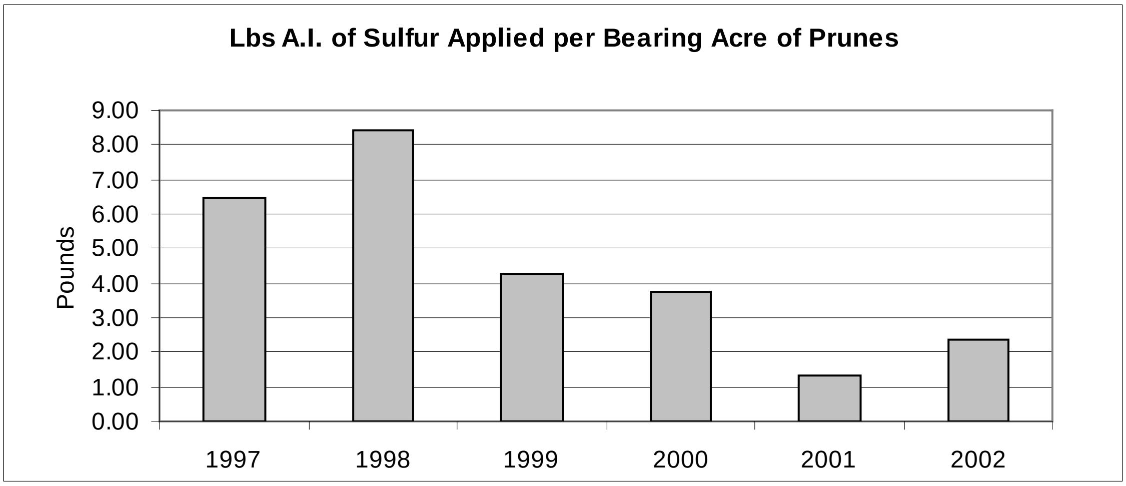


Figure 14. Total pounds of Sulfur used in prune production two years before and four years during the project.



Future Plans:

Future plans include continued efforts to implement the monitoring, treatment thresholds and reduced rates of pesticides researched and validated in the IPFP project. These plans include finishing the third edition of the "Integrated Prune Farming System Decision Guide" and disseminating the new sections to the farm advisors that have copies of the second edition of the guide for sale in their office. The new sections will be placed in the guide to bring them up to date. This will be done in time for two spring meetings spring meeting where topics relative to IPFP will be discussed. Those that already have the guide will be able to pick up the new sections to include in their existing guide.