



**UNIVERSITY OF CALIFORNIA
DIVISION OF AGRICULTURE AND NATURAL RESOURCES**

**FY 2006
ANNUAL REPORT OF ACCOMPLISHMENTS
AND RESULTS**

**AGRICULTURAL EXPERIMENT STATION
AND COOPERATIVE EXTENSION**

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SECTION A. PLANNED PROGRAMS

The University of California Division of Agriculture and Natural Resources (UC-ANR) is the major land-grant arm of the University of California, part of a nationwide public university system "built on behalf of the people" (Abraham Lincoln's words) with Experiment Stations established to develop "useful and practical information...and to promote scientific investigations and experiments," and Cooperative Extension programs to "aid in diffusing...useful and practical information." UC-ANR's mission, "... is to serve California through the creation, development and application of knowledge in agricultural, natural and human resources."

UC-ANR members are based on the Berkeley, Davis and Riverside campuses, and in more than 50 regional and county offices throughout the state. The Division is composed of the UC Agricultural Experiment Station (AES) and UC Cooperative Extension (CE), supplemented by 20 Statewide Programs and projects, and supported by nine Research and Extension Centers.

The AES has about 700 academic researchers, most of whom also have professorial appointments representing dozens of scientific disciplines. Cooperative Extension, the principal outreach arm of the Division, comprises academic appointees attached to campus departments as CE specialists or county offices as CE advisors; there are about 120 specialists and 235 advisors.

The following narratives report on California's planned programs for the five National Goals represent a sample of the research and extension efforts conducted by UC faculty, CE advisors and CE specialists.

NATIONAL GOAL 1

Through research and education, empower the agricultural system with knowledge that will improve competitiveness in domestic production, processing and marketing

California's producers of food, fiber, forage, and floral products are under considerable stress from rising costs. The inputs experiencing the largest increases are labor, insurance, and energy (electricity and fuel). This is making it very difficult to compete in the new global economy where most of California's competitors have lower costs. Those foreign competitors who do not have lower costs are sometimes subsidized, giving them a competitive advantage. Even though California is America's largest agricultural producer, it is a crowded urban state. This is putting incredible pressure on farmers to modify practices to accommodate the close proximity of urban neighbors. Normal farming practices that would have been acceptable to non-farm residents in the past are now objectionable. The rapid increase in population is causing the loss of productive farmland and a rapid degradation of air and water quality. Agriculture is under pressure to contribute to proposed solutions. This is manifested in stricter air emission rules and the almost complete prohibition of any form of run-off of soil, nutrients, or pesticides.

University of California AES scientists and CE academics have responded to these challenges with a large and diverse body of research and extension work to address all the pressing issues above. The following section provides a sample of projects and programs that directly address National Goal 1. UC-ANR seeks to make California and U. S. farmers more competitive by introducing new technologies that enable them to adapt to the new global paradigm. Innovative research helps to reduce total inputs and reduce costs.

Plant and animal improvements are being introduced that will increase production and per unit cost while at the same time introducing natural resistance to plant pests. Resistance to pests will allow the world's farmers to reduce their dependence on pesticides. Increased yield efficiency will reduce inputs of nitrogen and other nutrients, which will reduce unit cost and minimize environmental impacts. The University of California is a world leader in the introduction and testing of new or improved specialty crops. Many of these crops are especially useful to smaller farmers. Many are targeted to growing ethnic markets, which are a rapidly growing sector of the US marketplace.

With the assistance and leadership of UC researchers and extension academics, California is a leader in new product development and improvement. Farmers, in partnership with processors, are developing new agricultural products that will add greater diversity to diets and provide new marketing opportunities in the world marketplace.

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Last year, 428 local extension programs were delivered in this program area. In addition, 35 statewide collaborative workgroups and continuing conferences composed of both AES and CE academics planned and conducted research and extension projects. UC ANR has 6 Statewide Programs that brought together AES and CE resources and personnel that addressed critical issues in the state that are included within National Goal 1. California academics received 20 patents and published 876 peer-reviewed articles and 25 extension publications that addressed Goal 1.

FY 2005-2006 Allocated Resources

Extension Federal Funds (Smith Lever 3 b&c)	Extension State Match	Research Federal Funds (Hatch)	Research State Match
\$3,057,678	\$3,057,678 (99.37 FTE)	\$2,885,973	\$2,885,973 (226.90 FTE)

Theme: 1.01 Adding Value to New and Old Agricultural Products

Title: Investigating Factors Important to Sink Allocation in Wheat and Tomato

Description: IDENTIFICATION AND CHARACTERIZATION OF GENES IN WHEAT ENDOSPERM WHICH AFFECT SEED CHARACTERISTICS. (i)The aim of this project is to discover genes important to in wheat endosperm characteristics. From a population of novel, short cDNAs cloned genes related to the starch synthases, seed storage protein and transcription factors and other DNA-binding proteins. The UC researchers also recovered other known starch biosynthetic enzymes. (ii) They discovered mutants affected in seed storage product accumulation from an M2 EMS mutagenized population of cv Jerome. Some lines also showed agronomically important traits including early flowering and seed set. The traits are heritable and the genetic basis for these phenotypes is being investigated. (iii) They have developed two populations of a Californian-bred and adapted wheat (Summit) with deletion (M1) and point mutations (M2). These mutant lines may harbor new seed and other important traits of interest to Californian breeders. (iv)They have initiated a metabolomic and transcriptomic project to monitor the effects of over-expression of the High Molecular weight glutenin (HMWG) gene in transgenic wheat. HMWG affect dough quality and altering expression may improve bread baking and cooking quality. However, it will be critical to thoroughly characterize such lines to show the effect of genetic manipulation if these crops are to be ever used for public consumption. GENETIC AND BIOCHEMICAL CHARACTERIZATION OF PREVIOUSLY UNDESCRIBED STARCH SYNTHASES. Constructs for over-expression and

suppression of the wheat starch synthase IV isoforms have been completed and have been transformed into wheat by *Agrobacterium* and particle bombardment. These lines will be characterized with respect to physico chemical changes in starch granule structure. Characterization of the SSIV gene confirms that that it is almost certainly an ancient form of starch synthase more closely related to cyanobacteria. Expression in *E.coli* has been uneven. IDENTIFICATION OF TRANSGENIC TOMATO PLANTS WITH INCREASED YIELD AND ALTERED PATTERNS OF CARBON ALLOCATION. They conducted a screen of over 8000 transgenic (Tg) tomato plants which over express transcription factors (TF) cloned from *Arabidopsis* to detect plants with altered patterns of carbon allocation. This material could be used to delineate factors which regulate and control carbon flow to the ripe tomato fruit. A difference in leaf starch-levels often indicates a change in the carbon budget of a plant. They identified 26 Transcription Factors which when over expressed significantly altered leaf starch. Yield was negatively affected in all cases. The carbohydrate profile of ripe fruit from five of these lines appears to have disparate ratios of glucose to fructose compared to controls high fructose fruit is especially desirable because it is sweeter. Plants were grown in controlled conditions in the greenhouses in 2005 and characterized further. Early flower and fruit set, yellow leaves, large plants with large leaves are among the phenotypes visible. Fruit and leaves were collected for further biochemical analysis.

Impact: Wheat is the only grain suitable for making light-baked bread and pasta. Starch and protein in the grain are the key components which determine its use as a food, its nutritional value and yield. These compounds are biodegradable, and renewable are suitable as replacements for many polymers made from petrochemicals. Their goal is to understand how these compounds are made in wheat seed and to use this knowledge in breeding programs to add value to wheat for the grower, the industrial manufacturer and the consumer. Specifically they wish to (i) increase seed yields (ii) produce high protein flours and resistant i.e. low glycemic index starch and (iii) engineer novel biopolymers competitive in current and future markets. Tomatoes are high in antioxidants and are considered to promote good health. Consumers value fruit sweetness, the processor -high soluble content, and the grower - yield. The carbohydrate content of the ripe fruit directly determines aspects of these three characteristics. As much as 90 percent of the carbohydrates in fruit are imported from photosynthetic tissues. One approach to increasing fruit sugar is to study the factors influencing carbon allocation from the leaf to that organ. They hope this knowledge will contribute to improving fruit quality.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.01 Adding Value to New and Old Agricultural Products

Title: Potato Variety Selection Evaluation and Development

Description: Emphasis was on specialty potatoes in 2004. Of the 13 colored flesh selections grown at Tulelake in 2005, 7 were selected as potential varieties based on field evaluation. After post-harvest and tasting evaluations, this number was reduced to 5. Three of these 5 have also been selected by Oregon State University for future variety development. Thus, the 2 varieties that are being developed exclusively by the University of California are POR01PG25-1 and POR02PG21-1. The first is a red flesh, red skin selection with medium to large tubers, high yield and good chipping quality, as they'll be fresh market quality. The second is a purple skin, purple flesh selection with medium to large tubers and high yield potential.

Impact: The number of growers of specialty varieties and who are marketing through specialty channels has increased significantly, and continues to increase. Yellow flesh varieties are becoming more conventional. Colored flesh varieties are becoming more common and more known among the consuming public. More universities are following the lead of UC and devoting increasing effort to breeding, selection and development of specialty varieties. Post-harvest and consumer evaluations conducted by UC are sought by growers and marketers. The selected lines have been introduced into tissue culture as the next step towards commercialization, while commercial scale field trials are also conducted. In a broader context, nearly all varieties currently grown commercially in California have been developed or introduced through the University of California potato variety development project.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.01 Adding Value to New and Old Agricultural Products

Title: Natural Fibers and Biobased Polymers: New Structure and Functions

Description: This project aims to understand the structure of natural fibers and to investigate chemical means to create new fibrous products and polymers from natural sources. New polymers and fibrous products have been synthesized from biological precursors, converted to ultra-fine fibers via electrospinning and characterized for functional properties. Nanofibers have been generated from polysaccharides (cellulose, chitin, and their derivatives). Ultra-fine hydrogel fibers have been created with super-absorbent and volume expansion capacities. The mass and volume swellings can be regulated by changing chemistries to fiber/pore configurations. These behaviors are stimuli-responsive, i.e., triggered by pH, temperature or electric fields.

Impact: Novel fibrous materials have been generated from natural and biobased polymers such as proteins (including enzymes) and polysaccharides (including cellulose derivatives). Fibers with diameters between 100 nm and 1 μm have been formed with wide ranging inter-fiber porosity. Research has shown promise of nanoporous structure inside fibers, a basis for nano- and biobased materials science from agricultural components and materials. Research in this area helps to build basis for nano-materials science and has long term implications on high value-added applications of agricultural components and materials.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.01 Adding Value to New and Old Agricultural Products

Title: Edible Coatings to Improve Food Quality and Food Safety and Minimize Packaging Cost

Description: Oxygen-barrier edible film-coatings based on whey protein have better coverage (~100%) and adhesion on the hydrophobic surface of peanuts when the nuts have had mild pre-roughening and the coating solution contains surfactants to increase compatibility of the coating with the peanut surface. Addition of beeswax, a relatively soft material compared to harder carnauba wax, increases the whey protein film moisture-barrier properties through two mechanisms: increasing the hydrophobic nature of the film and 2) reducing the amount of hydrophilic plasticizer-additive necessary to achieve desired film flexibility and stretch ability. Natural antimicrobial compounds, such as lactoferrin, lysozyme and lactoperoxidase, maintain their microorganism-inhibiting activity when added to whey protein film-coatings. Antimicrobial-containing whey protein film-coatings were shown to inhibit *Penicillium commune* mold and *Listeria monocytogenes*, *Salmonella enterica* and *Escherichia coli* O157:H7 pathogenic bacteria.

Impact: Whey-protein film-coatings have demonstrated antimicrobial and oxygen-barrier properties. Thus, they can improve food safety and quality, as they'll reduce packaging requirements. Water-based whey-protein coatings have potential for replacing ethanol-based food coatings and synthetic plastic and paper coatings, thus reducing environmental problems. Utilizing whey protein for these applications adds value to this former waste product and enhances the economic viability of the dairy industry.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.01 Adding Value to New and Old Agricultural Products

Title: BioBased Substances and their Use in Fibrous and Textile Materials and Products

Description: The objectives of this project are to identify and study sources of fibers and bio-based materials, to characterize their physical properties, to match sources/properties with new design prototypes. With these analyses, new textile and related design items using bio-based materials are being developed through the use of bio-based materials. The UC researchers are also assessing possibilities for ultimate marketability and public policy by analyzing agricultural producers', policy makers', and consumers' perceptions of bio-based materials. The initial activities of the project included the evaluation of a broad spectrum of natural materials and by-products for their potential use in fibrous products. The main goal is to find efficient, economically viable, and renewable replacements for petroleum-based substances. Several classes of natural products have been considered for their potential replacement of petroleum derivatives in high value-added products. These bio-based materials include polysaccharides, proteins and oils. For instance, natural oils from animals and plants are primary sources of long chain fatty acids, mostly with 12 to 24 carbons, that can bear both saturated and unsaturated bonds. Along with end group and side chain structures, the carbon length and degree of instauration determine the properties of these oils, including their softening/melting points, solubility and reactivity. Throughout human history, many of these oils have been used in foods and medicines, and their use has also expanded into other areas such as fragrances and cosmetics. The structures of oils allow their conversion and modification to derivatives that have many unexplored potentials as precursors for industrial products. Plants are among the most abundant natural sources of oils. Plant oils possess diverse structures, yet with moderate, unsaturated carbon that lies in between animal fats and marine mammal oils. There are efficient industrial processes for their generation, thus there is a potential economy of scale. The investigation on plant oils involves understanding their reactions with cellulosics, thus their potential applications as binders, coating and composite matrices.

mpact: New textile products will be developed utilizing natural plant oils (bio-based materials) derived from economically efficient processes.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.01 Adding Value to New and Old Agricultural Products

Title: A Time Series Approach to Analyzing Market and Food Demand Systems

Description: Data were collected for various California commodities - almonds, walnuts, tomatoes, alfalfa and cotton. Supply and demand elasticities for various California commodities are estimated using supply and demand models. The elasticities of demand are all inelastic. Producers' response to price incentives is on the supply side. Supply and demand models are being estimated for table, raisin, and wine grapes. Severe data problems have hindered the estimation of these models. Disaggregate data, however, are being collected. And marketing channel issues involving retail, farm-gate or wholesale are being addressed. Work on a demand system book is in the process of beginning.

Impact: Consumers, producers, and policy makers will greatly benefit with updated estimates of demand and supply elasticities. There has not been a comprehensive update of supply and demand elasticities of California commodities for at least 25 years. These estimates can be used to measure the changes on producers, consumers, and tax payers with respect to changes to policies.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness

Title: Agricultural Policy, Trade and Economic Welfare

Description: Work on this project involved the analysis of state trading enterprises, the importance of the WTO negotiations and other policy developments for California agriculture. An edited book on Agricultural Policy Reform and the WTO was published in 2004.

Impact: Trade is extremely important for California agriculture and this project helped identify how the WTO negotiations will impact California agriculture.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness

Title: Emergence of China as a Trading Nation and Its Impact on Global Food Markets

Description: While the economy as a whole benefits from accession to the WTO, the case of agriculture is somewhat mixed. Producers of rice, most vegetables and fruits, many livestock and aquatic products and other higher-valued, labor-intensive goods will benefit if trade liberalization leads to higher exports. While maize, cotton and wheat farmers will be adversely affected, since most farmers are diversified and able to change product mix when relative prices change, the overall cost will be small. The only groups that are likely to be adversely impacted are a subset of poor, inland farmers. China needs to make complementary policy changes. The WTO agreement challenges China's farmers with competition in output markets from producers in the rest of the world. To compete, farmers need to have access to low-cost inputs and high-quality technologies. There are many restrictions keeping seeds and other inputs from moving around the country. There also are barriers against importing inputs and technologies or investment by foreign technology firms. These should be sharply reduced and eventually eliminated to improve the income of farm households. International experience shows the entry of foreign seed and technology firms into the country could lead to more competition and better transfer of technology. While most of the facts on the accession of WTO are well known, China faces another set of issues in how they should move forward in the next round of international trade talks. While there is always going to be uncertainty, research by economists inside and outside of China are producing many ideas with broad consensus. On the three 'pillars' of WTO agriculture negotiations now underway - market access, reducing export subsidies, and reducing domestic supports - China's interests lie in a robust liberalizing outcome to negotiations. China's analytical capabilities in agriculture policymaking have increased significantly in recent years. Although still far behind many nations, for the first time China has the expertise to make quantitatively derived choices about the best directions for its welfare. Chinese leaders know what is good for them and can pursue it with new confidence as a result. China's agriculture is evolving in the direction of national comparative advantage, in terms of sown area, investment in R&D and exports. China is shifting toward labor-intensive, high-value added production, instead of the land-intensive crops it emphasized in the past and where it has less comparative advantage. The negative impact some expected on China's agriculture has not occurred; China's agriculture is doing well post-WTO. China is increasingly concerned about market access problems abroad, as its competitive exporters bump into tariff and non-tariff barriers. Like all economies, China must address concentrated economic pain from structural adjustment at home if it is to push further reform; but China has sufficient WTO-consistent means to do so while remaining a good player internationally. If China can continue to improve in managing ongoing trade problems, it could gain in credibility that will allow it to be a positive player in future trade reform efforts.

Impact: The UC researcher's papers and publications were presented in a number of forums and been heard by a number of different audiences. The information in the corn report was made available to members of the US Grains Council that were in contact with the embassy officials in China who were

negotiating with China to stop or reduce the subsidies that were being given to corn producers/traders. The information from the soybean report have been used by the American Soybean Association personnel to lobby for freer soybean trade, showing how even with the rise of soybean imports, prices did not fall and production was steady (and consumers and those in the livestock sector benefited). The work on horticulture has been the basis for educating many grower groups in California about the opportunities and competition that China will give to California in the coming years.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness

Title: Regulation of Flower Senescence

Description: The UC researchers continued their work using Virus-induced gene silencing (VIGS) to test the function of genes that they have found to be associated with flower senescence. Of particular interest was a gene encoding a protein called prohibitin. This protein has been intensively studied in humans because it was found that a mutation in the gene encoding it was associated with uncontrolled cell division in mammary cancer. Studies in yeast have demonstrated that it is a mitochondrial protein with two isoforms that polymerize to form a mega-complex in the mitochondrial membrane that is critical for proper assembly and maintenance of the proteins comprising the respiratory chain. Mutations in the prohibitin gene cause abnormal mitochondrial structure and function. In plants, genes that have high homology to animal and yeast prohibitins have been identified in Arabidopsis, maize, rice, and tobacco. Attempts to determine the function of these plant prohibitins have been unsuccessful, apparently because silencing or over-expression of this protein is lethal in young plants. They used VIGS to silence prohibitin1 in Petunia, and obtained phenotypes that are consistent with a similar function, in plants, to that already observed in animals and yeast. Flowers of silenced plants were smaller than controls, yet the petal cells were considerably larger. They interpret this to indicate a negative effect of silencing prohibitins on cell division during petal development. Petals of silenced flowers had a higher respiration rate, wilted earlier, and contained more abundant transcripts of catalase, an enzyme involved in detoxification of reactive oxygen species (ROS). As in yeast and human systems, therefore, they feel that they have established a case that plant prohibitins are involved in mitochondrial structure and function. As part of their project, they have been isolating genes that are up- and down- regulated during petal senescence. Using the four o'clock flower (*Mirabilis jalapa*) as a model system, they have demonstrated changes in a large number of independent genes. In some cases, there were very large changes (for example a 30,000 fold

increase in transcript abundance of a ring zinc finger protein), and they have been isolating promoters from genes showing these dramatic changes at the onset of senescence. Their intent is to test a strategy where these promoters are used to turn on synthesis of a protein that will interfere with protein synthesis and thereby prevent the synthesis of the enzymes responsible for petal senescence.

Impact: The per-capita consumption of cut flowers in the US is much less than that in other first-world countries, less than a quarter, for example of that in Britain. This is directly attributable to consumer dissatisfaction with the low vase life of flowers as they are presently marketed. Focusing on increasing vase life of flowers in supermarkets (the major outlet for fresh cut flowers) will increase consumption, and thereby improve profitability for farmers and traders. Their outreach activities already have increased the focus of the industry in improving freshness, and they have set a goal of doubling cut flower consumption in five years, a target that mirrors the recent increases in consumption in Britain, also driven by improving (and guaranteeing) flower freshness.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness

Title: Identifying Cotton Genotypes with Superior Performance in Commercial Production

Description: On March 1, 2005, one new Acala and one new Pima cotton varieties were approved by the SJVCB and released for commercial production in 2005. These varieties were higher yielding when compared to the standards, Maxxa and S-7. Acala varieties in 2005: C-702 is from CPCSD is a conventional variety, and has 11% higher yields than Maxxa and equal with PHY-72. C-702 has lower seed coat fragments than Maxxa and has good quality. Specifically, C-702 has better fiber strength, uniformity and maturity, as well as better yarn comber waste, neps and evenness. Pima varieties in 2005: PHY-800 from Phytogen out-yielded the standard S-7, by 12%. PHY-800 had similar yields to DP-340 and significantly higher yields than PHY-76. Phy-800 has Fusarium Wilt tolerance and good fiber and yarn quality. Specifically, PHY-800 had superior fiber length, uniformity, elongation, Micronaire, fineness and color, as well as better yarn strength and appearance. The SJV growers continued to see improved yields and quality because my testing program that holds the bar high for new varieties to be approved. Also, the SJVCB approved the testing of cotton varieties with regulated technology, such as Roundup Ready Flex. These cottons are regulated by USDA. Although regulated trials are more costly and time consuming, testing them will allow these improved varieties to be available to the growers years sooner. Acala varieties up for release in 2006: C-403 and C-503,

from CPCSD; DP-6222R from Delta Pine and Land Company; and PHY-710R from Phytogen. Pima variety up for release in 2006: E-303 and E-503, both from CPCSPD.

Impact: Maintaining a strong cotton industry is vital to the economic well-being of the San Joaquin Valley (SJV) where more than 95 percent of the crop is grown. The purpose of this program is to identify cotton genotypes with superior performance in commercial production in the SJV. The SJV Cotton Board relies entirely on this cotton variety testing program for data used in making decisions for approving cotton varieties for the SJV. Cotton approved by the Cotton Board has long maintained a world-wide reputation for high-fiber quality.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness

Title: Mergers in Vertically Separated Markets and Wholesale Price Discrimination in Agricultural and Resource Markets

Description: The research question is to assess the heterogeneous welfare implications of simulating changes in uniform wholesale pricing policy in a yogurt retail market in a large US metropolitan area. A flexible demand model for the major manufacturer yogurt products was estimated, in terms of a flexible mixed logit specification, allowing for consumer heterogeneity. A model of vertical interactions between yogurt manufacturers and final retail store chains has been specified, taking into account the most frequently purchased/sold yogurt products. Two model specifications were derived and estimated, (i) considering first that manufacturers may choose to set different wholesale prices to different retailers; and (ii) where manufacturers are subject to uniform wholesale pricing restrictions. Models have been estimated and margin estimates have been used to simulate uniform wholesale pricing scenarios within this market. Welfare estimates in terms of changes in consumer surplus and changes in retail and manufacturer surplus have been estimated in the context of unobservable wholesale prices. The UC researchers focus their approach, first, by using data on yogurt produced by multiple manufacturers and sold in several stores, and estimate there to be positive welfare effects from preventing wholesale price discrimination, originating from positive effects on consumer surplus although negligible effects on joint vertical producer surplus, resulting from counterbalancing negative effects on manufacturer and positive effects on retailer surplus.

Impact: They make inferences about wholesale price discrimination and uniform wholesale pricing policy. This is an important question when there is a policy goal

to enforce uniform wholesale price legislation in a variety of markets and they address this question by simulating the effects of such uniform wholesale price legislation in a local urban grocery retail market of the United States. Given a demand and supply model of multiple retailers and manufacturers oligopoly-pricing behavior they consider: (i) wholesale price discrimination and (ii) no wholesale price discrimination (via uniform price regulation). They demonstrate how wholesale price legislation simulations may be performed given observed data on retail and input prices and retail quantities sold and not available data on wholesale prices. In general for multiple oligopolistic retailers and multiple oligopolistic manufacturers, whether uniform wholesale pricing (that is banning wholesale price discrimination) leads to higher or lower final goods retail prices and to lower or higher welfare is ambiguous and remains an empirical question whether in the presence of linear wholesale pricing as well as with non-linear wholesale pricing. This question is of policy relevance in a variety of markets, in particular where there are policy goals to enforce uniform wholesale price legislation and generally given that antitrust authorities have been significantly concerned with price discrimination in intermediate goods markets (Robinson Patman Act).

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness

Title: Economic Performance in the Food System: Costs, Productivity, Efficiency and Competitiveness

Description: Research proceeded on measuring the impact of factors affecting economic performance in the food system, with a focus on fisheries, but also including agriculture and food manufacturing. Work on fisheries included guidance for the measurement of productivity and capacity utilization in fisheries. It was found that traditional productivity measures to assess performance of fisheries do not account for key issues unique to the industry, such as by catch, environmental, and stock levels and fluctuations. Methods to recognize these factors, as well as limit the restrictions embodied in existing measures, were suggested. The importance of recognizing substantial investments in technical improvements to boats and equipment in fishing fleets, motivated by current regulations but contribution to excess fishing capacity and low returns to fishing effort, was targeted in another study. Detailed data on innovation patterns for a Mediterranean fishing fleet was used to evaluate the contributions of technical change to catch rates, and it was found that productivity enhancements from investment expenditures caused and were counteracted by falling fish stocks. Additional work addressed the estimation of capacity utilization in fisheries, to guide policy to restrict overcapacity in fisheries and resulting overexploitation of

fish stocks. One study evaluated standard deterministic methods for estimating capacity in fisheries, compared to an alternative stochastic estimating method recognizing the random nature of fishing success. It was found that the two approaches provide similar guidance about overall and even relative boat-specific capacity levels under certain circumstances, although the deterministic models suggest even higher capacity levels, and implied larger necessary capacity reductions. A second study suggested the use of standard economic rather than frontier methods to measure fisheries' capacity, since in situations where regulatory, environmental, and resource conditions affect catch levels but are not independently identified in the data, frontier-based capacity models may interpret such impacts as production inefficiency. A multi-output multi-input stochastic transformation function framework was developed and applied to measurement of capacity for Alaskan catcher-processor pollock vessels, which recognized also different possibilities for how output composition might change if the fishery moved toward full capacity production. Another study published during this period explored the adoption, usage patterns, and perceived benefits of computers and the internet for Great Plains farmers, and suggested that exposure to the technology through college, outside employment, friends, and family is more influential than farmer age and farm size. A final study addressed the spatial aspects of productive impacts on manufacturing firms of public infrastructure (highway) investment, to untangle the private cost-savings effects of inter- and intra-state public expenditures. It was found that recognizing such spillovers both increases the magnitude and significance of cost-savings from intra-state public investment, and augments these productive impacts.

Impact: This research contributes to an understanding of how methods used for the measurement of economic performance - in particular, productivity, capacity, and costs of fishermen, farmers, and food manufacturers - may affect the resulting measures and policy implications. This is very important for policy makers designing and implementing public policies to enhance performance in these industries, while limiting harm such as pressure on falling biological fish stocks.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness

Title: Economic Analysis of the World Wine and Grape Economy

Description: The UC research project resulted in one research paper accepted at a peer-reviewed journal. The paper analyzed the determinants of contract choice and contract provisions for California winegrape contracts between growers and vintners. The analysis used data from a 1999 survey of California

winegrape growers. Growers in the premium coastal growing regions are more likely to use formal written contracts than are growers in the Central Valley. Written contracts for high-quality grapes are more likely to include provisions regarding the production process, while written contracts for low-quality grapes are more likely to include financial incentives for sugar content and other product attributes. Wine production and consumption remain concentrated in France, Italy, and Spain, which have 3% of the world's population, but produce 52% of the world's wine, and consume 43%- an average 22 gallons per adult/year (there are 5 750-ml bottles in a gallon). Most Americans do not drink wine regularly, and US wine consumption fell in the 1990s; Americans average 2.2 gallons or 12 bottles of wine/year. The 30 million Americans who drink wine regularly drink 90% of the wine consumed in the US, an average 12 gallons or 60 bottles/year. There is a battle fermenting in the wine business between Old World European producers and New World producers in Argentina, Australia, California, Chile, New Zealand, and South Africa. Do consumers prefer the Old World approach to making wine, to mix varieties of grapes and make wine that reflects the local terroir (soil and climate), which means the wine varies from year to year, or the New World approach of using one variety of grapes, aiming to produce wine with a consistent taste year after year, such as Mondavi Chardonnay? During the 1990s, the price gaps between the major types of wine widened, even though quality gaps narrowed. Americans and Western Europeans drank less but better and more expensive wine. In California, falling jug wine sales put downward pressure on land and winery prices in California's Central Valley, where 70% of the state's wine grapes are produced. Growers received an average \$462/ton in 2002 or 23cents/pound for wine grapes, but Napa grapes were worth an average \$2,942/ton (\$1.50/pound), while Fresno-area wine grapes were worth \$136/ton (\$.07/pound). It takes 2.7 pounds or about 600 grapes to make a 750 ml bottle of wine, so the average value of the grapes in a bottle of California wine was \$.62 in 2002-and ranged from less than \$.02 for Fresno grapes to \$4 for Napa grapes. Pesticides and labor are two very important inputs for winegrape production. International labor migration and government policies regarding migration are important determinants of the costs of winegrape production. In a globalizing wine economy, differences in labor costs can have significant impacts upon the competitiveness of specific production regions. In order to improve air quality in the San Joaquin Valley, California pesticide regulators are considering new rules that will affect the set of pesticides available to winegrape growers statewide. Affected pesticides are used on a substantial share of California winegrape acreage.

Impact: This analysis provides the wine industry with its first overview of contract design and use, and helps growers and vintners understand the value of grape quality, which plays a key role in decisions on whether or not to use a contract. The market analysis papers explain how the wine industry could evolve to operate at very different levels of profitability, depending on market segment. Information regarding the importance of labor and pesticides to winegrape production will aid policymakers and stakeholders in understanding the impacts

of proposed policies on the industry. In a globalizing wine economy, differential impacts of regulation can affect the competitiveness of specific production regions, such as California.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness

Title: Internet and the Agricultural Economy

Description: The proposed survey was completed and the data was analyzed. They are in the process of completing an article for Rural Sociology.

Impact: The study results suggest that exposure to the technology through college, outside employment, friends, and family is ultimately more influential than farmer age and farm size. Notably, about half of those who use the Internet for farm-related business report zero economic benefits from it. Whether a farmer perceives that the Internet generates economic benefits depends primarily on how long the farmer has used the Internet for farm business and for what purposes.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: Seed Dormancy and the Regulation of Germination: The Ecological Implications of NO Synthesized in Soil

Description: Seeds germinate when environmental conditions are normally favorable. Seeds that do not germinate under these conditions are dormant and require additional cues to germinate. These cues include changes in temperature, light, or mechanical perturbation of the seed. Endogenously produced hormones also play a key role in regulating dormancy and their work has focused on abscisic acid (ABA), gibberellins (GAs) and nitric oxide (NO) as potential regulators of germination. The chemical composition of soil solution is also known to promote germination of dormant seeds, and nitrogen is one of the components of the soil that has an impact on germination. It has been proposed that changes in soil nitrogen act as a trigger for germination and that seasonal changes in nitrate can act as a gap detecting mechanism bringing about an increase in the population of seeds that germinate. The UC researchers have

investigated the role of hormones and nitrogen-containing compounds on the germination of dormant seeds using barley grains and Arabidopsis seeds as model systems. Their investigation of the effects of N-containing compounds began with seeds of dormant barley because of the agronomic importance of this cereal. They have investigated the molecular and biochemical basis of dormancy in various cultivars of barley and shown that the ability of grains to convert stored lipid to sugar, the process of gluconeogenesis, is strongly correlated with dormancy. Cultivars that are deeply dormant convert stored lipid to sugar only when the embryo synthesizes hormones of the GA class, whereas non-dormant grains catabolize lipids constitutively in the absence of GA. They have proposed that sugar derived from stored lipid is required as a source of energy and building blocks for germination to occur. In dormant seeds this process occurs only when GAs are produced by the embryo, but in non-dormant seeds this process does not require a trigger. They have used dormant Arabidopsis seeds to examine the role of nitrogen containing compounds on germination. Nitrate, nitrite, cyanide, ferrocyanide, azide, hydroxylamine as well as nitric oxide donors such as sodium nitroprusside (SNP) and gaseous nitric oxide (NO) all stimulate germination of Arabidopsis seeds. They have investigated the role of these compounds in the germination process by determining which of the tissues of the seed is the target of these compounds. The Arabidopsis seed consists of an outer dead testa, a single layer of living endosperm cells that envelops the embryo. When the tests is removed from dormant seeds the seed remains dormant, however, when the single cell layered endosperm is removed the embryo grows and is not dormant. They have shown that the endosperm of Arabidopsis seeds undergoes changes in the cytoplasm and cell wall prior to germination and that treatments that stimulate germination promote changes in the endosperm leading us to conclude that the endosperm is the primary target for dormancy breaking compounds.

Impact: Dormancy and the lack thereof is a major agronomic problem. In cereals, grains that are not dormant often sprout precociously in the ear, a phenomenon called pre-harvest sprouting. Losses to cereal growers worldwide as a result of pre-harvest sprouting can be enormous. Sprouted cereal grains are unsuitable for milling or malting and their commercial value is reduced to that of feed grain. Recent Canadian data show that 8 million hectares of bread wheat and 2 million hectares of durum wheat are grown each year, and the downgrading of the crop due to pre-harvest sprouting costs growers more than \$100Can million each year between 1978 and 1988. Similar crop losses occur in the UK and Australia. For example, the wheat crop lost 20% of its value in Western Australia in the 2003/04 seasons because of pre-harvest sprouting. Clearly, efforts to identify the mechanisms underlying dormancy will have enormous benefits to agriculture.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: Economics of Commodity Markets and Commodity Price Behavior
Justification

Description: This UC research project was devoted to the development of a textbook on commodity futures and options markets. The book is now published and it has received good reviews, with two 5 star reviews at amazon.com. It was published in November 2002 and the University of Maryland and Texas A&M have decided to adopt the book for their futures and options classes.

Impact: This book will be helpful to students and practitioners with an interest in commodity futures and options markets. These markets serve as mechanisms for price discovery and risk shifting. Commodity price risk is a critical issue facing California agriculture

Funding Source: Hatch & state

Scope of Impact: State specific

Theme: 1.03 Agricultural Profitability

Title: Cotton Management Practices, Variety Choices for Quality and Production Efficiency Improvements

Description: Grower choices in crops, varieties and production systems are changing in many agronomic crops, including cotton, due to numerous production concerns. The considerations include rising production costs, stagnant commodity prices, potential for improved yields with changes in type of crop, impact of crop quality characteristics on price received, and input constraints such as higher cost fertilizers and water, or reduced availability of good quality water. Variety trials included different cotton types (Pima, CA Upland, Acala), with evaluations of growth, quality, disease resistance (Fusarium or Verticillium wilt), and field evaluations of newer-generation herbicide or insect resistant transgenic varieties. Research identified yields and fiber quality differences that impact grade and price. Planting date, growth regulator and water management studies in Acala and Pima cotton demonstrated significant differences in crop growth and gas exchange responses to timing and degree of water deficits. Trials have shown changes in crop growth, consistency in plant emergence and survival under different seed fungicide treatments, under different bed planting patterns (double-row, conservation tillage), reductions in number of tillage passes, and utility of herbicide-resistant transgenic varieties in these alternative systems. In long-term evaluations of double-row plantings, yield increases of 4 to 15 percent occurred with double-row compared with single row

in about one-half tested locations, with no significant impact at remaining sites. Yield increases were consistent typically at sites where plant vigor was lower and plant size limited yield potential. In field trials, tested transgenic herbicide resistant varieties with an extended allowable application period (glyphosate resistant) provided yields and fiber quality statistically the same as conventional, closely-related cotton varieties. Long-term trials evaluating feed-back nitrogen management approaches for Acala cotton (soil, plant tissue testing and plant mapping) demonstrated an approach to use in decisions to adjust fertilizer nitrogen application rates to avoid unnecessary applications. A race of Fusarium, which can cause fungal disease in susceptible varieties, was identified as newly-recognized race (race 4) with potential to seriously impact susceptible varieties. Disease screenings to evaluate plant survival, foliar and root damage were done at 2 grower field sites and one greenhouse site. Information on varietal susceptibility and relative damage was produced, indicating existence of highly susceptible and highly-resistant varieties in Pima, including commercially-available and experimental entries. Results were less definitive in Upland cotton, where tested varieties ranged from moderate to severe in percent infected, but with less severe impacts on plant survival, plant growth and vigor in most tested varieties. Late season foliar decline symptoms were investigated and found related to multiple nutrient deficiencies late-season, but with severity of symptoms and yield losses more related to root system limits in depth or density.

Impact: Grower interest in changes in practices (reduced tillage, bed configurations, cotton types, irrigation systems) is high due to potential to impact production costs, environmental protection or improve yields. Options tested include double- row beds, transgenic herbicide tolerant varieties. Trials showed system changes often reduce some costs and tillage pass number, but yields and crop earliness were improved mostly under conditions with less vigorous plants. Reduced costs, reduced tillage must be balanced against some increases in planting and harvest expenses. Studies evaluated residual soil nitrate sampling, crop nitrogen (N) status, plant growth, fruit retention monitoring to provide information to improve N use efficiency and reduce losses. Data on best-performing varieties, irrigation, nutrient management in Acala, Pima, Uplands in multi-county tests helped growers with variety decisions impacting yield, quality, profitability. Disease problems (Verticillium, Fusarium) were investigated to give growers updated information to reduce disease impacts. A newly-described race of Fusarium was described, and screening work continues to provide growers with information on varietal differences in resistance. Problems in Pima called early decline and late season potassium deficiency problems in Upland cotton both were found to slow vegetative growth rates earlier than typically desired, with foliar damage shown to be correlated with potassium or nitrogen deficiency, and foliar symptom severity and growth reductions related strongly to rooting depth and distribution limitations.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: Agronomic Practices Affecting Yield, Forage Quality, and Sustainability of Irrigated Alfalfa

Description: This UC research focuses on agronomic practices, water-use efficiency, irrigation management, variety adaptation, forage quality and pest management of alfalfa, and the interaction of forages with environmental and resource-use issues. A 3-year trial on cutting schedules and varieties was completed in 2005, and they reported the final data for the yield-quality tradeoff in alfalfa, and its implications for harvest management, variety selection, and stand longevity. Economic tools to judge that tradeoff have been provided, and the data reported in the California Alfalfa Symposium Proceedings. Variety trials conducted at UC A wide range of environments are included including desert environments, Mediterranean environments, and intermountain environments (see <http://alfalfa.ucdavis.edu>). Continuing studies on improving IPM thresholds for alfalfa weevil has resulted in a re-examination of these thresholds; they should be coming out with revised thresholds during 2006. A project on the effect of deficit irrigation of alfalfa on grower's fields and in small-plot studies documents yields losses of 1-2 Mg in yield during late-summer deficit irrigations, but this did not occur at all locations. Where high water tables contributed to ET, yield losses were negligible. At one location, where ET was measured, differences in ET between fully watered and deficit trials were approximately 28 cm in water savings. There is a need for better understanding of the yield losses associated with deficit irrigation, methods for approaching deficit irrigation, and the economics of water use efficiency. Studies on the sampling and measurement of the Roundup Ready Trait in alfalfa hay were conducted during 2005; they sampled field-grown crops with 0,1%,5% and 10% adventitious presence of this genetically modified trait. Two commercially available test strips were always able to detect AP at 5%, and sometimes 1%. Methods to enable coexistence of biotech and non-biotech traits in alfalfa were described. A new project was initiated in 2005 to study the nutritional value of hydrolyzable tannins in alfalfa for increasing protein utilization efficiency and reduce the environmental impact of dairy wastes. Studies were conducted on alternative forages in 2003 including ryegrass, sudangrass and BMR sorghum crosses, and various cool-season perennial grasses.

Impact: Their research on varieties is worth between \$50-\$400 million/year to CA growers due to increased yields. They have enabled a scientific evaluation of the yield-quality tradeoff with varieties and cutting schedules, very important to growers. Deficit irrigation work on alfalfa may enable orderly voluntary water transfers in future droughts.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: The Impact of Foreign Investment on Firm-Level Credit Constraints

Description: Firms often cite financing constraints as one of their primary obstacles to investment. Direct foreign investment (DFI), by bringing in scarce capital, may ease host-country firms' financing constraints. Alternatively, if foreign firms borrow heavily from domestic banks, DFI may exacerbate financing constraints by crowding host country firms out of domestic capital markets. The goal of this project is to identify the impact of incoming foreign investment on domestic firms' credit constraints. The project has identified different conditions under which foreign investment has offsetting effects on domestic credit constraints. A cross-section time series analysis for a number of countries suggests that foreign investment eases credit constraints for multinational firms. However, a case study focusing on the Ivory Coast shows that when domestic markets are characterized by financial distortions, such as ceilings on local interest rates, foreign investors exacerbate those distortions and crowd domestic investors out of local credit markets. This implies that foreign investors should be carefully managed under distorted regimes, and can have adverse effects on domestic firms under such conditions. Two papers have been completed and published in the top developing and international economics journals. The project has been expanded to examine the effects of foreign expansion abroad in the form of creating foreign affiliates on domestic employment at home. This allows us to answer whether different modes of globalization hurt employment and wages at home, or whether foreign expansion in fact helps the domestic labor force.

Impact: While many policy makers are optimistic about the gains from attracting foreign investment, that optimism may be misguided if foreign investors crowd domestic credit markets and reduce access to much needed financing for domestic enterprises. This project shows that foreign investors only confer gains to domestic competitors when the domestic banking sector is not distorted. Under regimes with distorted interest rates which set borrowing rates too low, foreign investment can be harmful for local enterprises competing for rationed foreign credit. Consequently, this research provides a warning for governments seeking to maximize the gains from incoming foreign investors.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: Agricultural Industrial Organization and Labor Studies

Description: UC researchers estimated new models that control for endogeneity to analyze milk marketing orders and the effects of fat taxes. This work was based on new incomplete demand system, aggregate model estimates, which are consistent with economic theory (unlike most previous works). They showed that the aggregate model is the proper aggregation of individual demand equations. They found that milk marketing orders are regressive and that fat taxes are unlikely to have much impact on fat consumption.

Impact: They were interviewed by a reporter for the Seattle Times about the Chinese income distribution based on several of their academic articles. They provided data and information about their techniques to researchers at universities around the world and at the World Bank.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: Cotton Upland Variety Evaluations

Description: Difficult economic times and the introduction of transgenic cotton varieties in other parts of the United States have caused California cotton growers to wonder if they have been missing a valuable opportunity by not making use of varieties grown elsewhere. Changes in the San Joaquin Valley cotton-quality law, in 1999, have allowed farmers there to grow a much broader range of cotton varieties. However, many varieties originated outside of California and little was known of their yield potential and adaptability to San Joaquin Valley conditions--for example, their susceptibility to fungal organisms such as Verticillium. Growers needed independent, scientific evaluations of the suitability of these varieties for San Joaquin Valley production. Since 1999 UCCE trials have been conducted in San Joaquin Valley counties (Kern, Kings, Tulare, Fresno, Madera and Merced) to provide a continuing evaluation of various cotton varieties from elsewhere for crop earliness, susceptibility to diseases, potential for higher yield, and fiber quality. Each year as many as 18 to 21 newcomers were compared to Acala or Pima varieties. To determine crop responses under a range of environmental conditions and management, the research was conducted in large-scale field trials on grower fields and UC Research Center plots. The trials focused on mapping data to determine primary plant growth

characteristics related to fruit development and timing important to yield and earliness. Information collected in these trials has been reported at UC and industry meetings, and has been made available in both UCCE newsletters widely distributed in California and on a UC cotton web site (cottoninfo.ucdavis.edu) where multiple years of yield and fiber quality data can be reviewed at any time.

Impact: This program provided growers year-by-year updated comparisons of lint yield and fiber quality of non-Acala Upland cotton varieties widely grown elsewhere, compared to standard Acala varieties. Also, non-Acala Upland varieties with true short-season growth characteristics have been identified for potential use in double-cropping situations. This UC-developed information is crucial to growers and industry in deciding if higher lint yields possible with many non-Acala Upland varieties offset some of the low fiber quality issues identified with those varieties.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: Economic Study Helped Determine Growers' Compensation for Vineyard Losses

Description: Beginning in 1998, over 40% of the Temecula Valley vineyards were pulled out due to Pierce's disease spread by the GWSS. As part of the federal law passed in the year 2000, the California Department of Food and Agriculture (CDFA) received money to help/compensate growers for grapevine losses resulting from the disease. Information on costs of establishment for areas impacted by the disease was needed to determine the amount of compensation/help to growers. An economic study analyzing the costs of establishment and production was developed for wine grapes in Temecula, Riverside County. This study detailed production practices, and estimated and analyzed the capital needed to establish vineyards and produce wine grapes in the area. The study was developed in cooperation with growers using the practices and costs of their vineyard establishment and production. The values and analysis in the study were used to determine the amount of compensation that growers could receive. The costs of establishment and production provided both growers and CDFA the detailed cultural practices and economic basis for discussion and determination of a fair compensation.

Impact: Wine grape growers in Temecula received \$5.6 million dollars compensation from CDFA for vine losses. This compensation enabled many of the growers to replant their vineyards and stay in the business of wine grape

production. Today, the Temecula wine grape industry has recovered many of its losses and continues to build the economy of the community. In 2005, the industry contributed about \$4 million in crop value to the economy. The revival of the industry also restored employment in agriculture and service industries. It enabled the wine industry to stabilize and continue generating income to the community through tourism

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: Nickels Soil Lab Research Supports New Orchard Plantings

Description: Significant acres of California farmland are lost each year to residential and commercial development. The consequent economic and environmental impacts are of great concern to most Californians. To maintain rural environments and agricultural productivity, farms are relocating to the edges of the Central Valley, away from prime soils. Alternative farming practices must be developed to maintain production under these challenging conditions. In an innovative cooperative arrangement between UC ANR and the private Leslie J. Nickels Trust, a retired UC CE farm advisor established an experimental orchard, located in southern Colusa County, in 1973. This public/private collaboration, the Nickels Soil Lab (NSL), is unique within the ANR research system, using private farmland and financial resources to conduct University research for the betterment of local agriculture. As stipulated in Mr. Nickels' will, ANR manages 200 acres of orchard land to develop and investigate farming practices that allow profitable agricultural production on marginal soils. UC campus-based faculty and UC CE farm advisors address a broad research agenda targeting five key areas: irrigation, soil modification or fertility, variety or root stock evaluation, pollination and orchard design. From these efforts a complete package of recommendations emerged, including drip irrigation, fertigation, the use of optimal varieties and rootstocks, and a hedgerow orchard design. Surprisingly, yields in the test orchards are nearly comparable to the best in the Central Valley, proving to local growers that high yields are attainable under these challenging conditions. NSL also serves as a teaching facility where large research plots demonstrate the viability of newly developed orchard practices. Growers from throughout the Central Valley attend annual Nickels Field Days, where researchers report trial results and discuss ways to implement the new concepts.

Impact: Some 250,000 acres of orchards have been planted in the Central Valley in the last two decades, representing \$1.6 billion in additional agricultural production. By adopting techniques first developed for almonds and walnuts at

NSL, such as hedgerow planting, drip and micro-irrigation and minimal pruning, growers are now producing profitably on the outlying, marginal land of the Central Valley.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 1.07 Apiculture

Title: Conserving and Protecting Bee Pollinators in Disturbed and Managed Habitats of California

Description: The bee research expanded from 4 residential environments of the San Francisco Bay Area to 6 major urban residential areas state wide; these were Ukiah, Sacramento, Santa Cruz, Monterey, Paso Robles and Santa Barbara. In each of these cities, the UC researcher conducted surveys and did frequency counts of bees on 22 conspecific ornamental plant species. He also developed a mostly native plant bee garden at the UC Berkeley Oxford Tract for intensive bee studies (in 2004 it had 50% exotic and 50% native plant species). Finally, he continued a survey of urban bees on ornamental plant species in a tropical dry-forest urban area in Costa Rica (3 years of data to date). Results are summarized here: 1) Conspecific plant species in all 6 areas state wide attracted mostly the same bee taxa (at generic and often specific level) and at the same relative levels. It was also noted that each city had its own characteristic garden culture where certain kinds of ornamentals were found throughout given cities. Results of this survey are in a paper review in "California Agriculture" 2) The UC Berkeley Oxford Tract has now attracted 40 bee species; the city of Berkeley has 82, and they are still counting. 3) It seems clear that urban residential areas can serve as reserves for native bee species, and the US National Academy of Sciences through the NRC has recognized this fact through their new work and a very few others who are just starting. 4) The urban tropical gardens being surveyed in Costa Rica have yielded almost 120 bee species, which is about half of the known species from the surrounding wildlands. Also, bees commonly nest in tropical urban gardens.

Impact: This is the first large-scale technical research program on urban residential bee diversity, abundance and host plant preference in the US. Other US labs are now following. Also, the NAS in Washington asked for a formal presentation on the subject, which he provided. Urban areas especially in CA and Costa Rica are now known to offer resources required for reproduction and survival of diverse bee species.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.07 Apiculture

Title: Pollination by Insects

Description: CROP POLLINATION: In addition to proximity to wild land areas, urban areas and farm restorations provide and may enhance native bee populations for pollination of nearby crops. BIODIVERSITY AND ECOLOGY: The narrow endemic *BOMBUS FRANKLINI* and widespread *B. OCCIDENTALIS* were not found during intensive searches in CA and OR in 2005. Related eastern bumble bee species are also declining. Declines appear due to an exotic strain of pathogen, *NOSEMA BOMBI*. Five new species of *ANDRENA* were described in two subgenera. BEE BIOLOGY: Small bees avoid *MALACOTHAMNUS* stigmas when foraging for nectar. INVASIVES: No honey bees were found on Santa Cruz Island in 2005. Tests showed that invasive yellow star-thistle reduced native bee visits to native gumplant.

Impact: In addition to the importance of adjacent wild land areas, crops may benefit from enhanced native bee habitat in urban gardens and farm restorations. Decline of bumble bee populations is of increasing concern. Investigations are needed to determine causes and remedies. Invasive pollinators enhance reproduction of invasive plants. These invasive plants may reduce visits of native pollinators to native plants via competition.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.10 Biofuels

Title: The Science and Engineering for a Biobased Industry and Economy

Description: Properties and Utilization of Saline Biomass: Properties of biomass grown under saline irrigation as part of integrated on-farm drainage water management were investigated to determine potential applications as bioenergy and bioproduct feedstocks. Physical, chemical, structural, and fuel properties were determined for three species of biomass including two woods (*Athel* and *Eucalyptus*) and one grass (*Jose Tall Wheatgrass*). *Jose Tall Wheatgrass* has high fouling potential for combustion systems and the *Athel* exhibits high uptake of calcium and alkali sulfates yielding an unusual ash composition compared to most other woods. Both downdraft and updraft gasification of pelleted wheatgrass resulted in severe ash slagging. The saline biomass was also studied as potential feedstock for biogas and ethanol production.

Thermochemistry of Ash in Biomass Combustion and Gasification: Experimental melting of biomass ash blends demonstrated that the addition of rice straw to a dominantly wood based fuel causes a marked freezing point depression in the liquidus temperature of the inorganic slag from well above 2000 C to a minimum of about 1260 C. The minimum temperature is achieved for ash blends with about 30% rice straw ash. Biogas Production from Organic Wastes: Food and green wastes collected from northern California were studied for biogas energy production. Continuous anaerobic digestion of food and green waste using a lab-scale Anaerobic Phased Solids Digester (APS- Digester) system was also studied. Anaerobic digestion research was also carried out to examine the feasibility of the co-digestion of onion juice extracted from solid onion waste and aerobic sludge generated by an onion processor. Hydrogen production from cheese whey permeate was investigated under mesophilic conditions (35-38 C). In the continuous fermentations the pH of the reactor was controlled in the range of 4.0-5.0. Loading rates of 5 to 14 g COD/L/day and hydraulic retention times (HRTs) of 12 to 24 h were tested. Under some operating conditions, continuous production of H₂ for 2 to 3 week periods was observed, with maximum H₂ yields of 2.0 to 2.3 mM/g COD fed. Transient Expression of Recombinant Protein in Biomass: Extraction, storage and purification methods for recombinant protein produced by agroinfiltration were studied. Lettuce leaves expressing beta-glucuronidase (GUS) were extracted by homogenization in several buffer combinations and the yield and stability were assessed. The reducing agent dithiothreitol (DTT) was found to be the most important (significant) component in the extraction buffer. Freeze-drying the lettuce leaves extended the estimated half-life of GUS at 4 C to 3.9 years versus 11 days for fresh lettuce. Chromatography and aqueous two-phase extraction (ATPE) were equally effective for separating E. coli-derived GUS from lettuce proteins. Follow-up work is underway to investigate purification differences between E. coli- and lettuce-derived GUS. Work is also underway to examine the post-harvest storage effects on expression in leaves.

Impact: Improved control of slagging and fouling in thermochemical conversion systems will reduce operating costs and increase the range of fuel types that can be considered for these systems. Energy and products from biomass produced as part of phytoremediation programs will help offset the costs of remediation. High rate anaerobic fermentation/digestion systems for waste conversion will reduce the cost of bioenergy production, making distributed energy generation more economically attractive for both rural and urban communities and also reduce the environmental impact by these waste streams. Transient recombinant protein expression in plant biomass using *Agrobacterium tumefaciens* mediated transformation appears to be a promising technology that could potentially be scaled up to produce high-value proteins. It provides safety and environmental advantages compared to other plant-based expression systems because no transgenic crop or vector is exposed to the environment and the possibility of animal or human consumption is eliminated. Improving recombinant protein expression and recovery are important for commercializing this technology.

Funding Source: Multistate Research and State

Scope of Impact: AZ, AR, CA-D, FL, HI, IL, IN, IA, KS, KY, LA, MI, MN, MS, MT, NE, NC, ND, OK, OR, SC, SD, TN, TX, VA, WA, WVA, WI

Theme: 1.10 Biofuels

Title: Structure-Based Optimization of Enzymes Composing a Xylose Assimilation Pathway

Description: Post harvest residues are a disposal problem in some cases and also represent a lost opportunity to recover energy locked in the complex sugars contained in the cells and cell walls. Although much of this material is composed of complex forms of glucose, a significant fraction are pentoses. Over the years, many different lab have attempted to engineer a fermentation pathway for use in yeast (an organism well optimized for fermentation) to convert these sugars into ethanol. Examination of yeasts which are able to metabolize xylose (the most prevalent pentose) reveals that this is done in a three step process: 1) reduction of xylose to xylitol by the NADPH-dependent xylose reductase (XR) 2) the reoxidation of xylitol to xylulose by the NAD⁺-dependent enzyme xylitol dehydrogenase (XDH) and 3) phosphorylation of xylulose to xylulose-5-phosphate by xylulose kinase (XK). Xylulose-5-phosphate can then enter yeast metabolism via the pentose phosphate pathway. Two problems have been shown to exist when the xylose assimilation pathway is inserted into yeast: 1) high flux through the first two steps creates an imbalance between NADPH and NADH cofactors within the cell and 2) the equilibrium across the XDH step favors xylitol and xylulose concentrations are therefore very low. To address the first problem, they have been generating and studying mutants of XR and XDH to generate an XR that is NADH-dependent or an XDH that is NADPH-dependent. Either one of these would allow cosubstrate recycling between the first and second steps of the pathway. A collaboration with Prof. Bernd Nidetzky at the Technical University of Graz has allowed us to improve the properties of XR from the xylose-utilizing yeast *Candida tenuis* from one that prefers NADPH 33-fold over NADH to one that prefers NADH 5-fold over NADPH. Although the conversion of specificity was incomplete, they now understand the structural reasons for this and based on these results believe that there are probably no obvious specificity improvements that they can make (ref. 1). Their work has also determined that the aldose versus ketose substrate specificity of these enzymes is controlled by a tryptophan at position 23 (ref. 2). Mutation at this position converts the enzyme from one that prefers aldoses such as xylose to one that prefers ketones. They have also pursued an alternate route to improving cosubstrate recycling by working on an XDH from *Gluconobacter oxydans*. This enzyme is NAD⁺-specific and the crystal structure reveals that the primary specificity determinant for this over NADP⁺ is an aspartate at position 38 which

prevents binding of a negatively-charged phosphate on the cosubstrate adenosine 2' hydroxyl (ref. 3). Additional specificity is provided by a methionine at position 39 which stacks below the adenine ring of the cosubstrate. Mutation of these to serine and arginine respectively has yielded an enzyme a complete conversion from NAD⁺ to NADP⁺ specificity (ref. 3). Work to express wild-type XR, the XDH double mutant and XK in yeast is currently underway.

Impact: The National Renewable Energy Laboratory estimates that 2.45 billion tons of agricultural waste are burned or otherwise disposed of in the US alone creating health hazards and wasting large quantities of potential energy. These byproducts contain large quantities of complex carbohydrates which could be fermented by yeast to produce ethanol if an adapter pathway existed to allow the yeast to utilize pentoses such as xylose, a major component in plant cell walls. Since the oil embargo of 1973, the US has been acutely aware of their dependence on foreign sources for energy. Rather than developing domestic production, an environmentally preferable partial solution to this problem is the conversion of biomass to ethanol. The federal government recognizes the importance of these types of fuels in benefiting human health - the Clean Air Act amendments of 1990 mandated oxygenated fuels in areas with unhealthy levels of carbon monoxide. This conversion will also aid in the disposal of agricultural residues. In 1999, President Clinton issued an executive order to triple bioproduction and bioenergy by 2010. Currently, biomass provides 3 percent of the energy in the US Fermentation of biomass already yields 1.5 billion gallons of ethanol per year. Their goal is to engineer pathways which will allow the fermentation of agricultural byproducts which are not metabolizable using current technologies.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.11 Biotechnology

Title: Economic and Environmental Impacts of the Adoption of Genetically Modified Foods

Description: This project involves economic analysis of genetically modified crops. Work in progress involves the study of international differences in genetically modified food labeling regulations and the economics of the co-existence of genetically modified crops and conventional crops in California agriculture.

Impact: The UC researchers have published a book on genetically modified wheat, where they describe the controversy over this new technology that is not yet commercialized. Their research shows that developing countries have a huge

stake in this new technology, but European policies are holding back adoption of genetically modified wheat. They outline the similarity in the controversy between genetically modified rice and genetically modified wheat, both food crops. Their book provides economic welfare estimates of the cost of not adopting genetically modified wheat. The costs are found to be quite large and they conclude that the optimal time to adopt genetically modified wheat is now.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.11 Biotechnology

Title: Engineering Crops Resistant to Abiotic and Biotic Stress with Improved Growth and Enhanced Quality

Description: 1. Development of salt tolerant crops. The UC researchers have completed a number of field trials aimed to characterize the ability of transgenic tomato, rice and cotton to grow at high soil salinity conditions. Some of the trials show encouraging results, showing the ability of rice and cotton to produce significant yields at conditions where the wild-type plants were severely reduced by the environmental conditions imposed. 2. Development of drought tolerant crops. They have generated transgenic tobacco plants that show enhanced tolerance to severe drought conditions. These plants have been modified in order to strengthen source tissues and produce sinks able to withstand complete dehydration. They are now in the process of demonstrating in the greenhouse the ability of these plants to produce high yields under extremely low watering regimes. The trait is being introduced in cotton and rice and they expect to have homozygous transgenic plants in the next granting year. 3. Global gene expression analyses under salt stress. They have identified and characterized a T DNA insertion knockout mutant of the vacuolar sodium/proton antiporter in *Arabidopsis thaliana* and used these mutant lines and also lines overexpressing the antiporter to analyze global gene expression under salt stress using DNA arrays. They are now in the process of submitting their results showing the molecular network that is affected by ion and pH homeostasis. 4. They have made significant advance in the characterization and identification of the key enzymes and transporters controlling the sugar to acid ration in citrus fruits. They have also identified molecular determinants that control the final sugar concentration in the fruits and started experiments aimed at altering the sucrose/fructose ratio during the post-harvest process producing sweeter fruits with a high marketing capacity.

Impact: Environmental stress due to salinity and drought is one of the most serious factors limiting the productivity of agricultural crops, which are predominantly sensitive to the presence of high concentrations of salts in the soil

and low water availability. California crop production in both the Imperial Valley and the San Joaquin Valley is particularly affected by drought and soil salinity. Their work has generated a number of patents that have been licensed by the California biotechnology industry to develop cultivars that will produce better on saline soils and/or low water availability. Substantial water savings could be realized by reducing or even eliminating the need to either over water or leach to remove salt from the soil profile; this further savings of water will also contribute to balance state watersheds that are largely dependent on water imported from other regions.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.12 Bioterrorism

Title: Virulence Factor Secretion by Pathogenic Bacteria

Description: The UC researchers have expanded their studies of how virulence factors are secreted by pathogenic bacteria. Significantly, both flagellar and contact-dependent type III secretion systems were demonstrated to display conserved requirements for polypeptide targeting. They have additionally made strong progress toward defining the role of the Ysa type III secretion systems in the pathogenesis of food-borne illness. Their recent results indicate the Ysa type III secretion system is important for bacterial survival in the small intestine.

Impact: Food-borne illnesses have a direct impact on human health and economic productivity of California and the United States as a whole. Most food-borne illnesses occur as a result of accidental contamination, but there is growing concern that food may be used as a vehicle for delivery of a bioterror agent. This research positively impacts the stakeholders by providing a clear understanding of how food-borne pathogens survive and promote disease.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.15 GIS/GPS

Title: Monitoring and Control Measures for Pierce's Disease in Kern County

Description: Pierce's disease (PD), caused by the bacterium *Xylella fastidiosa*, is a killer of grapevines. Significant vine loss from PD has occurred in Southern California, North Coast and portions of the southern San Joaquin Valley including

Tulare and Fresno counties over the last 100 years. However, the arrival and spread of the glassy-winged sharpshooter (GWSS), a more effective vector of the disease, caused devastating losses in the wine-growing regions of Temecula and threatened Kern County, a major grape production area of the state with more than 87,000 bearing acres and a farm gate value of approximately \$438 million dollars. A large-scale, joint research project was initiated in 2002 between the UC Cooperative Extension and the California Department of Food and Agriculture to map the incidence and track the spread of Pierce's disease (PD) within 215 vineyard blocks in Kern County. The area was selected for evaluation because of its importance as a major grape production area and its short history of GWSS infestation. The acreage surveyed within the project represents over 4,000 acres of grapes or, roughly 5% of the total bearing grape acreage in the county and 15 cultivars of varying ages were examined.

Impact: This project has provided multiple positive impacts to grape growers, public agencies working to reduce the populations of GWSS and limit the spread of PD and to those in the research arena. First, the benefits to growers included one- on-one education about the disease and a three-year personalized data set revealing the PD status of individual vineyards and the locations of affected vines for more than 30 growers that cooperated in the project. This data set was used to encourage growers to pull out diseased vines in order to eliminate sources of the bacteria for spread by the GWSS. Since the inception of the project, they have observed an 83% reduction of PD from 2002 to 2003, and a subsequent decrease of 60% from 2003 to 2004 in the vineyards located in the General Beale Pilot Project, an area where the GWSS was first discovered and significant vine losses had occurred due to PD (see photo above). Secondly, the data set provided an essential layer of information to the USDA Area Wide Management of GWSS Project on the history and location of PD in Kern County. This information was used to designate treatment zones in which it was absolutely critical to keep GWSS populations down to slow the spread of PD. The information generated from the project was modified for presentations at several field meetings to demonstrate that effective PD control can be obtained with a combination of areawide GWSS treatment program and monitoring for and removal of infected vines. Finally, the data, maps and information has been shared with UC Riverside and UC Berkeley researchers to maximize the opportunity for generating projections of economic loss and new methods of disease management and sampling. The project has generated multiple hypotheses regarding the factors that contributed to the spread of PD in Kern County. There are three projects being conducted at Riverside and Kearney Research & Extension Center to test these hypotheses.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 1.19 Invasive Species

Title: Interactions among Bark Beetles, Pathogens, and Conifers in North American Forests

Description: In March 2000, twenty disease progression plots were established in Marin Co., California, to characterize the progress of disease symptoms. Symptoms of sudden oak death and signs of associated organisms were recorded from coast live oaks (*Quercus agrifolia*) and tanoaks (*Lithocarpus densiflorus*), four times per year, from March 2000 through March 2003. Symptoms and signs in *Q. agrifolia* progressed from bleeding, to infestation by scolytid beetles, to the development of fruiting structures of the fungus *Hypoxylon thouarsianum*. Mortality of symptomatic trees increased from 2000 to 2003 as follows: *Q. agrifolia*, 5.8% to 17.4%; and *L. densiflorus*, 8.3% to 22.2%. From 2000 to 2003, bleeding trees were 25.0% to 23.6% of living *Q. agrifolia*, and 39.0% to 62.4% of *L. densiflorus*. Scolytid beetles colonized more than 95% of the living symptomatic *Q. agrifolia* that subsequently died. The host-colonization behavior of the red turpentine beetle, *Dendroctonus valens*, was investigated in stands of ponderosa pine, *Pinus ponderosa*, with black stain root disease in the central Sierra Nevada of California. By felling live trees, they found that trees with pitch tubes produced during the initiation of tunneling by *D. valens* had a significantly higher incidence of black stain root disease than trees without pitch tubes. Trees with the most *D. valens* pitch tubes had the greatest likelihood of being diseased. Additionally, observations over a 3-year period revealed that trees with *D. valens* pitch tubes had a significantly higher mortality rate than trees without pitch tubes. In experiment was conducted to compare the attraction of *D. valens* and other insects to wounded-diseased, wounded-symptomless, and unwounded trees. More *D. valens*, *Spondylis upiformis*, and *Hylastes* spp. were attracted to wounded trees than to unwounded trees. Catches of these beetles on wounded- diseased trees were not significantly different from catches on wounded-symptomless trees. Comparisons of intraspecific spatial synchrony across multiple epidemic insect species can be useful for generating hypotheses about major determinants of population patterns at larger scales. They compared patterns of spatial synchrony in outbreaks of six epidemic bark beetle species in North America and Europe. Spatial synchrony among populations of the Eurasian spruce bark beetle *Ips typographus* was significantly higher than for the other bark beetle species. The spatial synchrony observed in epidemic bark beetles was also compared with previously published patterns of synchrony in outbreaks of defoliating forest Lepidoptera, revealing a marked difference between these two major insect groups. The bark beetles exhibited a generally lower degree of spatial synchrony than the Lepidoptera, possibly because bark beetles are synchronized by different weather variables that are acting on a smaller scale than those affecting the Lepidoptera, or because inherent differences in their dynamics leads to more cyclic oscillations and more synchronous spatial dynamics in the Lepidoptera.

Impact: Their studies attempt to determine the role of bark beetles in the death of trees, such as spreading the pathogen to new areas and hosts and causing structural failure of infected trees. These investigations are important to the development of management guidelines for these new destructive diseases that are becoming more widely distributed in California's wildland and urban forests. They are exploring biochemical processes in diseased trees that are colonized by bark and ambrosia beetles. These studies should produce new basic information on the interactions among trees, pathogens, and insects. That might lead to development of new treatment methodologies against for mitigating the effects of pathogens and insects on their host trees. For example, they have identified 4 volatile compounds produced by *P. ramorum*-infected coast live oaks. These compounds, as well as others, may attract bark and ambrosia beetles that may cause breakage of *P. ramorum*-infected trees. In addition, understanding mechanisms of spatio-temporal patterns of spread of exotic pests and diseases is important to predict rates and patterns of spread for developing management decisions.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-B, CO, FL, ID, IA, KY, OH, UT, WI

Theme: 1.19 Invasive Species

Title: Insect Invasions: Molecular Genetics, Database, and Modeling Approaches

Description: This project contains 3 elements, molecular genetics, databasing, and modeling. 1. Molecular Genetics. The UC researchers continue to develop genetic methods for the studies of origins and biology non-indigenous, invasive (exotic) insects. Insects that they have worked with this year include a number of tephritid fruit flies (Medflies, Mexican fruit fly, walnut husk fly, pumpkin fruit fly, olive fly, flies in the *Bactrocera dorsalis* complex), rice brown planthopper, Argentine ant, glassy-winged sharpshooter, and some insect parasitoids used for biological control. They have developed methods to distinguish between ancient and recent (cryptic) invasions of insects and they have developed markers for new species. This work is in collaboration with a U Arizona researcher, an IRRI researcher, a UC Riverside researcher, a CSIRO researcher (Australia), a U Hawaii researcher, an INRA researcher (France), and a researcher from Siena, Italy. 2. Database. They are continuing to develop a prototype of a database of exotic organisms which includes exotic insect pests of California and the Pacific Rim, original and current distributions, as well as links to ecological and genetic data. This work is in collaboration with a San Diego State University researcher, a UCB researcher (Moorea) as well as database scientists with the UC Berkeley Natural History Museum and the Consortium for the Barcode of Life. They are using a Distributed Generic Information Retrieval (DiGIR) model in which different databases can be queried from a central location. To date, they have

linked the Essig Museum (UC Berkeley), the Australian National Insect Collection, (CSIRO, Australia), and the Bishop Museum (Honolulu). 3. Modeling. They are building on their prior approach to analyze recent histories of populations using simulation studies. They are continuing the use of approximate Bayesian methods to estimate simultaneously relevant population parameters of population size and dispersal.

Impact: Methods and analytical methods have been developed for studying the biology and history of invasive insects that are economically important for agriculture, biodiversity, and human health. The approach uses molecular genetics, databases, and computer modeling.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.19 Invasive Species

Title: Limits to Colonization of Insect Species

Description: Leaf feeding beetles (*Diorhabda* spp.) imported for biological control of the Eurasian riparian woody weed *Tamarix* spp have been released by us along Cache Creek, California, and they have also studied successful releases in Nevada in this first year of the project. The releases near Cache Creek have failed to establish. Host plant species is very important to colonization success of the beetles, with larvae prospering in Nevada on *Tamarix ramosissima* (which has been heavily suppressed across two different release sites), but not *Tamarix parviflora*, on which larval performance seems poor. Unfortunately, *Tamarix parviflora* also dominates the Cache Creek site. *Diorhabda* beetles have been collected from Greece and Crete and their population subdivision is being studied with a mitochondrial DNA marker to determine if there is any difference in collections from different species of *Tamarix*. Predation differs across the Nevada and Cache Creek sites, but exclusion experiments show that predation is generally dominated by generalist lady beetles, ants and spiders, and tends to be most intense on first instar larvae. Representative specimens of predators have been collected and are being identified to use existing biological literature to help determine which is likely to have the greatest impacts (to add in the design of further experiments next field season), and any methods of suppressing predation. The existing published and 'grey' literature is being surveyed for quantitative data on colonization success in biological control agents with respect to release numbers. Previously unpublished data sets have also been identified among researchers who work on pest fruit flies (*Tephritidae*), data sets, which are very relevant to calculating detection efficiencies in fruit fly traps.

Impact: The UC research is unraveling the sources of the failure of biological control agents to colonize against one of the most important woody weeds in the US, which is a key to facilitating improved biocontrol. An improved understanding of colonization success and trap efficiency can help to more efficiently prevent establishment of new populations of pest fruit flies.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.19 Invasive Species

Title: Invasions of Exotic Weedy Species and Their Interactions with Native Vegetation and Cultivated Plants

Description: (1) There is no relationship between native plant species richness and invasive plant species richness in seven plant communities of the Stebbins Cold Canyon Reserve. Comparing means for individual communities, the only significant correlation is between percentage of invasive species and total cover of invasive species. (2) The results from a small-scale pilot study did not translate to the landscape level in terms of control of invasive weeds and native community recovery on Santa Cruz Island, California. Therefore, active restoration should be an organic component of large-scale projects. (3) In the Kruger National Park, there is no difference between frequency of invasive *OPUNTIA STRICTA* (prickly pear cactus) under trees suitable and unsuitable for baboon roosting. Elephants are the major dispersal agent of this species. (4) There are six European invasive plant species that are substantially more widespread in Chile than in California. At least 14 European invasive plant species are more widespread in California than in Chile. (5) A general theory of seed plant invasiveness was further developed.

Impact: Evaluations of biological attributes of invasive plants and vulnerable plant communities help to develop management protocols for screening of introduced plants and prioritization of their control, containment, and eradication.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.19 Invasive Species

Title: Genetic and Reproductive Factors Contributing to the Invasiveness of *Cortaderia jubata* and *C. selloana* in California

Description: In the first study on *Cortaderia selloana*, the UC researchers isolated and characterized microsatellite loci for purposes of identifying cultivars and assessing genetic relationships among cultivars. They developed nine primer pairs, which amplified 10 polymorphic and putatively disomic loci, and used these to genotype 77 individuals representing 17 named cultivars and four selections of ornamental pampas grass. The ten microsatellite loci distinguished the majority of pampas grass cultivars. A neighbor-joining consensus tree, based on proportion of shared alleles among individuals, revealed clusters of cultivars corresponding to origin and morphological characteristics. Primers designed for *C. selloana* amplified microsatellite loci in other *Cortaderia* species concordant with phylogenetic relationships among the species. Cross-amplification was 100% in *C. jubata*, 77% in *C. pilosa* and *C. rudiusscula*, 66% in *C. fulvida*, and 55% in *C. richardii* and *C. toetoe*. In a second study, they used the microsatellite markers to assess the genetic diversity and structure of invasive pampas grass populations and infer the demographic processes underlying the invasiveness of the species in California. Individuals in 33 California populations were genotyped. F_{ST} -values among populations within versus between geographic regions suggested range expansion due to independent introductions from shared source(s) across regions, as supported by the neighbor-joining clustering of populations. A model-based Bayesian clustering method indicated the presence of five or more genetically distinct source gene pools, representing introductions from native South America into cultivation. The presence of all five of the identified gene pools in populations adjacent to plantings indicated the invasive populations originated from gene pools represented in current landscape plantings. They hypothesized source-sink dynamics between landscape plantings as sources and invasive populations as sinks as the mechanism of invasion. The hypothesis was supported by significant family structure detected in all but three invasive populations. Based on source-sink dynamics, the extensive admixture in invasive populations most likely occurred in cultivation. The inferred source-sink dynamics suggest a key role of landscape plantings and propagule pressure in the invasion success of pampas grass. A third study focused on genotyping landscape plantings for the purpose of assigning invasive plants to genotypes (cultivars) of ornamental pampas grass. They found that invasive populations predominantly assigned to two of seven identified gene pools. The cultivated genotypes that assigned to the same two gene pools made up the majority of the landscape plantings. These results are in agreement with a key role for landscape plantings and propagule pressure in invasiveness of pampas grass in California. Their analyses support consideration of propagule pressure in risk assessment for invasive potential of ornamental plants. They focused their efforts on *Cortaderia selloana* in 2005 but will resume their studies of *C. jubata* in 2006.

Impact: The UC research studies identified ornamental cultivars/selections and landscape plantings that have functioned as sources of invasive populations of pampasgrass in California. Further research will seek to identify additional factors and processes that contribute to the success of the species in invading coastal

and inland wildland habitats. The results obtained will provide information on means by which new invasions may be prevented and/or managed and will have a direct impact on the horticultural industry and California Department of Food and Agriculture. Whereas jubatagrass is on the California Noxious Weed list, pampasgrass continues to be sold as an ornamental. Their study will indicate what needs to be done to ensure that continued sale of pampasgrass does not result in further invasions of wildlands. Results will show whether there is a need to restrict the sale of specific cultivars, modify horticultural practices to ensure ornamental plantings do not produce seed or pollen, or ban the sale of pampasgrass outright and place it on the California Noxious Weed list

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.19 Invasive Species

Title: Ecology and Physiology of Weedy and Invasive Plants in Wildland and Agricultural Ecosystems

Description: *Cynara cardunculus*, artichoke thistle, is a perennial invader of California coastal grasslands. They quantified *C. cardunculus* dispersal in an exotic grassland (vegetated site) and an agricultural field (non-vegetated site). Dispersal distance increased dramatically from less than 20 m in the vegetated site to more than 40 m in the non-vegetated site. Plants producing fewer seeds produced heavier seeds and dispersal distance decreased over time, but seed size was not related to dispersal distance. Management of *C. cardunculus* and other wind-dispersed plant invasions may be improved by prioritizing populations with open or disturbed areas downwind and minimizing the removal of vegetation during dispersal. The UC researchers conducted a phenology experiment to construct degree-day models for *Cynara cardunculus*. Seeds were planted monthly and growth data were recorded twice weekly for 18 months. Median days to each stage of development were calculated and used with temperature data to develop degree-day models that incorporated phenology, daily temperature, developmental temperature cutoffs, and cutoff methods. A field experiment was conducted to validate the models. Observed phenology data was compared to predicted phenology data determined by the best fit models. The model with temperature cutoffs of 10 C and 20 C using a vertical cutoff method best predicted seedling emergence and production of 2 leaves. By predicting when sensitive stages occur, land managers can schedule control timing to be most effective. *Brassica tournefortii*, Sahara mustard, is an exotic invasive mustard increasing in dominance throughout southwestern deserts. They conducted experiments to characterize phenology of desert and non-desert populations compared with other invasive mustards not present in the deserts and with native desert species, and observe impacts of *B. tournefortii* density on

native annual diversity, dominance, survival, and fecundity. Greenhouse and field results showed that *B. tournefortii* developed faster than *B. nigra*, *B. geniculata*, and native desert annuals. Results suggest that sites beneficial for natives may also be most beneficial for *B. tournefortii*. California riparian areas have become dominated by *Arundo donax*, giant reed, an invasive perennial grass. A field experiment determined the susceptibility to *A. donax* invasion by experimental restoration plots differing in functional diversity. Three riparian species (tree, shrub, reed) differing in physiognomy were planted into experimental plots in all possible combinations. *A. donax* rhizomes were introduced into half of the plots the following spring and the other half the following winter. Establishment of the spring group differed between functional types, with *A. donax* plants senescing more quickly in plots that contained the shrub *B. salicifolia* alone or in any combination. Colonization of experimental plots by surrounding riparian plants was reduced in plots that were originally planted with *B. salicifolia*. Functional identity rather than functional diversity influenced success of *A. donax* and other colonizers. Efforts should be made to identify such important species groups in restoration designs.

Impact: Results of this research have direct applications for developing ecological approaches for prevention and management of wildland invasive weeds. Management of artichoke thistle and other wind-dispersed plant invasions may be improved by focusing on populations upwind of open or disturbed areas and minimizing the removal of vegetation during seed dispersal. Application of degree-day models to predict phenology of wildland weeds would allow land managers to schedule timing of control efforts to be most effective. Sahara mustard likely invades desert areas due to its early germination and rapid completion of the life cycle, suggesting that control measures should begin early both to prevent its spread and avoid damage to native annual species. In riparian areas, species identity rather than functional diversity has the greatest impact on slowing establishment of giant reed and other colonizing species. Efforts should be made to identify such important species groups when developing restoration plans for riparian communities.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.19 Invasive Species

Title: Mesoscale Habitat Control of Microbial Community Composition: Effects on Soil Carbon and Nitrogen Transformations

Description: Plant invasions have dramatic aboveground effects on plant community composition, but their belowground effects remain largely uncharacterized. Soil microorganisms directly interact with plants and mediate

many nutrient transformations in soil. Belowground changes to the soil microbial community may provide a mechanistic link between exotic plant invasion in grazed annual grasslands and changes to ecosystem nutrient cycling. To examine this possible link, UC researchers maintained monocultures and mixtures of exotic and native species for four years in lysimeters at Hopland Field Research and Extension Center. They measured gross rates of nitrogen mineralization and nitrification with ^{15}N pool dilution and characterized soil microbial communities with DNA-based methods. Exotic grasses doubled gross nitrification rates, in part by increasing the abundance and changing the composition of ammonia-oxidizing bacteria in soil. These changes appear to translate into altered ecosystem nitrogen budgets after invasion. They also examined how plant invasions altered the arbuscular mycorrhizal fungi of native plant roots in the same California annual grassland site as well as one in Utah. In the California site, they used experimentally created plant communities composed of exotic (*Avena barbata*, *Bromus hordeaceus*) and native (*Nassella pulchra*, *Lupinus bicolor*) monocultures and mixtures. In the Utah semi-arid grassland, they took advantage of invasion by *Bromus tectorum* into long-term plots dominated by either of two native grasses, *Hilaria jamesii* or *Stipa hymenoides*. Arbuscular mycorrhizal fungi colonizing roots were characterized with PCR amplification of the ITS region, cloning, and sequencing. They saw a significant effect of the presence of exotic grasses on the diversity of mycorrhizas colonizing native plant roots. In the three native grasses, richness of mycorrhizas decreased; in the native forb at the California site, the number of mycorrhizal RFLP patterns increased in the presence of exotics. The exotic grasses also caused the composition of the mycorrhizal community in native roots to shift dramatically both in California and Utah. Invading plants may be able to control the network of mycorrhizal fungi in soil that is available to natives through either earlier root activity or differential carbon provision compared to natives. Alteration of the soil microbial community by plant invasion can provide a mechanism for both invasion success and the resulting effects of invaders on the ecosystem. Alterations in soil microbial communities may be the invisible legacy of exotic plant invasions.

Impact: Invasion of exotic plants into California annual grasslands can substantially alter the value of these ecosystems for grazing by cattle and sheep. Understanding the interactions of invading plants with the soil microbial communities that mediate nutrient availability in these ecosystems allows us to understand why some plants are such effective invaders and provides information necessary for management to minimize the negative impacts of these invasions.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.19 Invasive Species

Title: Invasions and Diversity in California Grasslands: Studies at the Landscape Scale

Description: Non-native grass species invade and replace native species in Californian grasslands. One primary goal of this project was to determine whether within this region, spatial isolation from roads provides a refuge for remnant native grasslands. Another objective was to determine whether grassland and chaparral communities on serpentine soils responded differently than corresponding communities on "normal" soils to such perturbations as livestock grazing and fire, especially in terms of the diversity of native and alien species they support. The collaborative research findings follow. (1) Roadside grassland communities (10 m from a road) are more invaded by exotic species than grassland communities 100 m or 1000 m from the nearest road. The effect of roads on grassland composition also interacts with soil type, slope and grazing. (Gelbard and Harrison, 2003). (2) Both fire and grazing by cattle enhance native forb richness in serpentine grasslands, and exotic forb richness in nonserpentine grasslands (Safford and Harrison 2001; Harrison, Inouye and Safford, 2003). (3) Disturbance and seed supply limit the spread of exotic species equally in heavily invaded oak woodland, and lightly invaded serpentine grasslands (Williamson and Harrison, 2002). (4) Roads and distance from the "mainland" both affect the distribution of exotic species on a peninsular nature reserve (Harrison, Hohn and Ratay, 2003). (5) Roadside grasslands are more invasible by yellow starthistle (*Centaurea solstitialis*) than isolated (1000 m from roads) grasslands, and this difference is associated with biotic rather than abiotic factors (Gelbard and Harrison, 2005). (6) Small grasslands surrounded by chaparral are less invaded if they are not connected via roads to larger grasslands; this effect appears to be associated with disturbance levels, rather than with propagule supply (Gelbard, submitted). (7) In serpentine as opposed to nonserpentine chaparral, native and alien species diversity increase less strongly in response to fire, and the recovery time of biomass and species composition is considerably slower.

Impact: This project demonstrated the effect of roads, interacting with natural environmental variation, on the distribution of native exotic species at a landscape scale. This project also identified how the impacts of livestock grazing on exotic species invasions and native species persistence may vary along natural environmental gradients. Finally, the project produced one of the first studies of fire ecology in serpentine plant communities, which are a major reservoir of unique native plant diversity. These results have provided for improved landscape-scale maintenance of native species and the strategic control of exotics. Aspects of these results have been incorporated into management plans being prepared for the California Department of Fish and Game's Knoxville Wildlife Area, the McLaughlin UC Natural Reserve, and lands managed by the US Bureau of Land Management.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.21 New Uses for Agricultural Products

Title: Breeding, Genetic, and Agronomic Studies in Barely in California

Description: The feed barley UC 1047 is being commercialized and there is a very high probability that a new crop product, naked or hulless barley, will soon be available to California growers. One more year of yield trial results is needed to confirm the results of the last two years that UC 1134 is highly adapted to Central Valley growing conditions. Because of the initial success of UC 1134 the number of new segregating populations was increased in order to follow up on the initial success. On-farm trials of UC 1134 were planted at six locations in Nov. 2005 after a summer seed multiplication at Tulelake. One-thousand heads were provided to a Foundation Seed Program representative for seed multiplication and about 330 lb of seed increased at Davis are available for future multiplication for Foundation Seed. One additional new line, 11HB13 from ICARDA/ CIMMYT, was added to statewide trials for the 2005-06 growing season. New lines are in the pipeline and four new populations were created for selection using UC 1134 as a parent in April 2005 with a subsequent generation advance at Tulelake. The resulting F2 populations were planted at Davis in Nov. 2005. For the second new goal, the creation of malting barley for the Central Valley, they are well on the way to filling a breeding pipeline to create a new array of advanced lines with malting potential. About 52 lines were sent to the USDA Malt Lab in Wisconsin in July in a preliminary screening of selected breeding material. Parental lines from Anheuser-Busch, Coors, North Dakota St. U., Oregon St. Univ., and ICARDA/CIMMYT have been used as parents after visual selection for adaptation at Davis and malting results from Wisconsin. The two-rowed variety "Orca" from Oregon St. Univ. has been identified over two growing season as having very good malting quality but is very susceptible to net blotch. Orca has been used in the creation of several new segregating populations. A small number of six-rowed malting populations have also been created using two Oregon winter barleys, the line B98-9339 from Anheuser-Busch, "Drummond" from North Dakota St. U., and the Barley Yellow Dwarf Resistant selection STUC 6, which is derived from Stander/UC 960. Six-rowed populations are in the early generations of breeding whereas the two-rowed populations are now producing numerous advanced lines.

Impact: California barley growers will probably have no problem accepting UC 1134 as a new cultivar along side the feed barley UC 1047.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.23 Organic Agriculture

Title: Control of Gene Imprinting in the Endosperm

Description: Imprinted genes, where only the maternal-derived allele is active, influence seed size and quality. The endosperm supports development of the embryo and is the primary site of gene imprinting in plants. The MEA gene is imprinted in the Arabidopsis endosperm. MEA is a SET-domain Polycomb group protein that methylates histones and silences genes promote endosperm development. The UC researchers find that MEA gene imprinting is established in the central cell, which is the progenitor of the endosperm. The mechanism involves the action of the Demeter (DME) DNA glycosylase that excises 5-methylcytosine from the DNA sequences that flank the MEA gene, allowing only the maternal allele to be expressed in the endosperm.

Impact: Seeds provide a significant fraction of the nutritional requirements of humans and their domesticated animals. Important oils and starches are also produced and harvested from seeds. Genes that are imprinted in the endosperm of the seed are important regulators of seed size and quality. Understanding the mechanisms that control gene imprinting in the endosperm will improve their ability to produce higher quality seeds.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.23 Organic Agriculture

Title: UC 'Organically Grown' Help

Description: With the US market for organic products expected to top \$20 billion in 2006 and national organic standards in place, many farmers and consumers are looking for clarification on what constitutes "organic" and how to grow it. ANR is responding to these questions through local research and extension programs, publications and online resources. UC SAREP provides an organic farming information Web site with valuable information for growers involved in or transitioning to organic production. Two key resources on the Web site include: 1) UC Organic Farming workgroup directory, which lists contact information and areas of expertise for UC faculty, UC CE specialists, and UC CE farm advisors working in organic research and extension; and 2) Online Organic Farming Compliance Handbook with information on principles of organic production,

National Organic Program standards, materials compliance, organic marketing and economics, and extensive links to other resources and organizations. With a grant from the Clarence E. Heller Charitable Foundation and the True North Foundation SAREP also supported county level activities in organic research and extension in 11 California counties (Marin, Humboldt, Ventura, San Diego, Santa Barbara, Fresno, San Joaquin, Sonoma, Mendocino, Sutter-Yuba, Pacer-Nevada). With support from a CDFA Buy California Initiative grant, SAREP is working on a series of organic production manuals for four crops: olives, winegrapes, vegetables and strawberries.

Impact: The dramatic increase in California organic growers (more than 2,500 are officially registered on more than 200,000 acres) is beginning to be served by UC CE advisors and research. Client growers are applying what they have learned from on-farm research plots in soil fertility management, pest control, plant pathology, productivity, cover crop evaluations, biofumigation, compost effectiveness and weed prevention. Growers have also used information on medicinal herb farming, natural and organic beef, farm diversification, organic strawberry production, organic livestock opportunities, direct marketing, farmstead cheeses, specialty crops and organic transition and certification.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 1.24 Ornamental/Green Agriculture

Title: Improved Vegetative Propagation of Fruit Frees, Other Woody Perennials, and Small Fruits

Description: Research was conducted to regenerated shoots, and eventually complete plants, from non-meristematic material of the peach rootstocks Nemaguard, Nemared and the dihaploid Lovell. The regeneration of continued to be very difficult and was limited to the epicotyl and hypocotyl of recently germinated seeds of *Prunus persica* 'Nemaguard' and 'Nemared' rootstocks, and not from the dihaploid Lovell. Sequential transfer of plant material onto different media was required for regeneration. Regeneration occurred in several explants in one trial but was not able to be repeated. Transformation was achieved in callus of peach derived from hypocotyl tissue but this tissue could not be regenerated into shoots. Strawberry plants were regenerated from leaf discs treated with *Agrobacterium tumefaciens* carrying a gene for salt-resistant on medium containing kanamycin. The putative transformants were rooted, acclimated to greenhouse conditions and were tested for the presence of the gene. The use of PCR to determine whether strawberry plants transformed with a putative salt tolerant gene showed that no plants had been transformed for the gene. Date palm cultures grew well and were moved to the light. Embryos were

dissected from the base of one of the cultures and grown further to provide material for protoplasts. Several cultures were moved to the light and have continued producing leaves and initiated roots. All these cultures had been started from meristems initially. Studies on the ecology and reproductive and vegetative biology of *Rorippa subumbellata* (Tahoe Yellow Cress), an endangered plant, were initiated. Initial germination studies indicate that the seed has conditional dormancy which disappears after several years. Studies on the timing and mechanism of the dormancy and the method of vegetative reproduction of rhizomes are also being conducted.

Impact: Regeneration of plants from non-meristematic tissue and induction of roots on shoots are often difficult to induce; however important for plant improvement. The project focused on developing a method to regenerate *Prunus* rootstocks from leaf tissue for further use as a system of transformation and improving adventitious rooting of a variety of perennial species in order to enable them to be propagated in large numbers. A reliable regeneration method must be developed before transformation can occur that will impact fruit trees, other woody perennials, and small fruits.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.24 Ornamental/Green Agriculture

Title: Above- and Below-ground Developmental Physiology of Woody Ornamental Plants

Description: Vegetatively propagated *FRAXINUS UHDEI*, *PISTACIA CHINENSIS*, and *ZELKOVA SERRATA* trees were planted in the field for long-term (3 years) evaluation of their root architecture. Pneumatic soil excavation techniques were used in winter, 2005 to expose the root systems of the *FRAXINUS* trees so photographic evaluations could be conducted. Models of those root systems are being constructed. The same process will be followed in winter, 2006 for the *ZELKOVA* trees. Unfortunately, insufficient numbers of *PISTACIA* trees have been produced via vegetative propagation to date. Studies using microcalorimetry to predict the response of *ROSA HYBRIDA* (rose), *BUCHLOE DACTYLOIDES* (buffalograss) and *POA ANNUA* (annual bluegrass) to varying environmental conditions (soil moisture tension, temperature, pH) have been conducted to: 1) determine the respiratory and metabolic heat rate responses of rose leaflets to various soil moisture tensions, 2) determine the respiratory and metabolic heat rate responses of rose roots to varying temperature and 3) determine the low-temperature tolerance of buffalograss stolons and roots and 4) determine the metabolic heat and respiration rate of annual bluegrass seeds and seedlings. They are continuing to find applications

for calorimetry in the plant sciences. Studies have been initiated with the bacterium (XYLELLA) responsible for Pierce's Disease and with nematodes to determine environmental conditions that both stimulate and inhibit their growth and metabolism.

Impact: A method for the selection and propagation of deep-rooted trees will help minimize the damage tree root systems cause to city sidewalks and curbs. Accurate predictions of plant growth response using calorimetric data will drastically shorten the time necessary to genetically improve plants and enhance their ability to tailor plants for specific climate zones. Studies using microcalorimetry to predict the response of ROSA HYBRIDA (rose), BUCHLOE DACTYLOIDES (buffalograss) and POA ANNUA (annual bluegrass) to varying environmental conditions (soil moisture tension, temperature, pH) have been conducted to: 1) determine the respiratory and metabolic heat rate responses of rose leaflets to various soil moisture tensions, 2) determine the respiratory and metabolic heat rate responses of rose roots to varying temperature and 3) determine the low-temperature tolerance of buffalograss stolons and roots and 4) determine the metabolic heat and respiration rate of annual bluegrass seeds and seedlings. They are continuing to find applications for calorimetry in the plant sciences. Studies have been initiated with the bacterium (XYLELLA) responsible for Pierce's Disease and with nematodes to determine environmental conditions that both stimulate and inhibit their growth and metabolism.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.24 Ornamental/Green Agriculture

Title: Salinity and Environmental Stress Resistance in Turfgrass and Landscape Plants for Recycled Water Irrigation and Phytoremediation

Description: A review of the research on remediation of the selenium contaminated grassland in the Central Valley California over the last 15 years indicated that habitat modification from the wetland to dry land significantly reduced the selenium transport in the food chain and the negative impact on wildlife. Five California native grass species were tested for response to recycled-water irrigation and two coast redwood varieties were tested for salt and boron tolerance and response to recycled-water irrigation. The results revealed that there are sensitivity differences among the grass and landscape plant species and varieties. It is possible to select plants with increased tolerance for recycled water irrigation.

Impact: The research on selenium dissipation and remediation of the selenium contaminated land at Kesterson in the central valley California indicated that

transformation from wetland to dry land habitat can effectively reduce the selenium toxic impact on wild life and it may also serve as a restoration guideline for future problem. The research on salt and boron resistance and recycled water irrigation generated a guideline and landscape plant selection list for landscape irrigation management using recycled water.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.25 Plant Genomics

Title: Signaling Pathways for Stress Responses in Higher Plants

Description: The UC research laboratory has been working on the isolation of genes related to plant stress responses. The researchers' recent work identified several genes involved in response to salt and drought conditions. In some cases, these genes may function in nutrition sensing in plants, providing information vital for development of crops with higher tolerance to low nutrient soils.

Impact: The research results in their lab have impact on molecular breeding of crops with higher tolerance to low water availability, high salt content, and low nutrient status of soils.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.25 Plant Genomics

Title: Photoperception, Signaling and Gene Regulation by the Phytochrome Family

Description: Evidence has been presented that a negative transcriptional feedback loop formed by the genes CIRCADIAN CLOCK ASSOCIATED (CCA1), LATE ELONGATED HYPOCOTYL (LHY), and TIMING OF CAB (TOC1) constitutes the core of the central oscillator of the circadian clock in Arabidopsis. Here they show that these genes are expressed at constant, basal levels in dark grown seedlings. Transfer to constant red light (Rc) rapidly induces a biphasic pattern of CCA1 and LHY expression, and a reciprocal TOC1 expression pattern over the first 24hrs, consistent with initial induction of this synchronous oscillation by the light signal. UC researchers have used this assay with wild-type and mutant seedlings to examine the role of these oscillator components, and to

determine the function of ELF3 and ELF4 in their light-regulated expression. The data show that whereas TOC1 is necessary for light-induced CCA1/LHY expression, the combined absence of CCA1 and LHY has little effect on the pattern of light-induced TOC1 expression, indicating that the negative regulatory arm of the proposed oscillator is not fully functional during initial seedling de-etiolation. By contrast, ELF4 is necessary for light-induced expression of both CCA1 and LHY, and conversely, CCA1 and LHY act negatively on light-induced ELF4 expression. Together with the observation that the temporal light-induced expression profile of ELF4 is counter-phased to that of CCA1 and LHY and parallels that of TOC1, these data are consistent with a previously unrecognized negative feedback loop formed by CCA1/LHY and ELF4 in a manner analogous to the proposed CCA1/LHY/TOC1 oscillator. ELF3 is also necessary for light-induced CCA1/LHY expression, but it is neither light-induced, nor clock regulated itself during de-etiolation. Taken together, the data suggest that (a) ELF3, ELF4, and TOC1 all function in the primary, phytochrome-mediated light input pathway to the circadian oscillator in Arabidopsis, and (b) that this oscillator consists of two or more interlocking transcriptional feedback loops that may be differentially operative during initial light induction and under steady-state circadian conditions in entrained green plants.

Impact: The identification of new components involved in the phytochrome signaling and transcriptional networks not only provides additional insight into the underlying mechanisms responsible, but also presents potential new targets for intervention in the generation of plants with improved agronomic traits.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.25 Plant Genomics

Title: Molecular Genetics of Floral Repression in Higher Plants

Description: 1. Global gene expression studies showed that prior to flower development and independent of the floral activators, germinating *emf1* and *emf2* mutants ectopically express ten flower MADS-box genes (Moon et al., 2003). This suggests that EMF represses flower development, resulting in vegetative development. To confirm that AG, AP3, and PI are target genes, Chromatin Immunoprecipitation (ChIP) analysis was carried out. Results showed that selected regions of the AG, AP3 and PI promoter sequences were able to recruit EMF1 proteins tagged with 3X FLAG. 2. Previous results showed the existence of a multi-protein complex similar to the Drosophila PcG Responsive Complex (PRC)2 in Arabidopsis, EMF2/CLF/FIE/MSI1, which is responsible for the repression of floral homeotic gene expression during vegetative development

(Chanvivattana et al., 2004). The *Drosophila* PRC2 complex methylates histones and recruits PRC1 to the target genes to maintain transcriptional repression. PRC1 proteins have not been reported in plants. Recently, their results suggest that, despite its distinct sequence, EMF1 may function like a PRC1 protein, implying that plants have recruited different proteins for the PRC1 task. In animals, the components of the PRC1 complex are localized to nuclear speckles or nuclear bodies, and some members of the protein complex can bind RNA and/or DNA in a non-specific manner and can inhibit both chromatin remodeling by the SWI/SNF complex and transcription. Transient expression in *Nicotiana benthamiana* leaves showed EMF1-GFP fusion protein in a speckled nuclear pattern. They also demonstrated that EMF1 binds DNA and RNA *in vitro* in a non-specific manner and that EMF1 is able to repress transcription *in vitro* by blocking the template and interacting with the polymerase (Calonje, unpublished results). *In vitro* protein interaction studies showed that EMF1 interacted with the EMF2 multi-protein complex through MSI1 (Calonje et al, in preparation), not FIE or EMF2. Together, these results indicate that EMF1 in *Arabidopsis* functions like PRC1 in *Drosophila*. Its interaction with MSI1 of the PRC2 would create a repressive chromatin complex around the target genes. 3. To study stage- and tissue-specific requirements for EMF1 activity, they examined the phenotypes of transgenic plants expressing antisense EMF1 cDNA under the control of flower meristem-specific AP1 and LEAFY, seed storage protein At2S3, and phloem-specific SUC2 promoters. Their results suggest a) EMF is cell-autonomous in that knocking out its activity in the vascular tissue or shoot apex caused early flowering, and b) floral fate could be determined in the embryo in that a temporal knockout of EMF1 activity in the seed would cause early flowering (Sanchez, unpublished results).

Impact: EMF mutants flower extremely early. UC has patented the *Arabidopsis* EMF1 and the rice OsEMF1 genes. Transgenic rice with reduced OsEMF1 gene activity flowers early and displays short and bushy stature. These qualities are important in breeding rice that would flower early and more resistant to water lodging.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.25 Plant Genomics

Title: Genetic and Molecular Analysis of Ovule Development

Description: The *Arabidopsis* INNER NO OUTER (INO) gene is a critical regulator of ovule development. INO shows expression only in the outer layer of the integuments (seed coat layers) of ovules. UC researchers have used systematic deletion of the INO promoter region to define positive regulatory

elements in this promoter. They find three redundant elements, any two of which can combine to duplicate the INO expression pattern. They have identified a new family of transcription factors, the BASIC PENTACYSTEINE (BPC) proteins, that can bind to (GA)₆₋₉ repeat structures in the INO promoter. Progress is being made in identification of additional factors governing INO regulation. While most higher plant species have two integuments, some groups have a derived state of a single integument. They have now shown that members of the largest of these derived groups, the asterids (that includes a wide variety of agronomic species), have evolved a single integument through a fusion of the two integuments. They have used a variety of mutants in ovule development in combination with comprehensive examination of expressed genes to define novel genes involved in ovule development. More than two hundred such genes now serve as candidates for further study as potential regulators of ovule development.

Impact: The research provides new information on the critical process of spatial regulation of gene expression and organogenesis. An understanding of the interactions between transcription factors and the genes they regulate reveals the basic mechanisms responsible for many developmental processes in higher organisms. This understanding can translate into novel methods for engineered regulation of gene expression for crop improvement or biomedical applications. Regulatory regions they have identified can be use in engineering superior seed quality, or in producing seedless fruit crops.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.25 Plant Genomics

Title: Introduction and Expression of Transgenes to Improve the Quality and Production of Tree Crops

Description: The research focuses on understanding of the relationship between genes and phenotypic traits that regulate productivity of tree fruit crops. Phenotypic traits include disease and pest resistance, fertilization and fruit set, a variety of metabolic phenotypes that regulate stress tolerance, fruit quality and safety. The experimental strategy has involved developing the technological (such as transformation technology) and experimental approaches (such as gene silencing) in fruit and nut crops to increase the knowledge base and to understand the relationship between genes pathways and phenotypic traits. The UC researchers are evaluating resistance to Pierces disease (PD) in grapevine and to Citrus Tristeza virus (CTV) in citrus. In apple and walnut they are evaluating quality traits in transgenic fruit that display alterations in underlying pathways and discreet metabolic activities. In citrus they are examining the transcriptional profile of fruit specific traits. Many of these phenotypic traits are

important as they determine the economic sustainability of fruit and nut tree crops in California and many parts of the world.

Impact: The discovery and analysis of genes in fruit and nut crops that determine quality and productivity identifies genetic resources useful for the study of biological mechanisms as well as for genetic improvement of these important tree crop species. Enhancing fruit productivity and quality is an important trait recognized by consumers and key to marketing of fresh fruit and nuts and thus preserves the livelihood of fruit and nut growers all over the United States.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.25 Plant Genomics

Title: Molecular Genetic Improvement of Fruit

Description: Horticultural crops, including fruit constitute a significant agricultural economic sector and contribute to a diversified and healthy diet. The proposed research will 1) develop new information to identify genetic targets for improved fruit quality 2) develop non transgenic approaches to deliver a subset of these new traits for new cultivar breeding 3) develop strategies to access a broader range of intellectual properties for applications to horticultural crops.

OBJECTIVES: Horticultural crops, including fruit constitute a significant agricultural economic sector and contribute to a diversified and healthy diet. The potential benefits of modern genetic research have not been realized in the majority of these crops and there is a critical need for public research to extend the benefits of genomics information to the wide diversity of horticultural crops that are critical to California's agricultural economy. The research will 1) develop new information to identify genetic targets for improved fruit quality 2) develop non-transgenic approaches to deliver a subset of these new traits for new cultivar breeding 3) develop strategies to access a broader range of intellectual properties for applications to horticultural crops. **APPROACH:** A series of approaches will be utilized to identify targets for enhancing fruit quality characteristics. These include screening of tomato populations introgressed for chromosomal segments of a wild species' genomes or expressing transgenes to serve as guides to the genes that confer the enhanced trait. Finally, working with other public sector research institutions (Universities and USDA) they will develop a unified database of intellectual property related to agricultural biotechnology and provide this as a collective tool to manage, and make more accessible, public sector IP in this arena. **PROGRESS:** This project has three main objectives to: 1) identify genetic targets for improved fruit quality 2) develop non-transgenic approaches for new cultivar breeding and 3) develop strategies to

access intellectual property for horticultural crops. Research over the last year focused on confirming the role of selected transcription factors to control complex traits in fruit development, particularly ripening-associated pathogen susceptibility. The research used transcription factors selected by screening a transgenic tomato population expressing all plant transcription factors under the control of five distinct promoters. In addition to transcription factors potentially affecting disease resistance, they also identified candidates that regulate pigment accumulation in fruit. They have continued to develop an agricultural biotechnology intellectual property clearinghouse in collaboration with 30 major universities and public sector research institutions and deployed a database comprising technologies from all member institutions. The Public Intellectual Property Resource for Agriculture which has its primary goal to make intellectual property in agricultural biotechnology more widely available for both commercial uses in specialty crops and for humanitarian uses.

Impact: The greatest impact over the last year has been the demonstration that new and creative approaches to intellectual property management will be an important approach to stimulate new technology development in agricultural biotechnology.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm

Title: Physicochemical Aspects of the Role of Water in Foods

Description: Studies on the effect of water content on starch gelatinization have continued, and are providing further insight into the swelling process. An attempt is in progress to develop improved process characteristics through partial gelatinization. The patented screening test for tomato consistency has been applied with some success by a company developing new tomato varieties for processing. UC research on the characteristics of the glass transition in frozen aqueous systems has continued. A modified procedure to identify the characteristic parameters is under evaluation, in cooperation with researchers in other countries. This is part on an IUPAC project. Nucleation and crystallization studies on lipids in the presence of emulsifiers have been performed using techniques first developed to study ice crystallization.

Impact: The patent provides important information to breeders in the early stages of developing new processing cultivars. The development of improved protocols to identify aqueous glass parameters is part of an important international collaboration to define standards.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm

Title: Genetics and Breeding of Cool Season Vegetable Crops

Description: Two main groups of cool season crops are involved in this project. The first one consists of Brassica crops, where the main objectives are comparative genomics and development of lines possessing specific glucosinolates. The second one is celery, where the goals are to develop and release improved disease and insect resistant lines. Brassica: After identifying and cloning three key candidate genes in the aliphatic glucosinolate pathway in *B. oleracea*, BoGSL-ELONG, BoGSL-ALK and BoGSL-PRO, they developed markers associated to these genes for marker assisted selection. They applied these markers to a segregating population for aliphatic glucosinolates obtained by crossing *B. macrocarpa* (a *B. oleracea* relative) x broccoli. The wild species has at least 10X more glucosinolate content than cultivated Brassica. Using the markers for these three genes that were segregating in this population, they obtained lines with either 4X content of sinigrin or 4x content glucoraphanin. The first compound is precursor to isothiocyanates with biological activity against soil pathogens. The second one is precursor to sulforaphane, an isocyanate conferring protection against cancer in mammals. Selected plants were backcrossed to broccoli to improve the horticultural traits of the lines but preserving their high glucosinolate content. Celery: They continued with the development of Fusarium, late blight and virus (CeMV) resistant lines applying marker-assisted selection. These lines were advanced for further selection and improvement for horticultural traits. They are using markers associated to virus resistance to develop disease resistant lines for release to the celery industry. These include lines with resistances to two diseases, fusarium and late blight and fusarium and CeMV.

Impact: Cloning of major glucosinolate genes in Brassica will allow the creation of varieties of broccoli, cauliflower and related crops with specific glucosinolate content that can be used for different purposes, as functional foods and biofumigants. Discovery of markers for important traits will allow pyramiding disease resistance genes for the development of multiple disease resistant celery varieties. These lines will require less input of pesticides and fungicides representing savings to the growers, protection to the consumer and a cleaner environment.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm

Title: Plant Genetic Research Conservation and Utilization

Description: The researchers released celery lines (*Apium graveolens* var. dulce) containing two sets of two disease resistance genes: fusarium yellows and late blight, and fusarium yellows and celery mosaic virus (CeMV). Resistant plants to fusarium were selected in the field and their progeny was tested for resistance to late blight and CeMV in the greenhouse. They are using now marker assisted selection to obtain virus resistant plants in segregating populations. Seed increase of selected accessions of the *Apium* germplasm collection at UC Davis was carried out under isolation. For *Brassica oleracea* they selfed 250 F2 plants to perpetuate an F2 mapping population between doubled haploid broccoli and doubled haploid cauliflower. For *B. rapa* they screened different varieties of all major crops for glucosinolate content to associate these compounds to specific genotypes for three major glucosinolate genes. They advanced to BC1 and BC2 (to Chinese cabbage) the progenies from a synthetic *B. napus* hybrid obtained by crossing a doubled haploid broccoli x a doubled haploid Chinese cabbage. They are in the process of generating BC1 (to broccoli) seed with the purpose of resynthesizing alien addition lines for the C and A genomes.

Impact: The maintenance and development of a working germplasm *Apium* collection will assure the availability of sources for desirable traits to breeders. Maintenance and development of *Brassica* mapping lines segregating for traits such as glucosinolate and other genomic stocks will assure the availability of an important tool to *Brassica* researchers.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-B, CA-D, CO, HI, ID, MT, NM, OR, UT, WA, WY

Theme: 1.26 Plant Germplasm

Title: Genetics and Varietal Improvement of Strawberries

Description: Their project continued to develop and disseminate cultural practices recommendations for the day-neutral strawberry cultivar 'Albion', released in 2004. Grower experience in the first commercial year has determined this cultivar to be superior in all respects to the 'Diamante' cultivar, which until this year has been planted on 28% of California's acreage and produced approximately 35-40% of the state's fruit annually. They completed analysis of the polygenic inheritance of long-day flowering (day-neutrality) in strawberry

using Complex Segregation Analysis, which indicated the presence of a major locus that determines 75% of the variation for this characteristic. This finding creates the possibility of developing advanced strawberry breeding populations that are true-breeding for day-neutrality, but variable for the strength of this trait. Infection experiments with for strawberry with *V. dahliae* indicated that the resistance developed to date by the UC breeding program is stable to inoculum propagule type (conidia and micro-sclerotia). Likewise, variation was detected in the virulence of different *V. dahliae* isolates, but the resistance developed to date was stable over all isolates tested. A three-year study of the consequences of commercial nursery infection in susceptible and resistant strawberry genotypes was completed, and demonstrated that the most important resistance mechanism in this population acts by restricting the transfer of infection through vegetative propagules rather than exclusion of the pathogen by the root system. The research also completed a multi-year study on the inheritance of seedling characteristics for dried plums and their response to inbreeding.

Impact: 'Albion' fruit was harvested commercially from about 300 acres in 2005, fall plantings that will produce fruit for 2006 are estimated at 2,800 acres, or 40% of the target market; this acreage was limited by plant availability. Nursery estimates for the following year predict that the demand for this cultivar will be approximately 6,000 acres. The added value to California growers of this cultivar replacement is difficult to predict, but the rate of adoption they are experiencing is more rapid than any in the history of the UC breeding program. Demonstration of a major locus affecting the polygenic inheritance of day-neutrality opens the possibility of developing true-breeding populations for this trait could offer a substantial gains in efficiency for future strawberry cultivar development activities. Research results from studies of *V. dahliae* isolates will simplify genetic testing for this trait and create opportunities for understanding polygenic resistance mechanisms. The genetic information generated for dried plums is presently utilized by the UC breeding program.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm

Title: Plant Genetic Resource Conservation and Utilization

Description: The California Annual Report to the W-6 Technical Committee was presented at the 2005 Annual Meeting at Bozeman MT. Committee members reported on germplasm use and issues related to state and USDA germplasm maintenance and distribution. A project to characterize 61 persimmon cultivars was completed. Statistical analysis showed that Italian and Spanish cultivars comprise a single gene pool while Japanese, Korean, and Chinese persimmon

gene pools are related but distinct. A number of cultivars, formerly considered to be synonymous were found to be genetically distinct. Several Japanese cultivars are associated with the European gene pool and may have been used as parents.

Impact: The W-6 project supports the National Plant Germplasm System and provides a system for reporting the use and value of germplasm distributed by NPGS to California users. This information is used to justify NPGS funding. Molecular markers are used to characterize plant germplasm and help to understand diversity in germplasm collections. This information permits curators and breeders to make informed decisions when selecting materials for inclusion in preservation or breeding programs. The use of molecular markers for persimmon characterization has provided a better understanding of cultivar relationships and corrected some nomenclature problems.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-B, CA-D, CO, HI, ID, MT, NM, OR, UT, WA, WY

Theme: 1.26 Plant Germplasm

Title: Use of Wild *Lycopersicon* Species in Breeding for Improvement of Cultivated Tomato

Description: The identification and transfer of genes from wild to cultivated tomato (*LYCOPERSICON ESCULENTUM*) for improved chilling tolerance (CT), resistance to late blight (RLB) and aphids is the current focus of their tomato breeding and genetics research. The pathogen *PHYTOPHTHORA INFESTANS* (late blight) and chilling temperatures can cause significant yield and fruit quality losses, while aphids reduce yields. Previously, quantitative trait loci (QTL) for RLB and CT were mapped in interspecific populations and QTLs identified for introgression. DNA markers linked to the QTL regions were used to select interspecific progeny lines containing the desired wild species alleles at these QTLs (i.e., marker-assisted selection, MAS). RLB QTLs on chromosomes 3, 4, 5 and 11 were transferred into cultivated tomato using backcrossing and MAS. Selected QTLs were fine-mapped using recombinant sub-near-isogenic lines (sub-NILs) obtained via MAS for RLB QTL on chromosomes 3, 4, 5 and 11 (designated as QTLs lb3, lb4, lb5b, lb11b). Sub-NILs were tested in replicated field trials, and disease data was used to fine map each of these resistance QTLs to smaller chromosomal segments. QTLs lb4, lb5b and lb11b mapped to smaller intervals of 6.9, 8.8 and 15.1 cM, respectively, resulting in more suitable targets for MAS breeding efforts. The presence of severe fertility problems in the lb3 sub-NILs prevented fine-mapping of resistance loci, but a fertility locus was identified. Two CT QTLs from *L. HIRSUTUM* on chromosomes 5 and 9 associated with turgor maintenance under root chilling temperatures were

individually introgressed into *L. ESCULENTUM* using MAS and NILs were developed. The NILs were tested in replicated experiments and CT was measured as shoot turgor maintenance under root chilling temperatures. CT was most strongly and consistently associated with the QTL on chromosome 9 (designated as *stm9*). Sub-NILs were obtained for fine mapping, and *stm9* was localized to a 2.7 cM interval. This defined 2.7 cM *stm9* region can serve as a target for future MAS breeding for CT and high-resolution mapping. Physiological experiments with plants consisting of reciprocal grafts of roots and shoots of parental lines and marker-selected backcross plants with *stm9* strongly suggest that a root-shoot signal is involved in shoot turgor maintenance under root chilling temperatures. Sub-NILs for *stm9* are being used for further physiological studies to characterize the basis of CT. Aphid resistance was assessed in two interspecific inbred backcross line (IBL) populations derived from crossing aphid-resistant *L. HIRSUTUM* and *L. PENNELLII* with susceptible *L. ESCULENTUM*. The most consistently resistant IBLs over two years of field trials were from the *HIRSUTUM*-derived population. These six highly aphid-resistant IBLs are a source of genetic resistance for further breeding efforts.

Impact: Genes in wild tomato species that control agriculturally important traits can be used in breeding to improve cultivated tomato for agricultural productivity and sustainability. Transfer of wild species genes for resistance to pathogens, pests and chilling tolerance to cultivated tomato germplasm can be accomplished using molecular marker-assisted selection as a non-transgenic tool for effective gene transfer. Improved cultivated germplasm containing valuable wild species genes serves as a foundation for development of cultivars requiring fewer agricultural production inputs. Reduction of agricultural inputs such as pesticides and fungicides lessen environmental impacts and production costs for growers, enhancing agricultural production and sustainability.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm

Title: Conservation and Utilization of Germplasm at the C.M. Rick Tomato Genetics Resource Center

Description: The activities of the C.M. Rick Tomato Genetics Resource Center (TGRC) are summarized in several categories, as follows. ACQUISITIONS: 23 new accessions of the wild species *L. CHILENSE*, *L. PERUVIANUM*, *S. LYCOPERSICOIDES*, and *S. SITIENS* were collected from Northern Chile. The current total of number of active accessions is 3,633. MAINTENANCE: A total of 1,532 cultures were grown for various purposes, of which 828 were for seed increase, 207 for progeny or allele tests of monogenic mutants, including

recessive lethals, male-steriles, etc, and 173 for seed germination tests. For the wild species, 333 cultures were grown for seed increase, of which many were grown in the greenhouse, including large numbers of *L. CHILENSE*, *L. PENNELLII*, and *L. PERUVIANUM* accessions. As allowed by harvests, large seed lots were submitted to the NCGRP for backup storage. Samples of wild populations collected in Chile in 2001 were sent to that country as part of the original agreement. **DISTRIBUTION:** Over 4,400 seed samples, representing at approx. 1,500 unique accessions, were sent in response to over 325 requests from nearly 250 colleagues in 40 countries; an additional 30 requests were for information only. Information provided by recipients indicates TGRC stocks were used for research on a wide variety of topics. **DOCUMENTATION:** A large number of mutant stocks were photographed and digital images were uploaded to the TGRC database and website. New accessions were defined with appropriate genetic descriptors and/or collection site information. Their annual stock list, this year covering monogenic stocks, was published in the Tomato Genetics Coop. Report. **RESEARCH:** TGRC-related research projects focused on genetic strategies for ameliorating the low rate of recombination in *L. ESCULENTUM* X *S. LYCOPERSICOIDES* crosses, and transferring the chromosomes of *S. SITIENS* into cultivated tomato. In addition, genetic diversity within populations of *S. LYCOPERSICOIDES* and *S. SITIENS* was evaluated. QTLs for increased fruit antioxidant accumulation in *L. PENNELLII* were fine-mapped and their epistatic interactions were studied.

Impact: The impact of TGRC activities is demonstrated by the large number of published journal articles which mention use of their stocks. Uses include the study of resistances to diseases, insect pests, and abiotic stresses, and their transfer into tomato. TGRC stocks also facilitate much fundamental research on the biology of tomato.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Reproductive Biology of Tree Fruit and Nut Species

Description: Walnut pollination management requires a balance between sufficient pollen to set a crop but pollen loads below a threshold that triggers pollen-induced pistillate flower abortion (PFA). They have been working toward developing management tools to control PFA by inhibiting the post-pollination ethylene response by inhibitor of ethylene synthesis (AVG) and inhibitor of ethylene action (1-MCP). Results have shown promise and they expect registration of the first product for this purpose. Walnut pollination is complicated by the heterodichogamous mating system and the fact that pollen is the vector

for transmission of walnut blackline disease. They are creating research-based data on pollen flow, pollen sources, the need for pollinizer cultivars and the contribution of pollen from within and beyond orchard limits by using SSR markers for paternity analysis to follow the movement of pollen in orchard situations. Results indicate that few pollinizers are required in walnut orchards despite the dichogamous bloom habit that would appear to limit self pollination. Results show high levels of pollen from outside the orchard system play an important role in California walnut growing areas. SSR (microsatellite) markers are being shown to have great value in the analysis of gene flow in walnut orchards and they should have similar potential for use with other orchard crop species. They are developing a data base of SSR genotypes for olive cultivars. They are using this database to identify olive cultivars in table- and oil- olive production. There is an additional benefit for ornamental olive cultivars because some regional jurisdictions restrict ornamental planting of olive trees to low-pollen producing cultivars. As olives are among the most desirable ornamental trees in these locations there is a need for unequivocal identification methods for these cultivars. They have included the two commonly produced, low-pollen producing varieties in their data base.

Impact: Their data show that PFA in walnuts can be controlled by growth regulators that inhibit ethylene synthesis. Their results indicate that losses to PFA can be reduced drastically resulting in yield increases of 50 percent or more in the most affected cultivar by AVG. Preliminary results with 1-MCP indicate that this may also be a useful management tool to control PFA. Their data on pollen flow in walnut orchards will be used to generate orchard-management strategies to design orchards to optimize set, and to effectively manage blackline disease and pistillate flower abortion. Molecular genotypes of olive cultivars will be used to identify cultivars and relationships among cultivars which will be especially useful in the emerging California olive-oil industry. They are developing molecular markers for two specialized ornamental cultivars so that these can be validated for certification in jurisdictions that restrict ornamental landscaping to low-pollen- producing olives.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Crop Physiology of California Tree Crops

Description: UC researchers continued collaboration with a modeling group in Canada to develop a functional-structural simulation model to simultaneously simulate dry matter partitioning and structural development of fruit trees. This work has resulted in a completely new approach for simultaneously modeling

tree architectural growth, source-sink interactions and carbon partitioning in trees. The original version of this model was largely a "proof of concept", using abstract units to test the feasibility of the approach for modeling source-sink interactions and carbon partitioning in trees. Having "proved the concept" they are now improving the model and using experimentally derived data to quantitatively test its validity for simulating actual tree growth and architectural development. The evaluation and characterization of size controlling rootstocks for peach and nectarine has also continued. The role of plant water relations in determining the size controlling behavior of experimental rootstocks has been confirmed with controlled laboratory experiments. Additional physiological characteristics that may be involved in the size-controlling behavior have also been investigated but so far all results point to root hydraulic conductance as being the operative mechanism. Studies of the behavior and control of vegetative shoot growth and its interaction with reproductive growth have continued in pistachio and almond. Data from both projects are currently being prepared for publication.

Impact: The modeling project has provided a working model for studying and describing source-sink interactions at the whole plant level and identified key factors controlling fruit tree growth, fruit yield and fruit quality. The concepts imbedded in the PEACH model have been used to evaluate the impact of weather within thirty days after bloom on fruit maturity date and crop yield in peaches. The rootstock research has generated significant grower interest and two rootstocks have been released for commercial use to the California industry. Information on the mechanism of dwarfing has been made available to assist growers in understanding the physiological limitations of these rootstocks.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Horticulture, Biology, and Environmental Physiology of California Strawberries

Description: Approximately 13,000 strawberry seedlings resulting from 86 controlled crosses were evaluated at the University of California South Coast Research and Extension Center for agronomic traits and fruit quality during a 26-week fruiting season. Based on performance evaluations, about 450 seedlings were retained for propagation and subsequent evaluations in 2006. In addition, 140 advanced selections from crosses made between 1999 and 2003 were similarly evaluated. A subset of these items was screened for tolerance to *Colletotrichum acutatum*, and performances of a subset of these items were also evaluated in a protected culture system. In southern California, varieties that fruit

quickly after planting enable greater production efficiency and higher economic returns, as early season fruit obtains the highest market prices. A recently concluded genetic study enabled us to develop improved strategies for selecting seedling plants that have early season fruit production. Another genetic trial involved assessing performance of day-neutral selections planted in June and July for off-season production in autumn and early winter. The goal of these activities is the development of improved cultivars that have broad environmental and disease tolerances, extended fruit production seasons, high yields, excellent fruit quality, and improved production efficiencies. Additional research evaluated various modifications to standard California strawberry production practices with the goal of enhancing production efficiency and improving economic viability. One aspect of this production system research demonstrated that late-season nitrogen applications in strawberry propagation nurseries enhance transplant growth, early-season fruit yield, and fruit size. Another aspect of this systems research focused on continued evaluations of the use of polyethylene tunnels to accelerate plant growth and fruit maturity while protecting the crop from inclement weather and reducing fungicide use. A variation of this research examined the potential for producing strawberries in containers using soilless potting media without soil fumigation. Increased restrictions on use of preplant soil fumigants has prompted their program to evaluate the usefulness of herbicides in modern production systems here their main concern has been developing protocols (rates, timing of application) for using herbicides that control weeds without stunting strawberry plant growth.

Impact: Currently, California produces 90 percent of the US strawberry crop on about 60 percent of US strawberry acreage, and U.C. varieties account for more than 70 percent and 80 percent of California's acreage and fruit production, respectively. The University of California strawberry breeding program has enabled the California industry to compete successfully in an increasingly sophisticated global market by continually creating varieties with increased yields, and greater fruit quality and production efficiency. These factors contribute directly to the United States having the highest per capita consumption of strawberries in the world, and to a situation in which California production and US consumption of strawberries continue to grow annually. The recent cultivar release Albion is a prime example of such a variety it has outstanding flavor, excellent production efficiency, good environmental and disease tolerance, and in a very short period of time has become one of the major cultivars grown in California. Equally important to progress in breeding are advances in production system research. For example, application of nitrogen fertilizer in the latter part of the runner plant nursery propagation cycle represents an insignificant cost to the nursery grower, but result in increased early season fruit production at a time when market prices are highest, thereby positively affecting economic returns to fruit growers.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Rootstock and Interstem Effects on Pome and Stone Fruit Trees

Description: Apple: A Fuji rootstock trial was initiated at the UC Kearney Ag Center in 1999 with six single tree reps of 21 rootstocks. Valuable information regarding fireblight has been obtained. A total of 14 trees have died so far, presumably from fireblight. Thirteen of those were on the standard rootstocks M9 and M26. Of the experimental trees, only one on Supporter 1 has died. All of the Cornell-Geneva series (which were bred for fireblight resistance) have survived so far. A second NC-140 apple planting was initiated in 2003. The scion is Golden Delicious and there are 23 experimental rootstocks. Once again, fireblight has killed about 20 M9 and M26 trees but none of the experimental rootstocks. Peach: A NC-140 peach rootstock trial was planted in 2001. Fifteen rootstocks were planted in California and about 18 other states for evaluation. Of the semi dwarfing stocks, Bailey and Hiawatha looked the most promising. Both had good production and fruit size in 2005. Pumiselect had small fruit size and was not very productive. Of the dwarfing rootstocks VVA-1 looked the most promising. An ongoing evaluation program for peach rootstocks is now entering its final stages of evaluation. Initially, over 80 items were evaluated for compatibility, productivity, dwarfism and root sucker production. Ten rootstocks showed promise and were put into a replicated trial at two different spacings with two different scion varieties. Two selections have continued to meet the criteria for commercial peach rootstocks and have been patented. Both are semi-dwarfing rootstocks with no root suckering, compatibility with a range of scion varieties and good productivity. An ongoing breeding program for stone fruit rootstocks will continue with the objective of combining tree size control with resistance to important diseases and pests including nematodes.

Impact: The fruit growers in California have rated dwarfing rootstocks as one of their highest priorities. There is the potential for greatly reducing labor costs and disease resistance rootstocks can also reduce labor and pest management costs as well as improve productivity. Therefore, they are very interested in the potential this project offers for the future survival of their industry. For the apple industry, there are some very promising dwarfing rootstocks with good fireblight resistance. This will improve tree survival in the orchard and could eliminate such cultural practices as cutting out fireblight strikes. For the peach industry, currently there are no commercial dwarfing rootstocks. This project provides information on some very promising dwarf and semi-dwarf rootstocks that could greatly reduce labor costs in the orchard by eliminating much ladder work.

Funding Source: Multistate Research and State

Scope of Impact: AR, Arkansas Cooperative Extension, CA-D, California Cooperative Extension, CO, GA, IL, IN, IA, KY, ME, MD, MA, MI, MN, MO, NJ, NYG, NC, OH, OR, PA, SC, TN, UT, VT, WA, WI

Theme: 1.28 Plant Production Efficiency

Title: Genetic Improvement of Peach and Almond

Description: Endopolygalacturonase genotype has been shown to be strongly associated with final fruit texture in fresh market and processing peach. Three major functional alleles, F, f, and f1, have now been characterized in peach with a DNA marker assay that allows the prediction of melting/nonmelting and freestone/clingstone phenotype in breeding populations. A number of related and often unique alleles have also been identified in closely related peach and almond species as well as the more distantly related fruit species apricot, plum, and cherry. Interspecific hybridization and subsequent gene introgression have resulted in peach breeding lines showing a range of endopolygalacturonase genotypes and fruit phenotypes. Novel fruit phenotypes, including freestone-nonmelting fruit, and fruit in which the typical softening associated with overripe fruit mesocarp is suppressed, have also been characterized. The endopolygalacturonase DNA marker test has proven an effective predictor of fruit phenotype in a majority of breeding lines and has become an important tool for improving breeding efficiency. In breeding efforts to develop novel peach fruit types, knowledge of endopolygalacturonase genotype has been crucial for the dissection and characterization of other components of the endocarp-mesocarp interface and mesocarp texture. Vascular bundle ontogeny and ramification within the developing endocarp-mesocarp tissue appear to be an important determinant of endopolygalacturonase-associated phenotypes though control on the molecular and anatomical levels remain poorly understood.

Impact: Improved genotypes conferring high market quality to fruit and nuts yet able to withstand the rigors of harvest and post-harvest handling are essential for continued viability of these industries. New varieties with improved harvest and post-harvest quality result in greater production efficiency, reduced agro-chemical contamination of California ecosystems, and provide a safer, more nutritious product to the consumer.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Genetic Improvement of Walnut

Description: The goal of the Walnut Improvement Program is to breed or engineer new walnut cultivars and rootstocks that serve a need in the walnut industry and to develop germplasm, knowledge and tools for future breeding efforts. Traits targeted for improvement include pest and disease resistance, increased precocity and earlier harvest dates. Materials now under investigation include over 18 thousand full and half sib seedlings. Over 50 selections have been made from among the mature progeny. Three have been submitted for patenting. These are Sexton, Gillet and Forde characterized by an earlier harvest date than Chandler and large, light kernels. Sexton is protandrous and Forde and Gillet are protogynous. Seven field trials of selected rootstock clones were established. Two clones appear promising when challenged with *Phytophthora cinnamomi* in the field. Over 1200 of their micropropagated rootstocks were grown in the nursery row and over 2000 are ready for nursery planting or pest and disease testing now.

Impact: As a result of this program walnut growers are extensively planting the new cultivar "Tulare", a vigorous and precocious cultivar with high yields and quality. Tulare has also been identified as a unique source of resistance to aflatoxin. There is also significant demand for the three recently released cultivars: Sexton, Gillet and Forde. They have also been working with a California nursery to commercialize micropropagation techniques for clonal rootstock release.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Development and Application of Crop Models for Cut Flower Roses

Description: The greenhouse cut flower rose production industry is under significant pressure to improve production efficiency and to reduce pollution due to run-off. Growers are facing significant challenges as they try to comply with regulations that require elimination of run-off while facing challenges due to competition from abroad. Their objective is to develop, test, and implement tools and production methods to help rose growers manage the greenhouse environment more efficiently, while optimizing irrigation and fertilization to maximize crop productivity. Towards this purpose they have been developing computer simulation models specific to cut flower rose production and using these as basis for software tools that growers can use in production management. The model system in this case is cut flower rose production and the core model for this is a mathematical model of rose crop development. They are currently developing nutrient uptake models and implementing in their models the effect of root zone oxygen concentration. They have begun

dissemination of a rose crop scheduling tool that growers can use for managing the greenhouse environment of rose crops. The scientific basis for this software is the rose shoot model. Their recent research showed that this tool is compatible with the wide-spread practice of shoot-bending.

Impact: Cut flower rose growers are under significant pressure to find ways to be more productive and efficient. Development of improved horticultural techniques will allow growers to be more competitive, while at the same time improving their sustainability and to make their greenhouse operations more environmentally friendly. The information being developed in this project will be particularly useful in allowing growers to reduce fertilizer waste while minimizing pollution from runoff. A software tool for cut-flower rose growers is currently being disseminated to help them make decisions for timing rose crops for holiday markets.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Rootstocks, Cultivars, Training and Culture of Multi Density Deciduous Fruit Orchards

Description: Pistachios - The California Pistachio Rootstock Trial plots are now being used to develop additional information about the effect of rootstocks upon scion growth and productivity. Thus far the results are demonstrating that trees on rootstocks with *Pistacia integerrima* parentage, the Integerrima (AKA Pioneer Gold I or PGI) and the hybrid of *P. atlantica* X *P. integerrima* (AKA University of California Berkeley I or UCB-1) have multiple growth flushes within a season. The buds on these successive flushes are different in origin; buds of the first flush are formed the previous year, preformed, versus buds on later flushes which are formed in the current year, neoformed. These buds appear to be equally productive but the latter are more likely to be less well developed and abscise prematurely. It does not appear rootstock greatly influences end of season carbohydrate status suggesting carbohydrate depletion is not the mechanism of alternate bearing. Thus far it appears decreasing the neoformed growth would decrease management costs by decreasing pruning costs. This suggests mechanical pruning is the best option for trees on all rootstocks.

Impact: Pistachios-the information developed about UCB-1 has resulted it in being the second best selling rootstock in California. Foundation Plant Services produced and sold 545,000 seed in November, 2005. Additionally, Duarte Nurseries selected a specific rootstock based on the data produced and is now vegetative propagating this individual rootstock; approximately 300 acres have been planted thus far.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Wheat Breeding and Molecular Genetics

Description: Production of breeder and foundation seed of new wheat varieties: Hard Red Spring new variety Miwok (UC1494): planted at Davis in November 04. Fifty pounds of breeder seed was harvested in June 2005 and used to produce 2100 pounds of foundation seed during the summer at Salinas, CA. The Hard White Spring new variety Elkhorn (UC1419): 800 head rows were planted at Tulelake and produced 400 pounds of breeder seed, which was delivered to the FSP to produce foundation seed in 2006. An improved version of Anza including the high grain protein gene Gpc-B1, the strong gluten alleles 1 and 5+10, and the rust resistance genes Yr36, and Yr17/Lr37/Sr38 was planted at Tulelake. Segregation for height was observed in this environment, and both the short phenotype (UC1495) and the tall phenotype (UC1514) were repurified. Individual heads were harvested and planted as headrows in Davis in November 05 to produce breeder seed. Regional trials: Lines UC1418 (HRS) and UC1296 (HWS) were dropped because they became susceptible to stripe rust. The line UC1452 (durum wheat) will be re-tested in the 05-06 regional trial. The new HRS lines UC1493, UC1494, UC1495, and UC1514 and the durum lines UC1503, and UC1504 were included in the 05-06 regional trial. Yield trials: 70 lines of common wheat and 60 lines of durum wheat were evaluated in elite, advanced, and preliminary yield trials. Based on the agronomic characteristics, disease reaction, grain yield, and grain appearance, 23 lines of common wheat, and 16 lines of durum wheat were selected and sent to the CWC Quality Laboratory for a complete quality test. One line of common wheat will be retested in the elite trial together with 14 new lines included for the 05-06 cycle. Five lines will be tested in the 05-06 advanced yield trial. Six lines of durum wheat will be retested in the 05-06 elite together with 12 new lines. Seventeen lines will be tested in the 05-06 advanced yield trial. Observation plots: 385 lines of common wheat and 118 lines of durum wheat were evaluated in the field. Based on agronomic characteristics and disease resistance, 226 lines of common wheat and 118 lines of durum wheat were harvested and tested for grain protein content at the Department of Food and Agriculture in West Sacramento. Finally, 172 lines of common wheat and 64 lines of durum wheat were advanced to the 05-06 preliminary yield trials. Addition of new hybrids and segregating populations: A total of 153 new crosses (92 common and 61 durum wheat) were made during the winter and spring of 2004, the F1 seeds were grown at Tulelake during the summer and the F2 seeds were planted in the field in November, 2005. Other segregating populations advanced during the 2004-2005 cycle included 193 F2 families, 197 F3 families,

166 F4 families (5410 lines), 157 F5 families (2891 lines), and 190 F6 families (1190 lines). Thirty families (207 lines) of common wheat and 69 families (279 lines) of durum wheat were harvested in bulk and advanced to the observation plots or preliminary yield trials.

Impact: The release of new varieties with better yield and improved resistance to diseases and quality is an efficient way to transfer the value of research to the California wheat growers. In addition, the incorporation of new leaf rust, stripe rust, and septoria resistance genes will reduce the requirements of pesticides resulting in a direct benefit to the environment. The new hard red spring variety Miwok released by the UC Davis wheat breeding program combines simultaneously several resistance genes, a strategy called gene pyramiding. The rationale for this strategy is to increase the durability of the disease resistance of the released varieties. The new durum variety released by the UCD breeding program, named Desert King, represents a significant yield increase over the leading variety currently grown in the Imperial Valley. The University program has established collaborations with private breeding programs to help them accelerate the introduction of resistance genes in their own varieties. These collaborations have extended the impact of the University breeding program on the improvement of wheat varieties for California.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Integrated Canopy Management in California Nut Crops

Description: Objective 1- Original objective has been completed. Final results were presented in 2003 and final reports are listed below. New work is being conducted on influence of pruning or non-pruned treatments on growth and productivity of young Howard walnut trees. Objective 2- This project was initiated to investigate the dynamics of spur renewal, fruitfulness and longevity and to determine how these are influenced by nitrogen and irrigation. Monitoring will be carried out for 6 years to quantify the impacts of treatments on spur longevity. In 2005, all three deficit treatments had significantly lower midday canopy light interception than the control throughout the season. Once again, midday stem water potentials were maintained near target levels throughout the 2005 season. All three deficit treatments led to significantly lower yields in the fourth year of treatment imposition. However, if yields per unit light intercepted was calculated, all three deficit treatments had significantly higher yields than the control in 2004 and equivalent yields to the control in 2005. This suggests that if deficit irrigated trees had been planted closer together, they might have had higher overall yields compared to the control. Incidence of kernel mold has continued to be less in

deficit irrigated trees. Significant changes in leaf specific area (a measure of spur quality), particularly in inner canopy positions in the deficit treatments, may lead to improved spur longevity and shifts in canopy nut production patterns in the coming season. Objective 3- The emphasis for this work has shifted somewhat and preliminary work is now being done in studying role of water stress in seasonal variations in plant protective compounds in walnut as well as interactions with mold. In addition, work is being done on influence of deficit nitrogen and water treatments on shell seal and resulting potential for insect damage and microbial contamination potential.

Impact: Deficit water management combined with selective pruning has been shown to have applicability in managing dense plantings, if trees have filled in allotted space when deficits are imposed. In addition to providing canopy management benefits, deficit irrigation management may make the orchards less susceptible to insect and/or fungal pests. By minimizing irrigation events, pruning tower use and spraying operations, reliance on fossil fuels can be decreased while minimizing pesticide usage. Employing these techniques would provide direct benefits to growers by decreasing costs of production and reducing potential for worker and environmental pesticide exposure while producing products with the lower pesticide residues consumers' desire. Preliminary data suggests that deficit water and nitrogen treatments in almond may allow an equivalent or more productivity as the orchard matures. This information has been extended at numerous industry conferences as well as UC CE farm advisor's county meetings.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.29 Precision Agriculture

Title: Precision Technologies for Specialty Crop Production

Description: Real-time nitrate sensors are useful for monitoring ground and drainage water for nitrate contamination, and measuring and mapping soil nitrate content for site- specific nitrate fertilizer application. A mid-infrared (MIR) based soil nitrate sensor was developed that was able to determine nitrate content concentration in soil pastes derived from several different field soils obtained from US and Israel. The technique utilizes the MIR response corresponding to four different wavelengths. A low-cost spectrophotometer was evaluated to determine if it could be used to detect soil nitrate content. The results show good promise for the method. This technique is currently being extended to determine soil phosphorus, potassium, and organic matter. Weigh buckets are simple and inexpensive alternatives for weigh wagons used for measuring crop yield during fields trials. An impact-type electronic weigh bucket was further modified and

tested during the 2005 tomato harvesting season. A folding mechanism was added which removes the weigh bucket away from the boom conveyor so that continuous harvesting can be done without actually removing the weigh bucket. The device was successfully retrofitted on to both Johnson and FMC harvesters. A High Precision Differential Global Positioning System (HP-DGPS) based tree-specific fumigant applicator to treat re-plant disease in almonds is being developed. This type of fumigant applicator is expected to reduce the chemical cost substantially and minimize the environmental effects due to fumigants.

Impact: Precision agriculture is resulting in economic and environmental benefits since it involves applying inputs such as chemicals and water on a site-specific basis to enhance crop yield, reduce inputs, and/or reduce environmental damage.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.32 Small Farm Viability

Title: Mini Watermelon Research Benefits Small Farmers

Description: Four types of watermelons are available in supermarkets. Older diploid (seeded) watermelons, grown since 1629, weigh 18-35 pounds. Large seedless triploid watermelons weigh 15-22 pounds and have been popular since 1988. Icebox-size melons, 6-12 pounds, have been available since 2000. The newest melons are seedless mini or "personal" watermelons, sometimes called "palm" melons. The new triploid one-serving melons, weighing 3-7 pounds, became widely available in markets in 2003. Besides the smaller size, advertisers tout its thinner rind, which means more edible flesh. California growers started growing the personal-size melons, but research was lacking for recommended varieties, quality characteristics, pollinators and spacing requirements. UC CE farm advisors began evaluating varieties in 2003 and 2004 at the West Side and Kearney Research and Extension Centers in Fresno County. In 2005 their research expanded to include evaluating plant spacing, fertility requirements, and a location in Hollister with the cooperation of another UC CE farm advisor. They looked at 10 varieties, five plant spacings from 12 inches to 48 inches, and five fertilizer rates ranging from 0 to 300 pounds of nitrogen. They evaluated varieties for yield, Brix (sugar), rind thickness, rind color, individual melon size (weight and diameter), and flesh color. Certain varieties were consistently sweeter than other varieties at all locations. Flesh color, also an important factor, ranged from dark red to orange-red. The two most significant and variable factors were the rind thickness and overall melon size. Since the melons are small, a fairly thin rind is desirable to maximize the amount of edible flesh, however this must be balanced with the handling and shipping

distance since the thinner rinds leave the melons more susceptible to bruising. The variety Petite Perfection consistently had one of the thinnest rinds (0.6 centimeter), whereas Valdoria and Betsy had thicker rinds (1.5 centimeter). Research is ongoing to evaluate newer varieties and to identify more specifically the optimum plant spacing, fertility requirements, and pollinators for the 'best management practices' of this crop.

Impact: Personal-size watermelons are an expanding market, with California being one of the major producers. UC's work has been instrumental in helping growers make preliminary decisions on which varieties will perform well in different climate zones of California, what kinds of yields can be expected, and what quality characteristics are important to the broker, shipper, retailer and consumer.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 1.32 Small Farm Viability

Title: Farm Incubator Project Humboldt in County

Description: Beginning farmers often struggle to gain access to small parcels of land to test their farming ideas. The UC Farm Incubator Project was based on the concept of incubating new businesses by offering short-term leases, support services and fellow entrepreneurs to work with. Farmland will be preserved in rural communities if it is actively producing food, and if beginning farmers have successful experiences and can grow their farm business. For five years the Humboldt County CE Office held a lease on eight acres of prime farmland owned by the US Forest Service, part of a forest tree nursery. On the farm, eight subleases were created for new growers to test their ideas for crops. Since it is very difficult to find small parcels to rent, these one-acre sites met an important need. With low rent and a cooperative water supply, the UC Farm Incubator Project provided affordable-cost support for these entrepreneurial efforts. Workshops on farm business planning were offered to the participants, and the UC CE farm advisor was available for consultation on a myriad of agricultural topics. Crops varied from garlic to quinoa and included iris, hydrangea, vegetables, nursery crops and forest species for sale to tourists.

Impact: As a result of this project, the participants' experiences helped them gain credit and become landowners. Three businesses went on to buy their own farmland. Others benefited by testing their ideas and deciding that farming was not for them, either for personal reasons or as a result of business analysis during the project. The project ended when the Forest Service ended the lease,

as they had new uses for their land. The Farm Incubator project demonstrates a program that helps beginning farmers to get started.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

NATIONAL GOAL 2

A safe and secure food and fiber system. To ensure an adequate food and fiber supply and food safety through improved science based detection, surveillance, prevention, and education.

UC-ANR's Human Resources Programs Covering:

- Human Health and Nutrition - Food Borne Diseases

According to estimates from the Centers for Disease Control, approximately 76 million Americans last year suffered from some type of food-borne illness with an estimated 300,000 serious illnesses and 5,000 deaths attributed to food borne illness each year. This compelling statistic alone suggests the need for vigorous action to reinforce the food and fiber system to ensure its safety and security. Structural changes in the food system in the past several decades have led to a vulnerability that has been indicated, on several occasions, by propagation of human disease on a wide scale. These changes are primarily the consolidation of the food industry, in particular the fast food industry, so that large volumes of food are prepared at one location and partitioned to multiple distribution points. In addition, disease organisms that are highly toxic and require relatively few spores to cause an infection (like *E. coli* O157:H7) have become more common. The combination of these organisms with the new food handling system is one cause of the unacceptably high incidence of food-borne disease in the country. Division academics are conducting research programs aimed at reducing the risk of food-borne illness entering the food chain, and extension programs directed at education of food handlers at every step of the chain, from production to consumption, in safe food handling techniques.

These projects and research indicate that technological change embodied in high-tech, human, and research capital has had substantive effects on cost savings in food processing industries; that our knowledge of both the ecology and epidemiology of Lyme disease spirochete is expanding leading to strategies for preventing and controlling Lyme Disease; that a platform for the logical development of strategies to prevent food borne infections can be developed by conducting research on food borne pathogens; that knowledge of the mechanism of osmotic tolerance and of growth in the refrigerator should lead to the design of better cleaning regimens and handling methods to reduce the possibility of contamination of food by equipment or from the processing environment; that case studies can be used to provide insights into the challenges and opportunities small to medium scale growers and processors face in the California Central Valley; that methodology can be developed that will assist industry in lowering the food allergies in common staple foods and that by developing optimal procedures for preparation, packaging, and handling

conditions allows the fresh-cut produce industry to provide several new products including slices of kiwifruits and pear.

Twenty nine local extension programs were delivered in this area. In addition, one statewide collaborative workgroup composed of both AES and CE academics planned and conducted research and extension projects. California academics published 45 peer-reviewed articles to address Goal 2 last year. Four patents were issued to UC researchers for this goal.

Research and Extension Performance Goals

- Develop effective research and educational programs directed toward food producers, processors, retailers, restaurants, regulators and consumers to reduce the incidence of food borne disease.
- Develop effective research and educational programs directed toward food producers, processors, regulators and consumers to minimize the risks associated with chemical contaminants in food.
- Develop effective training programs addressing food safety and sanitation issues using bi-lingual educational materials.

FY 2004-2005 Allocated Resources

Extension Federal Funds (Smith Lever 3 b&c)	Extension State Match	Research Federal Funds (Hatch)	Research State Match
\$23,488	\$23,488 (2.76 FTE)	\$153,902	\$153,902 (12.10 FTE)

Theme: 2.01 Food Accessability and Affordability

Title: Sustaining Local Food Systems in a Globalizing Environment: Forces, Responses, Impacts

Description: In 2004/2005, researchers conducted a study of the regional agricultural marketing programs throughout California. The study was initiated to provide background information for the Yolo County Agricultural Commissioner and an advisory committee, formed to explore the development of a Yolo County organic label. The UC Sustainable Agriculture Research and Education Program (SAREP) agreed to gather and analyze data about the regional agricultural marketing programs emerging throughout the state (including those that focus on organic marketing), to determine the feasibility of creating a local and/or organic label and marketing effort in Yolo County. In the winter of 2005 more than 25 individuals associated with regional agricultural marketing programs, statewide commodity boards, and the statewide Buy California Initiative were interviewed. Information from twelve existing programs and three which no longer exist were

summarized. The study describes the efforts of a dozen regional agricultural marketing programs that have formed to date, the challenges they have faced, the costs they have incurred, the economic contributions they have made to their counties, and the opportunities they have created in their communities. In particular, they were interested in describing a cost/benefit analysis for farmers and communities in other regions of the state who are interested in potentially starting a similar program in their counties. The study has been completed and shared with agricultural marketing experts representing many of these marketing programs and will soon appear on SAREPs website. Two presentations about the study results were also given in November 2005-- at the California Small Farm Conference and at a Marketing Learning Community meeting organized by the Community Alliance with Family Farmers. Yolo Local/Organic Label Survey During the summer of 2005, a short telephone survey of Yolo County and Bay area producers, agricultural businesses, processors and retail buyers was conducted as a supplement to the Agricultural Marketing Study. Participants were queried about their interest in a local and/or organic label and their willingness to pay for the creation of a local marketing program. The results of this survey are currently being analyzed and will be made available on SAREPs website in the spring of 2006. Mandarin Marketing Study They completed a final revision of the Mandarin Marketing study they conducted for Placer County mandarin growers last year. They are printing hard copies of the study for distribution to policymakers (Board of Supervisors, Ag Commissioner and others) in Placer County as well as study participants. The study will also appear on SAREPs website.

Impact: The Placer County Agricultural Marketing Director plans to distribute the Mandarin Marketing report widely. First and foremost, the report will provide needed information to Placer County mandarin growers who are searching for new marketing venues for recent bumper crops of mandarins. In addition to local farmers, it will be shared with Placer County policymakers with the intent of convincing them of the importance of supporting regional agriculture and marketing efforts. The Placer County Marketing Director hopes to use this report in a larger effort to limit urban development in the Placer County foothills and preserve more land for agriculture. The Regional Agriculture Marketing Program study is already being read and used by new, emerging agricultural marketing groups to assess what it takes to initiate and sustain such a program. In particular, it is being studied by the Yolo County Agricultural Commissioner as the county decides if and how it might create a local/organic label. The telephone survey conducted with regional stakeholders will provide insights for the Yolo County Agricultural Commissioner and other decision-makers as they decide how much demand there is for a local/organic label in Yolo County and whether businesses are willing to pay for it. The data gathered in this survey could help in future organizing, fundraising and outreach.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, KS, ME, MA, MI, MN, MO, NH, NJ, NYC, OR, PA, PR, VT, WA, WVA, WI

Theme: 2.01 Food Accessibility and Affordability

Title: Emergency Mobile Food Pantry California Food Futures and Fiber (CF3) Grant

Description: According to the 2000 Census, 13% of Calaveras County's 40,554 residents live at or below the poverty level. In addition, almost 21% of the children in Calaveras County live in poverty. Hunger is a condition of poverty. Five remote areas in Calaveras County may suffer more from the impact of poverty due to their geographic isolation. The Emergency Mobile Food Pantry's goal is to reduce this isolation and diminish the effects of poverty by providing access to food, nutrition education and resource information by bringing these services to the community. A California Food, Futures and Fiber (CF3) grant was obtained to create an Emergency Mobile Food Pantry to serve five remote areas in Calaveras County. The goal of the grant was to improve the nutritional status of the target population. This goal would be met by providing access to food, nutrition education, and resource information on a monthly basis in the individual community. Food banks and pantries have traditionally just provided food to participants. This project is striving to break the cycle of poverty by providing information to families to decrease their dependence on emergency programs and become more self-sufficient by utilizing resources available. They are utilizing FSNEP to provide the nutrition education component creating a win-win situation. Families who utilize the pantry are generally food stamp recipients or are eligible for food stamps. They are collecting data using the FSNEP forms and will assess outcomes quarterly. The CF3 funding has expired but through collaborative efforts the project is continuing.

Impact: Approximately 100 families are served each month through the pantry. These families, in addition to receiving a food box, have also been exposed to a variety of information on basic nutrition, food safety, food budgeting and meal planning, food preparation and gardening. The project provides the opportunity to try new foods (brown rice, dried cherries, couscous and tofu) and ideas and recipes for including these foods in their monthly meal planning. In addition, information on many assistance programs is offered and participants are encouraged to enroll. Follow-up is conducted at the next visit. Valuable and useable information is provided to a population that was very resistant to any additional requirement. They are asked to become engaged in learning activities and the majority is now willing, if not eager, to do so. Another unanticipated impact is the change in the food-banks staff core belief of their role in the community. Prior to this project and other collaborative activities, the food bank staff believed their primary role was to provide food - they were concerned with

quantity. Today, they are concerned with the quality of food they give families and they are thinking about the nutritional needs of their clientele.

Funding Source: Smith Lever, State and CF3 grant

Scope of Impact: State Specific

Theme: 2.02 Food Handling

Title: Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Marketing Chain

Description: Industry sponsored research continued on developing a fast, nondestructive method of detecting freeze damage in oranges. Laboratory testing showed that a hand-held ethanol sensor could detect freeze-damaged lots of oranges with an 80% to 90% accuracy compared with visually inspecting the internal quality of the fruit. A test with oranges damaged by a natural freeze in Phoenix, AZ showed a similar accuracy in detecting freeze injury. A commercial prototype of their patent pending, suspended fruit tray was tested with pears and avocados. A clear plastic clamshell package with the tray incorporated into the design virtually eliminated transport vibration damage to even the softest ripe fruit. Extensive testing was conducted on a vacuum infrared dryer. The unit dries rice at least twice as fast as a conventional convection dryer. It also appears capable of allowing more moisture removal per pass without cracking rice kernels compared with a conventional system. Future tests on rice cooking quality are in process.

Impact: The new method for detecting lots of freeze damaged citrus fruit is a low-cost and effective replacement for the time consuming and subjective manual method now used by government inspectors. The suspended fruit tray system has been licensed to the FDS Mfg. Co. in Pomona, CA and its first commercial use is expected in 2006. Ripe fruit outsells unripe fruit by three-to-one. The tray allows high quality, unblemished ripe fruit to be marketed at retail with minimal losses. The system holds promise of increasing sales of fruit such as avocados, pears, peaches, and nectarines. Pending positive results from the quality testing, the IR vacuum dryer may be a fast, energy efficient alternative to conventional convection drying.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, GA, HI, IN, ME, MD, MI, NYG, NYC, NC, PA, WA

Theme: 2.02 Food Handling

Title: Characterization and Control of Moisture Redistribution in Food During

Storage and Processing

Description: Work during the past year has focused on developing novel experimental tools for investigating sample physical properties. Single-tuned nuclear magnetic resonance radio frequency microcoils and two planar gradient coils were fabricated and tested. The radio frequency coil was a variant of a Helmholtz pair and tuned to a proton frequency of 25.9 MHz. The gradient coils were geometrically fabricated to provide orthogonal magnetic field gradients in the Z and Y directions. These NMR spectrometer components were fabricated using microfabrication/micromachining techniques. These components were employed to measure chemical composition and image internal proton distribution in liquid test samples.

Impact: Development of new characterization and measurement tools to quantify component redistribution in foods is important for improving quality and extending shelf-life. Results obtained demonstrated the prospect of using the Helmholtz RF coil as part of a portable low-field NMR system for applications in analytical chemistry and process measurements of component redistribution in industrial settings.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.02 Food Handling

Title: Physiological and Biochemical Responses of Fruits to Controlled Atmospheres

Description: During the past five years, UC researchers were able to further explore the physiological and biochemical bases of reduced oxygen and/or elevated carbon dioxide atmospheres on several fruits, including apples, cherries, grapes, pomegranates, strawberries, and fresh-cut fruit products. They determined the optimal atmospheric composition for these fruits and this information is currently being used on a commercial scale. They identified the critical levels below which (oxygen) and/or above which (carbon dioxide) respiratory metabolism is altered and fermentative metabolites are formed resulting in off-flavors. This information is being used by those who are testing various surface coatings and polymeric films for commercial use. Continued improvements in polymeric films and other packaging materials will facilitate expanded use of MA packaging to extend postharvest-life of fresh-cut fruits and permit their distribution via vending machines and quick-service restaurants. MAP is an effective way to maintain the desired atmospheric composition between shipping point and the consumers' home. When evaluating polymeric films, it is important to place the control product in perforated plastic bags to

separate the effect of the film on reducing water loss from its effect as a barrier to carbon dioxide and oxygen diffusion. Although much research has been done on the use of surface coatings to modify the atmosphere within many commodities, this technology has not been used to any extent because of the variability in composition among batches of the coating material. When combined with the natural variation in the gas diffusion characteristics among individual commodity units, a portion of each lot is lost due to off-flavors caused by fermentative metabolites. Further research is needed to overcome these constraints to use of surface coatings for modification of internal atmospheres of fruits. More cost-effective methods for establishing and maintaining MAs will facilitate their use during storage at shipping points, transportation, and storage at destination points. Maintaining the MA chain is the second most important factor after the cold chain in keeping quality and safety of fresh produce between harvest and consumption. Further evaluations are needed of the synergistic effects of MA and the ethylene-action-inhibitor, 1-methylcyclopropene, on delaying ripening of partially-ripe climacteric fruits and deterioration (browning and softening) of fresh-cut fruit products

Impact: Research conducted under this project resulted in specific recommendations for optimal modified atmospheres for several fruits, including bananas, cherries, grapes, mandarins, pomegranates, and strawberries. These recommendations are being followed by the fruit shippers and transportation companies.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.02 Food Handling

Title: Postharvest Biology of Fruit

Description: Scald incidence and severity were greater on pomegranates harvested during late season than on those harvested during mid season, indicating that this disorder may be associated with senescence. All pomegranates from both harvests that were kept in air exhibited some scald after 4 to 6 months at 7C. Neither diphenylamine (DPA) nor 1-methylcyclopropene (1-MCP) alone or together reduced scald incidence and severity. In contrast, the three controlled atmosphere (CA) storage conditions tested significantly reduced scald incidence and severity on pomegranates from both harvest dates for up to 6 months at 7C. However, the two CA treatments with 1% O₂ resulted in greater accumulation of fermentative volatiles (acetaldehyde, ethanol, and ethyl acetate) than the CA treatment with 5% O₂, especially in the mid-season-harvested pomegranates. In addition to its fungistatic effects, 15% CO₂ appears to be critical for inhibition of scald development on pomegranates. These results

confirm the UC researchers' recommendation of 5% O₂ + 15% CO₂ (balance N₂) as the optimal CA for pomegranates at 7 C and 90-95% relative humidity. Since very little if any farnesene or its conjugated trienol oxidation products were found in the peel of pomegranates, it appears that the biochemical basis of scald in pomegranates is different from that in apples. They are examining the possible involvement of fatty acid oxidation in the development of scald on pomegranate skin.

Impact: The researchers identified 5% oxygen plus 15% carbon dioxide as the optimal controlled atmosphere storage conditions for control of superficial scald and decay on pomegranates kept at 7 degrees C and 90 to 95% relative humidity for up to 6 months. They also demonstrated that ethylene plays an important role in apple flavor development by regulating biosynthesis of aroma esters and some of the organic acids, sugars, and phenolic compounds that influence acidity, sweetness, and astringency, respectively.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, ME, MA, MI, MN, NYG, NYC, NC, OR, WA

Theme: 2.03 Food Quality

Title: Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Marketing Chain

Description: Research was conducted on the continued development of an objective sensing method for quantifying the existence of freeze damaged oranges following a freeze event for use by California Ag Commissioners. Research showed that freeze damaged oranges produced ethanol and an inexpensive, hand-held, battery-operated ethanol detector was effective in measuring the ethanol (etoh) produced by freeze damaged oranges. This years research evaluated the effectiveness of a method for identifying freeze damaged oranges using two Navel varieties (Atwood and Washington), with and without preharvest gibberillic acid (GA) treatment and with fruit harvested over the potential frost period from December through March. The etoh method agreed with the standard subjective USDA method in 92% and 94% of the Washington variety lots and 86% and 78% of the Atwood lots. Preliminary analysis indicates that the discrimination accuracy is not very sensitive to etoh threshold and overall accuracy may not be reduced much by using one threshold for GA and non-GA treated oranges. A test was conducted to determine if headspace ethanol concentrations change in the days following freeze injury. Fruit with no freeze damage and slight freezing had very stable etoh levels. However more severely freeze damaged fruit showed increased etoh. The increased ethanol production appears to be associated with decay development. During the 2005 clingstone peach season a research project was conducted to evaluate the operational

feasibility of using instruments to measure the flesh color and flesh firmness of clingstone peaches at California Cling peach inspection stations. Assessment of fruit quality is an important tool to both producers and processors in the California Cling peach industry. Currently, subjective methods are used to assess flesh color and flesh firmness at California inspection stations, resulting in a lack of satisfaction with the inspection process by many in the industry. Fortunately, flesh color and firmness are two measures of fruit quality that can be measured instrumentally. The flesh color and flesh firmness of over 6,800 Cling peaches were measured instrumentally in 2005 and compared to the current official inspection methods of the California Department of Food and Agriculture. The agreement between the color instrument and the standard visual inspection method for maturity was 78% for single cut fruit and 71% for double cut fruit. For firmness, the agreement between the standard finger touch method of identifying soft fruit and the nondestructive instrumental method was 68.5% and 70% for the two instruments evaluated.

Impact: The development of a robust and objective freeze damage sensor suitable for field use would be a valuable management tool for citrus growers and could help keep damaged citrus from entering the retail market. Being an objective method it offers significant advantages over the current subjective method both in terms of confidence in the results and in ease in training new inspectors. The method developed is simple to conduct and inexpensive, requiring re-sealable plastic bags and an \$800 ethanol sensor. The implementation of objective instrumental methods of determining the flesh color and firmness of clingstone peaches would be a valuable management tool for both peach growers and processors. Because peach color and firmness affect the value of the fruit at the time of purchase by peach processors, the adoption of an objective method to replace the current subjective method of assessing fruit quality would give both growers and processors more confidence in the accuracy and fairness of the assessment method. The instrumental methods are fairly simple to operate, making it easier to train new peach inspectors.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, GA, HI, IN, ME, MD, MI, NYG, NYC, NC, PA, WA

Theme: 2.03 Food Quality

Title: Taste, Flavor, and Perception: Sensory Methodology

Description: The research had five main thrusts: 1) Protocols were refined for sensory discrimination tests, studying statistical power, memory and sequencing effects as well as how the brain processes information. This has provided the industry with the chance to save millions of dollars with more powerful and rapid test procedures. 2) Protocols were refined to eliminate bias due to the test

conditions for preference and food acceptance testing and assess its efficacy. Such refinements have been adopted by the food industry. 3) R-Index measures were modified for measuring consumer acceptance and concepts. 4) Investigation of the brain information processes that take place during numerical estimation. Estimation of flavor strength is a common technique but is traditionally performed inefficiently. This research increases efficiency and saves money. 5) The relationship between the tasting ability of consumers and trained tasters was investigated further, so that consumer discrimination could be predicted from the performance of 'in-house' panels, thus allowing companies to reduce the volume of expensive consumer testing.

Impact: This current research has already begun to provide food, beverage, agricultural and personal products industries with new, improved, more efficient and more economical methods for consumer, sensory and market testing, based on a knowledge of sensory function and brain information processing. Such methods save the industry millions of dollars.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.03 Food Quality

Title: Enhancing Postharvest Quality of Fruits with Reduced Dependence on Chemical Treatments

Description: UC researchers have continued to work on a collaborative project aimed at enhancing their understanding of the biological basis for internal browning development in Pink Lady apples and practical methods for reducing the incidence of the disorder. They have demonstrated a correlation of susceptibility to internal browning with the calcium content of the apple fruit at harvest. Their data has shown that changes in polyphenoloxidase enzyme activity is not related to browning susceptibility and seasonal differences in weather have not been correlated with browning incidence from one year to the next. They have conducted a third year of evaluation of southern high bush blueberries varieties grown in Southern California. They have found significant differences in flavor quality between the varieties tested.

Impact: In response to their work on Pink Lady internal browning, the industry has become more cautious about storing this variety in controlled atmosphere storage and this has greatly reduced the incidence of internal browning. Their results have guided the practices storage operators used with this apple variety. Evaluating the post-storage quality of new blueberry varieties for California provides information to new growers so that they can plant the varieties with the

best field and post harvest performance. This is especially important for the flavor and texture quality.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.03 Food Quality

Title: Evaluation of Fruit Texture

Description: Commodity texture is one of the significant components of fruit quality. Despite the importance for assessing quality, objective methods for the determination of commodity texture remain elusive. In ongoing physiological and biochemical studies UC researchers have gained significant insights into adjustments of turgor and cell wall components during ripening but the interpretation of what these changes mean are confounded because of the lack of an objective method to consistently evaluate texture. The Doppler Vibrometer detection method is the focus of their recent studies. The method has distinct advantages because the measurements are rapid and accurate and there is no physical impact on the sample. They have designed experiments to evaluate the feasibility of using this approach for objectively determining the signals that disclose the sensory perception of quality. A series of studies have been completed with various commodities were evaluated by the Doppler Vibrometer and then the same fruit subjected to taste panels. There are patterns emerging showing that the procedure has merit in predicting sensory assessments. In parallel studies they continue to refine the interpretation of the rheological values in expressing viscoelastic parameters. Both of these approaches were used to evaluate the behavior of stored fruit. Depending on storage conditions (temperature and duration) they gained an appreciation of what physical parameters could be used to predict fruit quality after the storage interval. The pattern of viscoelastic change that occurs during ripening was consistent regardless of year when fruit were harvested at the proper stage. And second, fruit held for intervals shorter than 3 months ripened normally while fruit held more than four months was unacceptable for consumption. Tissue elasticity assessed by the Doppler Vibrometer was the most effective measure to predict the ripening process prior to the development of other visible symptoms of abnormality. The changes in tissue elasticity are a function of metabolic depolymerization of polysaccharides in the cell wall. Hence the pattern of these metabolic changes can be evaluated during the course of the experiment without destroying the sample. In addition to advances in identifying cell wall structural changes associated with expression of rheology they reexamined the curious reports that starch was a constituent in walls of developing kiwifruit. Using a rigorous analytical approach they extended studies showing that amylopectin type starch is present in these fruit walls. The amount of starch declines as fruit

approach maturity. The presence of this unique starch as a component of the fruit cell walls is the basis for ongoing studies. At this point the function of starch in these walls is unknown.

Impact: Internal aspects of commodity quality are very important quality parameters yet such attributes are very difficult to measure except by intensive and destructive procedures. At the same time losses due to handling and unanticipated developmental events in fresh commodities are enormous. The problem is exacerbated by commerce that demands extended postharvest intervals, globalization and extended distances to markets. Overall the economic and nutritional costs due to losses during post harvest distribution are enormous. More diligent monitoring of quality is an important way to mitigate these losses and they need better quality assessment techniques. In addition to suppressing losses they also seek to satisfy the consumer by supplying produce that has quality characteristics that please the palate. They seek to specifically identify the properties of commodities that accurately reflect texture with quantitative values that can be used to insure the delivery and marketing of a desirable product. The goal is to identify the problems, minimize mishandling and optimize the strategies to preserve quality. They have demonstrated that a new and innovative remote sensory system can probe the characteristics of texture very rapidly without damage to the product. They visualize the use of this technique for diagnostic imaging in commodity quality control and that the pertinent internal changes in tissue structure contributing to texture can be established. Ultimately the goal is to provide fresh produce for improved human nutrition and reduce the costs attributed to loss and spoilage.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.03 Food Quality

Title: Postharvest Quality and Safety in Fresh-cut Vegetables and Fruits

Description: A wound signal originates at the site of injury in lettuce (*Lactuca sativa* L) leaf tissue and propagates into adjacent tissue where it induces the de novo synthesis of phenylalanine ammonia lyase (PAL), the synthesis and accumulation of soluble phenolic compounds, and subsequent tissue browning. Exposing excised mid-rib leaf tissue to vapors or aqueous solutions of n-alcohols inhibited this wound-induced browning by 40% and 60%, respectively. Effectiveness of the alcohol increased linearly from ethanol to the seven-carbon heptanol, and then was lost for the longer n-alcohols 1-octanol and 1-nonanol. The 2- and 3-isomers of the effective alcohols did not significantly reduce wound-induced phenolic accumulation at optimal 1-alcohol concentrations, but significant reductions did occur at much higher concentrations of the 2-, and 3-

isomers. The active n-alcohols were maximally effective when applied during the first 2 h after excision, and were ineffective if applied 12 h after excision. Phospholipase D (PLD) and its products linolenic acid (LA) and phosphatidic acid (PA) are thought to initiate the oxylipin pathway that culminates in the production of jasmonic acid, and PLD is specifically inhibited by 1-butanol, but not by 2-, or 3-butanol. These results suggest that PLD, LA, PA, and the oxylipin pathway may be involved in producing the wound signal responsible for increased wound-induced PAL activity, phenolic accumulation and browning in fresh-cut lettuce leaf tissue. Exposure of excised 5-mm mid-rib segments of romaine lettuce leaf tissue to vapors or aqueous solutions of mono-carboxylic acids or their salts inhibited wound-induced phenolic accumulation (WIPA) and subsequent tissue browning. The decline in phenolic content followed a quadratic curve with increasing concentration, reaching a maximum inhibition of 74% after 60 min for 50 mM sodium acetate (2 carbons, C₂), and 91% for 20 mM sodium decanoate (capric acid, C₁₀). Carbon dioxide production was unaffected by concentrations of formic, acetic, or propionic acids that reduced WIPA or that increase ion leakage from the tissue into an isotonic mannitol solution. WIPA was suppressed 70% by 20 mM acetate that did not increase ion leakage over that of water controls. Various acetate salts (i.e., ammonium, calcium, magnesium, sodium) all produced the same level of inhibition. The effectiveness of the compounds increased with increasing number of carbons in the molecule from 1 to 10, but was unaffected by whether the carbons were a straight chain or branched, or whether the treatment was delayed by up to 6 h. The effectiveness of butyrate (C₄) in reducing WIPA (27% reduction at 20 mM) was less than that predicted from the response of the two adjacent mono-carboxylates similarly applied; propionate (C₃) (62%) and valerate (C₅) (73%). It appears that, unlike the n-alcohols, mono-carboxylates are not interfering with the synthesis or propagation of a wound signal, but are interfering with subsequent steps in the production and accumulation of wound-induced phenolic compounds.

Impact: Wounding induces physiological changes that can detrimentally affect quality by increasing phenolic metabolism, accumulation phenolic compounds, and tissue browning. Knowing how wounding is transduced into a physiological response allowed us to devise postharvest treatments that mitigate deleterious wounding effects on the quality of fresh-cut fruits and vegetables.

Funding Source: Multistate Research and State

Scope of Impact: AL, AZ, CA-D, FL, GA, HI, IL, IA, LA, MI, NYG, OR, TN, TX

Theme: 2.03 Food Quality

Title: Postharvest Biology of Fruit

Description: UC researchers have continued to work on a collaborative project aimed at enhancing their understanding of the biological basis for internal browning development in Pink Lady apples and practical methods for reducing the incidence of the disorder. They have demonstrated a correlation of susceptibility to internal browning with the calcium content of the apple fruit at harvest. Their data has shown that changes in polyphenoloxidase enzyme activity is not related to browning susceptibility and seasonal differences in weather have not been correlated with browning incidence from one year to the next. They have conducted a third year of evaluation of southern highbush blueberries varieties grown in Southern California. They have found significant differences in flavor quality between the varieties tested.

Impact: In response to their work on Pink Lady internal browning, the industry has become more cautious about storing this variety in controlled atmosphere storage and this has greatly reduced the incidence of internal browning. Their results have guided the practices storage operators used with this apple variety. Evaluating the post-storage quality of new blueberry varieties for California provides information to new growers so that they can plant the varieties with the best field and postharvest performance. This is especially important for the flavor and texture quality.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, ME, MA, MI, MN, NYG, NYC, NC, OR, WA

Theme: 2.03 Food Quality

Title: Effect of Environmental Variables and Cultural Practices on Phenolic Levels in the Grapevine and Its Relation to Phenolic Levels in Wines

Description: UC research work during the reporting period has been directed at understanding fruit components that influence extraction of tannin from grape berries. Work from previous years focused their attention on the role that grape berry cell walls play in adsorbing tannin, thereby influencing tannin extraction during fermentation. They prepared a fine suspension of the insoluble cell wall material from Cabernet Sauvignon berries from vines grown in the U.C. D. vineyard and determined their capacity to bind tannins at different times during ripening. Mesocarp cell walls collected from fruit 40 days after veraison had more than five times the capacity for tannin binding as walls from veraison fruit. The binding capacity appeared to decline as the fruit approached harvest. The significance of this result is that it may help us understand why some fruit has easily extracted tannins while others exhibit lower extractability. They also studied Cabernet Sauvignon at several commercial vineyards in Napa Valley and compared the amount of total cell wall material and the tannin binding capacity of cell walls derived from that fruit to those from Davis. They found considerable

variation in the binding capacity from location to location. The results also show that the amount of cell wall material in skins and mesocarp varied among the different vineyards. Their experiments allowed us to calculate the total cell wall binding capacity of fruit on a per berry basis. This is an important value because by comparison with the amount of tannin per berry they were able to determine that the capacity of cell walls to capture tannin can amount to more than a third of the tannin present in the fruit. This result shows that tannin binding to cell walls may be an important factor in their ability to extract tannin from fruit during fermentation. In order to see how cell walls from different varieties bind tannins they carried out a survey of different varieties for comparison to the Cabernet Sauvignon described above. They studied Grenache at three locations, Tempranillo, Pinot noir, Syrah and Tannat. The results show for the first time how cell walls from different varieties can bind different amounts of tannin. Just as Cabernet Sauvignon from different locations showed different binding capacities, Grenache from three different vineyards had remarkably different capacity to bind tannin. The tannin binding capacity was also found to be quite variable among the different varieties. They believe that their results may help explain why different varieties can exhibit such a range of tannins in finished wines when the amount measured in the fruit shows a much more narrow range of values. Likewise, their results may help explain how a single variety from different locations can have widely different amounts of tannin in the resulting wines when there is little difference in the tannin level in the fruit at harvest.

Impact: The impact of this work resides in the suggestion that the cell wall binding capacity for tannins is an important factor that influences tannin extraction from grape berries during fermentation. Current models for solute extraction do not account for adsorption to the insoluble cell wall matrix. The impact of the work will emerge in better models of tannin extraction during fermentation and the recognition that the binding characteristics of the cell walls of the berry influence the level of tannin in wines. It is likely that the tannin binding capacity and the total amount of berry cell wall material are important viticultural parameters that have been overlooked when considering the influence of growing conditions on overall phenolic extraction from fruit during winemaking. The impact of this work should be to draw attention to these factors when assessing berry quality.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.03 Food Quality

Title: Postharvest Quality and Safety in Fresh-Cut Vegetables and Fruits

Description: A number of projects related to improving the quality and safety of fresh-cut produce were carried out by UC researchers. These included the following: 1. Regeneration and structural changes of heat-treated broccoli peroxidase, as determined using NMR, circular dichroism and activity measurements; Funding: Government of Thailand 2. Low temperature blanching of diced tomatoes and green beans to improve firmness; Funding: California League of Food Processors 3. Influence of various processes on plant cell integrity and its application to quality and shelf-life extension of refrigerated fruit products; Funding: Center for Advanced Processing & Packaging 4. Shelf-life study of high pressure treated avocado products with Monterrey Institute of Technology; Funding: UC Mexus Foundation 5. Food Safety in Nonthermal Processing Technologies; Funding: USDA Food Safety Program Their research group addresses the Postharvest physiology and biochemistry of fruit and vegetable tissues, and determines handling and processing technologies that will result in the highest quality (color, texture, flavor and nutrient value) and safest products.

Impact: They anticipate that improvements in the color, texture, flavor and nutritional quality of fresh-cut fruit and vegetable products will encourage US consumers to increase their consumption of these nutritious commodities. Understanding the basic biochemistry and physiology behind the quality factors that influence consumer acceptance will allow us to optimize these attributes. They expect that if they can improve the real quality of fresh-cut fruit and vegetable products, consumers will purchase and eat more - thereby providing growers and the manufacturers with greater income and the consumer with a healthier diet.

Funding Source: Multistate Research and State

Scope of Impact: AL, AZ, CA-D, FL, GA, HI, IL, IA, LA, MI, NYG, OR, TN, TX

Theme: 2.03 Food Quality

Title: Production and Delivery of High Quality Stone Fruit

Description: Fruit flavor quality potential of peach and nectarine cultivars was investigated by UC researchers in the 2005 season, leading to the segregation of cultivars according to their organoleptic characteristics. Cultivar segregation according to the sensory perception of fruit organoleptic characteristics was attempted by using trained panel data evaluated by principal component analysis of four sources per cultivar of 23 peach and 26 nectarine cultivars. Fruit source significantly affected cultivar ripe soluble solids concentration (RSSC) and ripe titratable acidity (RTA), but it did not significantly affect sensory perception of peach or nectarine flavor intensity, sourness or aroma by the trained panel. The perception of the four sensory attributes (sweetness, sourness, peach or

nectarine flavor intensity, peach or nectarine aroma intensity) was analyzed by using the three principal components, which accounted for 92 and 94% of the variation in the sensory attributes of the tested cultivars for peach and nectarine, respectively. Season did not significantly affect the classification of one cultivar that was evaluated during these two seasons. By plotting organoleptic characteristics in PC1 and PC2 for peach and nectarine, cultivars were segregated into groups (balanced, tart, sweet, peach or nectarine aroma and/or peach or nectarine flavor intensity) with similar sensory attributes; nectarines were classified into five groups and peaches into four groups. On the genetics side of the project, the previous partial genetic map of their main segregating population, Pop-DG, was expanded with approximately 70 additional SSR and RAF markers. This expanded map covers an estimated 90% of the peach genome, with direct correspondence to two-thirds of the international *Prunus* reference map. QTL analysis was performed on the genetic map, using phenotypic data collected for three seasons. QTLs for flesh mealiness, browning, and bleeding were located, confirming the stability of certain previously-identified QTLs over a third season of data. Candidate gene analysis verified that the peach gene for endopolygalacturonase (endoPG), controlling the freestone and melting flesh traits, corresponded to a large QTL for mealiness and bleeding. Further investigation pointed to the cause of mealiness being the result of partial endoPG enzyme activity during cold storage followed by gradual softening during subsequent ripening with negligible endoPG activity. In the genetic populations studied, only freestone melting flesh trees were susceptible to mealiness. In contrast, bleeding susceptibility was confined to clingstone non-melting flesh trees.

Impact: Based on the investigations into fruit flavor quality potential, they recommend that cultivars should be classified in organoleptic groups and development of a minimum quality index should be attempted within each organoleptic group. This organoleptic cultivar classification will help to match ethnic preferences and enhance current promotion and marketing programs. In the stone fruit industry, one of the most frequent complaints by consumers and wholesalers is the internal breakdown (IB), also called chilling injury, which appears during prolonged cold storage and/or after subsequent ripening. Eventually, markers such as these can be used by breeders to select fruit with a low susceptibility to internal breakdown symptoms. Their research has helped pinpoint the role of endoPG in mealiness. Researchers can now examine other ripening enzymes, and their controlling genes, in perspective. Peach and nectarine breeders can use the DNA test developed for the freestone and melting flesh traits to verify the underlying genotype of any variety or seedling, and also consider susceptibility to internal breakdown in perspective.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.03 Food Quality

Title: Postharvest Quality and Safety in Fresh-Cut Vegetables and Fruits

Description: The influences of processing and storage on the post cutting life and nutritional quality of fresh-cut fruits were evaluated and compared with freshly-prepared slices made from fruits that were stored for similar durations. Fresh-cut pineapples, mangoes, cantaloupes, watermelons, strawberries and kiwifruits and whole fruits were stored for up to 9 days in air at 5C. Changes in quality attributes, total ascorbic acid (reduced ascorbic acid and dehydroascorbic acid), carotenoids and phenolics were determined. Fresh-cut processing reduced post cutting life to 6 days for fresh-cut kiwifruit and less than 9 days for fresh-cut pineapple, cantaloupe and strawberry. On the other hand, the shelf-life of fresh-cut watermelon and mango extended beyond 9 days at 5C. Changes in total ascorbic acid (vitamin C), total carotenoids, and total phenolics were small and mostly not significant within the 6 to 9 days of optimal post-cutting-life. Processing of whole fruit was found to induce similar variation of nutrient content compared to fresh-cut and resulted in no major changes after storage. Light exposure promoted browning in pineapple wedges and decreased total ascorbate content in kiwifruit slices. In addition, the content of total carotenoids in cantaloupe cubes and kiwifruit slices decreased under light while it increased in mango and watermelon cubes. There was no effect of light exposure on the total phenolics content. In general, fresh-cut fruits visually spoil before any significant nutrient loss occurs.

Impact: The results indicated relatively small (10 to 25 percent) losses in nutritional quality of fresh-cut fruits during their post-cutting life. These findings are being used by the industry to assure consumers of the nutritive value of fresh-cut fruit products.

Funding Source: Multistate Research and State

Scope of Impact: AL, AZ, CA-D, FL, GA, HI, IL, IA, LA, MI, NYG, OR, TN, TX

Theme: 2.03 Food Quality

Title: Postharvest Biology of Fruit

Description: The previous partial genetic map of their main segregating population, Pop-DG, was expanded with approximately 70 additional SSR and RAF markers. This expanded map covers an estimated 90 percent of the peach genome, with direct correspondence to two-thirds of the international Prunus reference map. QTL analysis was performed on the genetic map, using phenotypic data collected for three seasons. QTLs for flesh mealiness, browning,

and bleeding were located, confirming the stability of certain previously-identified QTLs over a third season of data. Candidate gene analysis verified that the peach gene for endopolygalacturonase (endoPG), controlling the freestone and melting flesh traits, corresponded to a large QTL for mealiness and bleeding. Further investigation pointed to the cause of mealiness being the result of partial endoPG enzyme activity during cold storage followed by gradual softening during subsequent ripening with negligible endoPG activity. In the genetic populations studied, only freestone melting flesh trees were susceptible to mealiness. In contrast, bleeding susceptibility was confined to clingstone non-melting flesh trees.

Impact: In the stone fruit industry, one of the most frequent complaints by consumers and wholesalers is the presence of mealiness, flesh browning, black pit cavity, translucency, red pigment accumulation (bleeding), and loss of flavor. These symptoms are a consequence of internal breakdown (IB), also called chilling injury, which appears during prolonged cold storage and/or after subsequent ripening. For this reason, the problem is usually not noticed until the fruit reaches retailers and consumers, reducing demand. In their work, they have identified several genetic markers for peach fruit internal breakdown traits (flesh mealiness, browning and bleeding). Eventually, markers such as these can be used by breeders to select fruit with a low susceptibility to internal breakdown symptoms. The cell wall degrading enzyme endopolygalacturonase (endoPG) has been implicated in the physiological development of mealiness for decades. Their research has helped pinpoint the role of endoPG in mealiness. Researchers can now examine other ripening enzymes, and their controlling genes, in perspective. Peach and nectarine breeders and other germplasm curators can use the DNA test developed for the freestone and melting flesh traits to verify the underlying genotype of any variety or seedling, and also consider susceptibility to internal breakdown in perspective.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, ME, MA, MI, MN, NYG, NYC, NC, OR, WA

Theme: 2.04 Food Recovery/Gleaning

Title: The Effect of Natural Polymer Composition and Structure on the Textural Quality of Foods

Description: Different commercial protease enzymes were studied by UC researchers for their ability to remove protein from milled rice. M202 rice (California medium grain variety) was used for testing of the various enzymes. Protease treatment was carried out at the optimal enzyme reaction condition for each protease, pH was controlled during the treatment. Alcalase (NovoNordisk, Denmark) was the most efficient. The remaining amount of protein was less than

1%. Conditions for an optimum process were found to with a starting pH of 10.0, an usage level of commercial Alacase of 0.1mL/30g rice, and reaction time of 4 hr. Under these conditions, the remaining level of protein was less than 0.7%. An additional aid to the process was tested. With the addition of a commercial cellulase (NovoNordisk) (0.4mL/30g rice) before the Alcalase treatment, the final level of protein was reduced to less than 0.5%. The pasting properties of rice starch prepared with Alcalase, Sodium Hydroxide, SDS (a detergent), and rice flour were compared. The pasting behavior of the rice starch prepared with Alcalase was found to be most similar to the rice flour. This suggests that the enzymatic removal of protein from the rice flour does not affect the properties of the starch. The chemical separation of starch from the flour with either NaOH or SDS did show changes in their pasting properties. Microscopic examination of the rice flours with scanning electrode microscopy showed that the starch granules prepared with Alcalase appeared to be unaffected by the separation process. This would also suggest that these starch granules are more like the native starch granules in the milled rice. The inhibition of Angiotensin converting enzyme (ACE) activity by the rice peptides, which were products from the preparation of rice starch with Alacase was evaluated. Soy peptides have been the most extensively studied peptide for ACE inhibition and cholesterol lowering. Their results showed that rice peptides obtained with certain protease treatment may be effective in inhibiting ACE, when compared to soy peptides. Dietary proteins have showed the ability to influence serum cholesterol level in many studies. Many studies have been carried out with soy and milk peptides. A recent hypothesis is that the hypocholesterolemic peptides derived from proteins (like soy) might exist and influence the serum cholesterol level. Using this hypothesis, the cholesterol lowering potential of rice peptides were measured and compared to that of soy peptides. These results suggest a potential for a cholesterol lowering effect by rice peptides as compared to soy peptides.

Impact: The project has identified a method for the production of rice starch with a commercial enzyme Alcalase (NovoNordisk). The rice starch powder prepared in this way is a very fine powder and less coarse than other starch powders. The average size of the rice starch granules is 5.5 microns. This method of preparation also minimizes damage to the starch granules as compared to other methods based on chemical treatments. The peptide by-products from the enzymatic preparation of rice starch have also been shown to have potential for healthy ingredients for foods. Thus this process, which separates starch from protein in milled rice, has provided some directions for the marketing of the two products. Finally, the rice used for the process could be older or broken rice grains.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.05 Food Resource Management

Title: California Food Industry Referral Guides

Description: Many of the services sought by existing small and large food processors, and entrepreneurs thinking about getting into production of a food product, are common. Supplying the information on an individual basis is time-consuming. A UC CE specialist created a database of companies that provide goods, services and consulting to the California and US food industry. Based on the information and services most commonly sought, she developed 16 searchable categories, calling them Food Industry Referral Guides. A food safety microbiologist assisted the UC CE specialist with the referral guides. Initially, guides were distributed as hard copies. In 2000, databases were installed on the Web (<http://fruitandvegetable.ucdavis.edu>), providing the California food industry instant access to the most current information available. The referral guides, which are updated as new information becomes available, cover the following topics: Aseptic Processing, Cold Storage, Consultants, Co-Packers, Dehydrators, HACCP, Ingredients, Lab Analysis, Lab Equipment, Nutritional Labeling, Packaging Containers, Packaging Equipment, Processing Equipment, Product Development/Sensory, Sanitation and Training/Continuing Education.

Impact: Food industry clientele find the guides an easy means of identifying local resources. Instead of spending an hour researching companies that perform laboratory analysis for a particular food industry client, the client is directed to the Food Industry Referral Guides on the Web and can search directly. This is a tremendous time-saver for clients. In 2001, tracking visitors to the Web site began. The website also includes information on extension short courses and an applied research program. By announcing the existence of the site to callers and conference attendees, site traffic increased to about 2,000 visitors annually. Sixty-four percent of hits came from North America; 11.5 percent from Asia; and 11 percent from Europe. Of the North America clientele, 61 percent came from the US. The international food science community utilizes the referral guides; consequently, there is more awareness of the expertise available through the University of California.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.06 Food Safety

Title: Postharvest Quality and Safety in Fresh-cut Vegetables and Fruits

Description: The UC research was to assess the presence and physiological significance of nutrients and other functional components of fresh-cut vegetables

and fruits as affected by storage and handling. a. Impact of 1-MCP treatment of romaine lettuce heads in relation to preprocessing handling and storage and to quality of the salad cut lettuce. The research was conducted with industry processor collaboration. Three tests conducted showed high variation in efficacy in relation to cultivar. b. Quality of fresh-cut tomatoes. The effect of initial maturity stage on slice integrity at table-ripe stage of tomatoes was studied for several fresh market varieties. c. Use of 1-MCP to retard deterioration of leafy green vegetables (broccoli, herbs [chives, cilantro, dill]). This work was done at reasonable storage temperature (5 degrees C) and temperature abuse conditions (10 degrees C). Visual quality attributes and compositional quality (sugars, chlorophyll, carotenoids, ascorbic acid, ammonia) were evaluated, and some physiology (respiration rates). The research, also, aimed to develop a better understanding of the physiology of fresh-cut vegetables and fruits in response to processing and during storage and handling. a. From the annual Fresh-cut Workshop held at UC Davis (Sept 13-15, 2005), materials and recent research findings were compiled and edited, as well as unpublished data on fresh-cut products. b. Golden honeydew melons, as fresh-cut product, were studied. Storage temperature and time studied in relation to the quality and shelf-life of the fresh-cut product stored at 5 degrees C. The fresh-cut product was evaluated for visual quality attributes, sugars, vitamin C, texture, color and aroma.

Impact: The applied studies are of direct relevance to successful pre- and post-processing handling of products by the fresh-cut industry. Their work provides benchmark data on quality changes and compositional changes for fresh-cut products. Some of the studies they have conducted have been specifically requested by fresh-cut processors.

Funding Source: Multistate Research and State

Scope of Impact: AL, AZ, CA-D, FL, GA, HI, IL, IA, LA, MI, NYG, OR, TN, TX

Theme: 2.06 Food Safety

Title: Methodology for Pathogenic and Indicator Bacteria in Food and Water

Description: In the final project period, UC researchers made progress in two areas: 1) Clarification of how aquatic aeromonads interfere with coliform tests for fecal contamination in water; and 2) Further optimization of the Colitag medium they devised some years ago. Details follow: 1) Aeromonas project: Their initial hypothesis was that aeromonads generated false-positive coliform tests and necessitated the development of the tedious coliform test that was used for most of the 20th Century. They tested the hypothesis by observing gas formation by a wide range of aquatic aeromonads in the Presumptive Coliform Test. They obtained this wide range of bacteria in four very different ways: 1) From local

creek water: They selected ampicillin-resistant bacteria, many of which were aeromonads. Then they tested the aeromonads. 2) From urban runoff: They did traditional coliform tests, cultured positive tubes, and isolated coliforms and aeromonads. 3) From the American Type Culture Collection. They ordered over a dozen lactose-positive aquatic aeromonads. 4) From their historical collection. They tested all the aeromonads that they had isolated in 15 years of water testing. They found that NONE of their PURE CULTURES of aeromonads produced false-positive presumptive coliform tests. These results leave us with an alternative hypothesis, that MIXED CULTURES of aeromonads and non-coliform enterobacteriaceae can symbiotically give the false-positive tests. In addition, they explored methods for eliminating Aeromonas interference from their rapid, one-step Colitag coliform test. They found that the antibiotic cefsulodin will eliminate the false-positives without compromising the test's sensitivity to environmentally injured coliforms.2) Further optimization of Colitag. When Colitag moved from the laboratory to the field, it got a great deal of feedback from commercial formulators and end users. A major complaint was the malodorous and hygroscopic nature of a key ingredient, TMAO. They found that nitrate or fumarate could partially replace TMAO, but that some TMAO was needed for the brilliant color and fluorescence that they expect of Colitag.

Impact: While the Aeromonas experiments did not solve the mystery of the false positives in the presumptive coliform test, they did provide an easily testable alternative hypothesis. The Colitag optimization experiments paved the way for making the commercial Colitag medium more acceptable to producers and users.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.06 Food Safety

Title: Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Marketing Chain

Description: UC researchers have developed a real-time polymerase chain reaction (PCR) assay and instrument for the detection of Salmonella enterica. The instrument is compatible with pumps and valves for automatically loading a sample and cleaning the reaction chamber once the reaction is complete. Silicone tubing for fluid transfer was attached to a round glass tube reaction chamber. By sealing the reaction chamber with pinch valves directly on a thermoelectric module for heating and cooling, it was possible to make copies of the intended DNA target, a segment of the invA gene. A two-step PCR was used, cycling temperatures between 94 and 62 deg. C for 30 and 60 seconds respectively, for a total of 35 cycles. AmpliTaq Gold polymerase concentrations were increased to 6.25U per 50 ul reaction and bovine serum albumin (BSA) was

also added to each reaction to a final concentration of 0.25 mg/ml. The increase in BSA and polymerase concentrations helped to increase the rate of the reaction. The signal to noise ratio of the fluorescence detection system was greatly improved by using an interference filter and making changes to the design of the signal conditioning circuitry. A low input bias current operational amplifier amplified the signal from the photodiode while fluorescence was generated. A conductive guard around the inputs to the op amp was connected to the common of the circuit and the case of the op amp package, reducing noise and allowing the gain of the circuit to be increased. Following a reaction it was possible to verify results by examining amplification and dissociation data stored in the memory of the embedded controller that controlled the system. The PCR mixture was removed from the automated system and the sample was placed into a commercial instrument where a dissociation analysis was run for comparison with the automated system. Additionally, agarose gels were run to verify that the correct size fragment was formed. They were able to detect *Salmonella enterica* serovar Newport over a range of 500 ng to 50 pg of extracted DNA per 50 ul reaction. This detection range corresponds to approximately 10⁸ to 10⁴ colony forming units of *Salmonella* per 50 ul reaction. These tests were run by using new silicone and glass tubes. Preliminary tests with pumping PCR mix into the reaction chamber with 5 ng of extracted DNA show that there is no difference in threshold cycle value or product melting temperature between the samples that were pipetted into the reaction chamber and those that were pumped in. They are now testing the reusability of the reaction chamber by cleaning with DNAZap and buffers, and using uracil DNA glycosylase prior to the reaction to remove any additional DNA carry-over contamination.

Impact: The process of growing sprouts, such as alfalfa and bean sprouts, can permit the growth of bacteria due to warm and moist conditions found in many sprouting operations. Several outbreaks of hazardous bacteria have been traced to sprouts. As a result, sprout growers are required to test sprout water samples for *Salmonella* and *E. coli* O157:H7. Testing may be done by shipping samples off site to a fully equipped microbiology laboratory for analysis of sprout water. However, shipping water samples off site is a time consuming process. Testing water samples on site with an automated sensor would let sprout growers know immediately if their product was safe to ship or not. While a wide variety of commercially available real-time PCR instruments exist, they are typically large and require skilled labor to operate and extensive equipment for liquid handling. Screening samples for the same bacteria from the same media (sprout water) is a repetitive task that is well suited to automation. An automated PCR sensor that requires minimal user input to detect pathogens such as *Salmonella* and *E. coli* O157:H7 would ensure that sprout growers are producing foods that are safe for consumption.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, GA, HI, IN, ME, MD, MI, NYG, NYC, NC, PA, WA

Theme: 2.06 Food Safety

Title: Isolation and Identification of Antioxidants in Foods

Description: A modified malonaldehyde (MA) assay for antioxidant activity, which involves derivatization and headspace solid-phase microextraction (HS-SPME) was developed and validated. The recovery efficient of MA as 1-methylpyrazole (product of MA and N-methylhydrazine) from a headspace of an aqueous solution containing MA, buffer, surfactant, and cod liver oil using HS-SPME with a PDMS/DVB fiber was 86.7 +/- 2.59 %. MA was analyzed by a gas chromatograph with a nitrogen-phosphorus detector and its detection limit was 0.0103 nmol/mL. Antioxidant activities of natural compounds were determined as percentage inhibition of MA formed from cod liver oil oxidized by Fenton's reagents in the above aqueous solution. Sesamol inhibited MA formation most (86.1 %), followed by eugenol (84.4 %), capsaicin (80.7 %), ethylvanillin (45.3 %) and vanillin (31.6 %) at a level of 50 ug/mL. This method did not require any organic solvents, is simple, fast, and a highly sensitive method for MA determination.

Impact: The assay did not require any solvent for extraction and vigorous conditions such as low pH and high temperature for derivatization, which is essential for TBA assay, thus it has advantage of less formation of artifacts. The HS-SPME method is simple and applicable for automation, which would provide fast and specific assay for MA. It is suitable for assessing antioxidant activity of complex samples, such as blood and urine as well as food.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.06 Food Safety

Title: Postharvest Quality and Safety in Fresh-Cut Vegetables and Fruits

Description: The primary focus of this project is to develop and validate standard methods that could be used to inoculate and recover foodborne pathogens from a variety of fresh and fresh cut fruits and vegetables and from tree nuts. These produce items present may challenges in this respect because of the remarkable difference in the surface structure of the vast number of products readily available. In addition, production, harvesting, processing, and storage conditions vary greatly and all of these factors will have an impact on the behavior of foodborne pathogens in these products. The standard methods

developed were used to evaluate antimicrobial agents such as chlorine and propylene oxide for reduction of pathogens on the surface of a variety of produce items and almonds. Several common foodborne pathogens of importance were evaluated including SALMONELLA, LISTERIA MONOCYTOGENES, E. COLI O157:H7, AND SHIGELLA. Greatest reductions occurred when friction such as rubbing or brushing was applied. Reduction on smooth surfaces (such as honeydew melon) was significantly greater than on complex surfaces (such as cantaloupe). Antimicrobial agents can reduce pathogens on surfaces and play a role in reducing cross contamination of produce; however, they are less applicable to tree nuts. Thermal or propylene oxide treatments were effective for reducing SALMONELLA on almonds.

Impact: Methods developed in this lab and in collaboration with others are being used to study to evaluate washing methods designed to remove foodborne pathogens from the surface of produce and tree nuts. Results are being used in publications directed to consumers and the food industry for the safe handling of fresh and fresh-cut fruits and vegetables and tree nuts.

Funding Source: Multistate Research and State

Scope of Impact: AL, AZ, CA-D, FL, GA, HI, IL, IA, LA, MI, NYG, OR, TN, TX

Theme: 2.06 Food Safety

Title: Chill and Osmotic Tolerance of *Listeria monocytogenes*

Description: When stressed by high salt concentration or low (e.g., refrigeration) temperature *L. monocytogenes* cells accumulate the protective molecules glycine betaine and carnitine from the environment by the action of three transport systems, Gbu, OpuC and BetL. The activities of the transport systems are regulated by the presence of the stress. Previous work in which genes encoding the transport proteins were deleted showed the relative importance of each transport system and the conditions under which it functions. Besides regulation of transport activity at the biochemical level, it is likely that *L. monocytogenes* regulates the amount of each transport system by controlling synthesis of the proteins at the genetic level. Regulation of synthesis is being studied using a promoterless lacZ gene inserted behind a copy of the promoter region of the gbu gene, and similar constructs involving two other stress-related transporters, BetL and OpuC. They grow the cells in the absence of stress and the absence of glycine betaine and carnitine, and test the expression of the reporter gene when the cells are subjected to salt stress, salt stress not involving sodium ion, sugar-mediated osmotic stress and chill stress. They are also testing whether the presence or absence of substrates glycine betaine and carnitine affect expression. Assays using the chromogenic substrate OMPG proved not to be sufficiently sensitive, and they have begun using the fluorogenic substrate MUG.

Preliminary results indicate that the transporters are at least partially constitutive, and are present even in rich media unsupplemented with salt.

Impact: The ultimate impact is to reduce the viability of *Listeria monocytogenes*, particularly persistent strains, by understanding the mechanism of resistance to environmental stress and refrigeration. Reducing the viability will decrease the loss of life and economic burden of product recalls due to *Listeria monocytogenes*.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.06 Food Safety

Title: Postharvest Quality and Safety in Fresh-cut Vegetables and Fruits

Description: In partnership with industry and industry associations, UC research focus has been given to irrigation water, manures and compost, ag-runoff, reclaimed water uses, and wildlife. Extensive environmental sampling on an implicated farm and surrounding production areas were all negative for *E. coli* O157:H7, underscoring the difficulty in finding a clear source of contamination. Ecology and source tracking of associated indicator bacteria is providing insights to survival. The purpose of this project was to document the regional presence of *E. coli* and thermo-tolerant coliform (TTC) in on-farm reservoirs intended for irrigation of lettuce. A further objective was to confirm the identity of the presumptive *E. coli* colonies isolated from these sources. Over a three-year reservoir survey across nineteen irrigation water sources from an area that extended approximately 65 km, no correlation between *E. coli* and TTC was observed. Pathogenic *E. coli*, *Salmonella*, or *Shigella* were never detected. For Romaine lettuce, the majority of samples were below the limit of detection for *E. coli*. Typically, up to 20% of plants sampled in any field had detectable levels of non-pathogenic *E. coli*, with a few samples having approximately 300 CFU/25g. In related survey evaluations, the problem of actionable economic cascades that result from "false-positive" results in presumptive screens for pathogenic *E. coli* has been a concern for some time. Rapid diagnostic test kits are increasingly being used by public health labs, commercial microbiological testing labs, and public researchers. They sought to determine the prevalence of these "false-positive" reactions from various lettuce production sources. Environmental, soil, water, and other samples related to lettuce production were also tested for reaction in the commercial immuno-diagnostic platforms. A total of 28 water samples, two soil, two sediment, and two compost samples were processed over eight sampling dates. According to commercial quick tests, 22 samples were positive for *E. coli* O157:H7. However, these same samples were negative for determinative PCR virulence-associated markers; and no viable *E. coli* O157:H7

colonies were recovered. This information will be essential towards future strategies to minimize the co-enrichment or detection of such "false-positives" and the development of more specific and discriminatory techniques. In addition, they have been conducting efficacy studies and process development research with a novel approach to ozone disinfection of whole and fresh-cut produce using a regulated vacuum ozonation chamber. The effect of high doses of gaseous ozone on the sensory and microbial quality of whole fruits and vegetables intended for fresh cut processing was investigated. The degree of reduction was dose dependent and greater reductions were observed with fresh cut pieces. Inactivation of Salmonella and E. coli O157:H7, in presence or absence of interfering organic matter, was greater on whole items compared to corresponding fresh cut pieces. All treatments were found to maintain initial texture and aroma on melons but not tomatoes or leafy greens.

Impact: This research has had a positive effect in building awareness and implementing commodity-specific Good Agricultural Practices. New formulations, interventions, and process recommendations are being broadly disseminated in trade journal publications, workshops, extension bulletins, and electronically.

Funding Source: Multistate Research and State

Scope of Impact: AL, AZ, CA-D, FL, GA, HI, IL, IA, LA, MI, NYG, OR, TN, TX

Theme: 2.06 Food Safety

Title: Food Safety Training for Extenders

Description: Food safety is a topic of much interest as foodborne illness is on the rise due to emerging microbes, food grown and shipped from further distances, and more foods prepared commercially. Health and family service professionals and consumers rely on UCCE to provide current and accurate food safety information.

Impact: One hundred percent of participants returning a 6 month follow-up survey for Make it Safe, Serve it Safe indicated they had made positive behavior changes in handling food and/or training staff in safe food handling. Changes included incorporating food safety information into college level courses, training staff and clientele, and calibrating thermometers for professional and home use. Trained food safety volunteers provided food safety information to approximately 200 consumers yearly. The safe food handling posters were shared with the Make it Safe, Serve it Safe development team, who made them available statewide to CE staff. Don't Give Kids a Tummy ache training programs were presented to preschool staff reaching 49 individuals from Head Start and private preschools.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 2.07 Food Security

Title: The Relationship of Poverty, Food Security, and Food Assistance to Child Nutrition in Latinos

Description: In the final phase of this project, UC researchers have finished analyzing data from an exploratory study related to past food insecurity and child feeding practices. In the last report, the preliminary findings were based on data collected to date. In the full dataset (n=87), they confirmed the findings that internal consistency of their past food security instrument is very good (Cronbachs alpha=0.84). Past food insecurity, measured by this tool, was significantly correlated with lower maternal education ($r = -0.45$, $p < .0001$), crowding in mother's childhood household ($r = +0.30$, $p < .006$, and greater past food insufficiency ($r = +0.74$, $p < .0001$). Compared to low-income US born mothers, foreign-born Latino mothers reported significantly greater levels of past food insecurity ($p < 0.01$). These findings were summarized in a paper that was submitted to the Journal of Nutrition Education and Behavior. Based on the research in their previous years, a review article was written and published in the Topics in Clinical Nutrition (#1). In that article, they conclude that household food insecurity or insufficiency may be associated with lower dietary quality and poor cognitive development and emotional/behavioral problems in children. Food insecurity or insufficiency is not associated with risk of being overweight in childhood, but deprivation during childhood may be related to adult obesity. In a clinical setting, neither anthropometric nor income measures are sufficient to determine whether food insecurity is a problem. Over the time period of this project, they have also conducted validation work of the food security instrument in rural Mexican communities, where many of their California immigrants originate (#2). They have found that the pattern of response to the 18 food security items in the Mexican population was similar to that previously reported for their Latino immigrant population in California, but the magnitude of food insecurity was much greater in Mexico. Only 2.8% reported being food secure, whereas 44% reported mild food insecurity, 33% reported moderate hunger, and 19.7% reported severe hunger. Greater food insecurity was significantly correlated with lower total food supplies ($r = -0.27^{**}$), animal source foods ($r = -0.23^{**}$), dairy products ($r = -0.19^*$), processed foods ($r = -0.31^{**}$), and refined sugar products ($r = -0.27^{**}$), $*p < 0.05$, $**p < 0.01$.

Impact: The 18-item food security instrument is valid in both Mexican-born and US-born Latino populations. Household food insecurity is associated with lower dietary quality and behavioral/emotional problems in children. Latino parents who experienced food insecurity during childhood (but are now food secure) may use more indulgent feeding practices with their own children, compared to parents

who did not experience food insecurity in the past.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.07 Food Security

Title: UC Riverside Researchers Develop Low-carb Corn with Enhanced Protein and Oil

Description: Projected world population growth from the current 6 billion to between 8 and 12 billion by the year 2050 is expected to outstrip food production. Over the last several decades, the Green Revolution has yielded many improvements in agricultural practices that increased crop productivity in the world's most important cereal grains. But the agricultural practices adopted during the Green Revolution are unlikely to generate the productivity gains needed in the future. A research team at UC Riverside led by a biochemist has developed a technology that doubles the protein and oil content of corn while reducing its carbohydrate content. The UC researcher, along with postdoctoral associates, reported the findings in the June 2004 issue of *The Plant Journal*. Flowers in the corn ear ordinarily develop in pairs but one from each pair aborts before pollination can occur. Because of the role that the plant hormone cytokinin plays in preventing organ death, the researchers reasoned that cytokinin might rescue flowers which were destined to abort. They introduced a gene that enabled production of cytokinin in developing flowers. Introduction of the gene prevented flower abortion and, importantly, the kernels produced from pairs of flowers fused into a single normal-sized kernel that contained two embryos and a smaller endosperm. Because it is the embryo that contains the majority of protein and oil, the presence of two embryos doubles their content in corn grain. The reduction in the size of the endosperm in the kernel, the tissue that contains most of the carbohydrate, means that the nutritional value of the grain has been improved considerably. The project was funded by the University of California Agricultural Experiment Station, the US Department of Agriculture, and the National Science Foundation.

Impact: The findings may provide a useful approach toward the goal of feeding the world's population. Cereal grains are the most important crops to humanity, used for animal feed, for production of oil, protein, and starch, and for feeding the majority of the world's population. As the oil content of corn is especially valuable, increasing the amount of oil will increase the profitability of this crop to farmers. Specifically, the findings are important to the field of flower development in corn in that they suggest that the level of cytokinin may determine whether flower abortion occurs and this knowledge may be used to engineer grain crops to improve nutrient and economic value. Such improvement would be particularly

important for those who depend on grain as their primary source of dietary protein.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.07 Food Security

Title: Food Insecurity and Overweight

Description: The number of overweight adults and children has steadily increased in the United States since 1995. In California, the largest increases have occurred in the low-income Latino population. Current research documents greater risk of overweight among low-income children and among food insecure children. Food insecurity may mean families have "limited or uncertain availability of nutritionally adequate and safe foods in socially acceptable ways." This study took place in six California counties, including San Joaquin County, in Spring 2001. Low-income Latino mothers (n=561) with one preschool age child (biological) were recruited from community-based agencies. Four types of data collection methods were used: 1) the USDA Food Security Scale; 2) a demographic record form; 3) a food inventory survey; and 4) measured heights and weights of mothers and children. Bicultural research assistants were hired and trained in each county to conduct interviews.

Impact: Overall findings from six counties: a) food insecurity related to overweight among the mothers but not children; b) significant association between greater food insecurity and lower household supplies of dairy, grains, meat, fruits and vegetables; c) lower variety of most foods in most food insecure homes, particularly fruits and vegetables, and d) mothers who experienced severe levels of food insecurity as children were somewhat more likely to now be raising children who were overweight. The study resulted in two abstracts/poster presentations, one research article, and six individual county reports, including San Joaquin County's report. Data from the study will inform further outreach efforts regarding obesity and food availability.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

NATIONAL GOAL 3

A healthy, well-nourished population. Through research and education on nutrition and development of more nutritious foods, enable people to make health promoting choices.

In California, five of the top ten fatal diseases (heart disease, cancer, stroke, diabetes and liver disease) are largely affected by poor diet, inactivity, and obesity. Poor diet and physical inactivity rank second only to tobacco in the number of premature deaths they cause. Childhood habits as they relate to food choices may persist into adulthood and as a result, influence an individual's risk for disease. Approximately 35,000 Californians will die annually from illnesses related to poor diet and physical inactivity. Regular physical activity reduces people's risk for heart attack, colon cancer, diabetes, and high blood pressure, and may reduce their risk for stroke. It also helps to control weight; contributes to healthy bones, muscles, and joints; reduces falls among the elderly; helps to relieve the pain of arthritis; reduces symptoms of anxiety and depression; and is associated with fewer hospitalizations, physician visits, and medications. Minorities have much higher chronic disease than non-Hispanic whites due to health disparities. In addition to the burden of avoidable human suffering, the related health costs total approximately \$15 billion annually, and even exceed those related to tobacco use.

A plethora of human epidemiological data indicates that improved nutritional and lifestyle practices will significantly reduce potential risks from chronic diseases including, but not limited to, many types of cancer, heart disease, non-insulin dependent diabetes, and osteoporosis. Better nutritional and lifestyle practices will also provide significant prenatal and postnatal benefits. Groups most at risk of nutrient deficiencies are children, women of childbearing years, substance abusers, and the elderly. Also, a disproportionate share of diet-related disease is borne by minority subgroups of the population. Forty-three percent of children in California live in low-income families (<200 Federal Poverty Level) in 2004, putting them at risk of food deprivation and making them vulnerable to under nutrition and other nutritional problems.

California research and extension professionals on the campuses and in the counties worked together to address health and nutrition issues affecting the complete spectrum of the state's citizens. Childhood obesity continues to be a major focus of research and extension programming in the state along with improving food resource management and nutrition practices. The primary focus is to impact the health and nutritional status of Californians. Specifically, our work has provided the capacity to measure cell proliferation and death rates in response to nutrients and note impact on their role in carcinogenesis and atherogenesis; to improve iron and zinc absorption; to measure the modulation of cancer risk in colonic epithelial cells; to assess insulin resistance and dynamic of

adipose tissue lipids and cells; to look at the chemistry of lipids in foods and tissues; to assess parent and household influences on calcium intake among preadolescents; to assess the merits of beer as a component of the diet; to identify determinants of early lactation success and infant feeding practices, growth and fatness; to assess bioavailability of vitamin A and zinc from selected foods of potential use for intervention programs in populations at high risk of deficiency; to test two treatment options for obese female restrained eaters; to look at how the school environment increases awareness about healthy habits; and to develop techniques for storing fruits that keep them fresh and juicy.

Eighty nine local extension programs were delivered in this area. In addition, five statewide collaborative workgroups composed of both AES and CE academics planned and conducted research and extension projects. In addition, UC ANR has one Statewide Program that brings together AES and CE resources and personnel that addressed critical issues in the state that are included within National Goal 3. Last year, California academics published 92 peer-reviewed articles to address Goal 3 and two patents were issued that addressed Goal 3.

UC-ANR's Human Resources Programs Covering:

1. **Human Health and Nutrition**

Research and Extension Performance Goals:

2. Identify interactions between nutritional status and health.
3. Identify the nutrition, health and lifestyle practices of California consumers who are at risk for nutrition-related health problems.
4. Identify unique food related behavior that put specific cultural groups at risk.

FY 2002-2003 Allocated Resources

Extension Federal Funds (Smith)	Extension State Match	Research Federal Funds	Research State Match
\$464,775	\$464,775 [11.50 FTE]	\$466,792	\$466,792 [36.70FTE]

Theme: 3.02 Human Health

Title: Beneficial and Adverse Effects of Natural, Bioactive Dietary Chemicals on Human Health and Food Safety

Description: In their continued studies of the modes of action and potential efficacy of dietary indoles as cancer preventive agents, UC researchers continued to characterize the antitumorigenic activity and underlying mechanism of action of these phytochemicals. Their major published findings for this period were that, a) DIM produced a concentration-dependent decrease in proliferation,

migration, invasion and capillary tube formation of cultured human umbilical vein endothelial cells and inhibited neovascularization and tumor growth in rodent models. b) I3C can block tumor cell proliferation by inhibition of CDK2 kinase activity by a mechanism that is accompanied by selective alterations in cyclin E composition, size distribution, and subcellular localization of the CDK2 protein complex. c) DIM can up-regulate the expression and stimulate the secretion of interferon-gamma in and human breast cancer cell line by a mechanism that involves activation of the JNK and p38 stress-activated kinase pathways. d) I3C can repress androgen receptor expression and responsiveness as a part of its antiproliferative mechanism in prostate tumor cells.

Impact: Results of their studies of the antiangiogenic effects of DIM establish the effects of the indole on the major steps in blood vessel formation in tumors. The determination that I3C can inhibit CDK2 by a mechanism that involves altered function of cyclin E provides a molecular target for I3C action in tumor cells. The observation that DIM can increase the expression of interferon-gamma by a mechanism that involves activation of certain stress-activated signaling pathways provides a rationale for identifying the primary molecular target for the immune modulating effects of DIM. Their finding that I3C can repress expression of the androgen receptor, combined with their previous observation that DIM is a potent antagonist of the androgen receptor, provides evidence that a formulation that includes both compounds or appropriate derivative may be highly useful against androgen-responsive prostate tumors.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-B, CA-D, CO, HI, ID, IL, MD, MI, OR, TX, UT

Theme: 3.02 Human Health

Title: Identification of Environmental Reservoirs of Salmonella Species

Description: UC researchers have made significant progress in the following areas: (1) They finished work and have a paper in press describing evidence that the carboxysome (organelle) made by Salmonella during growth on ethanolamine serves to conserve a volatile metabolic intermediate, acetaldehyde. Homologous organelles in cyanobacteria are thought to conserve another gas (CO₂) in support of photosynthesis. They suggest that both goals are achieved by the same mechanisms - maintaining a low pH compartment. (2) They found evidence that, contrary to previous believe, Salmonella cannot make dimethylbenzimidazole (the lower ligand of B12) but uses adenine instead under anaerobic conditions. Under aerobic conditions it must be given DMB (or B12 containing DMB). (3) They have used their finding, in a collaboration with others at UC Davis, to develop a new assay for uptake of B12 by humans. Their part was to produce B12 labeled specifically in one atom of B12. This compound is

fed to humans in amounts too small to detect by disintegration and is detected in serum by accelerator mass spectroscopy. (4) They have found that incorporation of adenine as the lower ligand of B12 requires formation of adenine free base which is activated by formation of adenine-adenine dinucleotide (a derivative of NAD). (5) They collaborated with a group at MIT in identifying a gene involved in DMB synthesis in Rhizobium. This work shows that B12 is essential for nodule formation by nitrogen fixers, which use the DMB form of the cofactor.

Impact: The carboxysome work is important because about 30% of CO₂ fixation on earth is done by bacteria, which requires carboxysomes. Despite this global importance, it is not clear how these organelles work and why bacteria make them. It further supports their notion that there may be natural environmental reservoirs of Salmonella (outside host organisms). The human B12 absorption assay is important because the only previous way of measuring this (the Schilling test) is cumbersome, non-quantitative, and involves use of radioactive cobalt - this test is seldom administered, even though many people are at risk for B12 absorption deficiencies.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.02 Human Health

Title: Host-Parasite Interactions in Malaria

Description: Sequestration in the microvessels of the deep tissues is a signal characteristic of the human malaria Plasmodium falciparum. The adhesion of P. falciparum- infected cells to the postcapillary endothelial cells in various tissues contributes to both the pathology of the disease (i.e. organ infarcts and coma) and parasite survival (i.e. the microaerophilic environment favors plasmodial growth while avoiding passage through and destruction in the spleen). UC researchers have identified a conformational change in a region of band 3 protein, called the DIDS-binding region that is involved in the enhanced adhesiveness of P. falciparum-infected erythrocytes to CD36 on the endothelial cell. Further, anti-peptide antibodies generated against an amino acid sequence of the DIDS-binding region (YETFSKLIKIFQDH) recognized P. falciparum-infected erythrocytes. In addition, sera from individuals living in a malaria endemic area (and who are presumably immune) contained immunoglobulins specific for this region of band 3. The anti-peptide antibodies reacted with the surface excrescences (knobs) on falciparum-infected erythrocytes. In uninfected erythrocytes the band 3 region was cryptic and its exposure on the falciparum-infected erythrocyte surface required clustering of band 3 protein. Thus, a parasite-induced modification of band 3 promotes adhesion and induces antigenic changes in the P. falciparum-infected erythrocyte. In an attempt to

identify other surface antigens of falciparum-infected erythrocytes (iRBC), antibodies were eluted from iRBC that had been treated with a pool of sera from malaria-infected individuals (IHS), and were used to screen a phage display library (PDL). After repeated panning of the PDL on immobilized antibodies, phage that selectively bound to IHS were accumulated. Of 23 randomly chosen clones that were sequenced, 13 individual sequences were detected at varying frequencies and 3 of the 13 sequences had homology with membrane proteins known to exist on iRBC. The majority of phage clones (7 out of 8 clones) selected after the 4th panning bound selectively to IgG in IHS. Specific binding of the selected phage to IgG in IHS was also confirmed using 24 IHS and 11 sera from uninfected individuals. One phage clone was the most frequently found in the sequenced clones after the 4th panning, and the binding of this clone to IgG in all IHS was greater than in any serum from uninfected individuals. A rabbit antiserum against the peptide expressed on the clone specifically recognized the surface of iRBC and resulted in iRBC haemolysis.

Impact: Malaria remains one of the world's greatest public health problems. At present, there are more than 300 million human infections and annually more than 3 million deaths, mostly children under 5 years of age. Because there is no protective vaccine against the most deadly of all the malarias, *Plasmodium falciparum*, identification of protective antigens remains a high priority. The surface antigens of the falciparum-infected erythrocyte, especially those involved in its increased adhesiveness, have been considered as prime candidates because they are exposed to the immune system for more than 24 hours. This work provides the basis for novel vaccines and therapies for falciparum malaria.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.02 Human Health

Title: Modulation of Cancer Risk in Colonic Epithelial Cells

Description: Epidemiological data suggest that obesity increases the risk of colorectal cancer in humans. To pursue this observation, a study was designed to determine whether C57BL/6J male mice, when made obese via consumption of a high-fat diet, were at greater risk of colonic cancer than their male littermates that remained lean via consumption of a low-fat diet. Risk of colonic tumorigenesis was assessed by numbers of aberrant crypts, aberrant crypt foci, colonic crypt cell proliferation and colonic tumors. Aberrant crypts and aberrant crypt foci were evaluated microscopically. Proliferation of the colonic epithelia was assessed histochemically following administration of BrdU. Availability of the procarcinogen, azoxymethane (AOM), to target tissues was assessed by quantifying, via HPLC, plasma AOM concentrations during the 60 min period

following AOM injection. The body weights of animals consuming the two diets were monitored weekly. AOM administration commenced after 45 weeks on diet, and when the average body weight of animals consuming the high-fat diet was about 1.7 times the weight of animals consuming the low-fat diet. These two groups will hereafter be referred to as the "obese" and "lean" groups, respectively. Lean and obese animals were injected with AOM (4 weekly injections at 15 mg/kg body weight for lean mice, and at 12.75 mg/kg body weight for obese mice) at doses that provided equivalent plasma AOM concentrations for these two groups of animals. Animals were sacrificed 6 and 32 weeks following the first of four AOM injections. Thus, animals consumed the diets for either 51 or 77 weeks. At both time points, the obese mice had significantly more aberrant crypts/colon and significantly more aberrant crypt foci/colon than the lean mice. Proliferation of colonic epithelial cells was higher for obese than lean mice as indicated by significantly higher values for labeling index and proliferation zone. No tumors were observed in the 51 week group as expected, since this group was sacrificed 6 weeks following AOM injection; and too few tumors were observed in the 77 week group to support a conclusion. Specifically, only 3 tumors were observed: 1 in the lean group of 14 mice and 2 in the obese group of 6 mice. The results of this study suggest that mice made obese via consumption of a high-fat diet are at higher risk of colonic tumorigenesis than are lean mice consuming a low-fat diet.

Impact: Epidemiological data suggest that persons who are overweight or obese are at increased risk of colorectal cancer. With the increased prevalence of overweight and obesity in children and adults in the US and elsewhere, this increased risk has the potential to greatly increase colorectal cancer incidence within the next 20 years. Strategies to reduce risk of colonic cancer in obese individuals are needed.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.02 Human Health

Title: Insulin Resistance and Dynamics of Adipose Tissue Lipids and Cells

Description: UC researchers have measured the effects of diet and insulin-sensitizing agents (PPAR- gamma agonist ligands termed glitazones) on adipose tissue turnover of cells and lipids. These measurements were made by use of the heavy water (2H₂O) labeling method that they developed recently for measuring de novo lipogenesis, triglyceride synthesis and DNA replication in living organisms, including humans. Leptin administered by mini-osmotic pump to genetically obese, leptin-deficient (ob/ob) mice reduced the markedly elevated rates of adipogenesis, de novo lipogenesis, and triglyceride synthesis present in

untreated mice to near-normal values, whereas caloric restriction (pair-feeding) did not alter adipose kinetics. Reduced or normal expression of lipogenic genes (by quantitative PCR of their mRNAs) in adipose tissue in these ob/ob mice did not correlate with the elevated fluxes actually present in the tissue. These studies demonstrate that this genetically obese mouse model is characterized by markedly elevated fluxes through lipogenic and adipogenic pathways which are driven primarily by leptin deficiency, not hyperphagia, and that mRNA levels may be misleading with regard to fluxes present in vivo. Studies in rats revealed that high-fat diet leads to weight gain and increased synthesis of adipose tissue triglycerides in several adipose depots. No increase in cell proliferation was observed in the mature adipocyte fraction in response to treatment with glitazones, however, indicating that glitazones do not stimulate clonal expansion of pre-adipocytes in vivo in this model. The relation between insulin sensitivity and adipose tissue dynamics was studied by use of the 2H -glucose disposal test (2H-GDT). Glitazone treatment of ob/ob mice, Zucker fatty rats or high-fat-fed rats increased insulin sensitivity by this assay. The improvement in insulin sensitivity induced by glitazones was independent of new proliferation of mature adipocytes in high-fat fed rats. Glitazones, like high-carbohydrate diets, increased glyceroneogenesis in rat adipose tissue, representing a mechanism for inhibiting fatty acid release from adipose tissue into the bloodstream. These results show that the relation between adipogenesis, lipid kinetics and insulin sensitivity is complex and that PPAR-gamma agonists may act by mechanisms other than increasing adipogenesis. Human studies using the same techniques (heavy water labeling for adipose tissue dynamics and 2H-GDT for insulin sensitivity) are in progress.

Impact: Obesity and related disorders, such as insulin resistance and diabetes mellitus, are enormous and growing public health problems. The techniques and results from this project provide direct information about the underlying biology and metabolism in fat tissue in obesity, in living organisms, including man. Relationships between the synthesis of lipids and the replication of new cells in adipose tissue in vivo may explain links between obesity, insulin resistance and diabetes, with implications for diet, genetic risk and therapeutic strategies.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.02 Human Health

Title: Bioanalytical Investigations Relating Dietary Constituents to the Development and Prevention of Disease

Description: This research in food chemistry, which relates to health and agriculture in the state of California, is appropriately aligned with the mission of

the Agricultural Experiment Station. The AES mission is served through interactions with UC CE specialists in several areas including examining the impact of pre-, and post-harvest factors on antioxidant microconstituent levels in tomatoes. During the past year, the specialists and researchers successfully competed for a University of California Agricultural and Natural Resources grant examining the levels of phytochemicals in a 12 year archive of tomatoes taken at the Long Term Research on Agricultural Systems (LTRAS) Project. The results from these studies indicate a strong correlation between crop management practices and the flavonoid content of tomatoes. These data help support sustainable agriculture efforts in the State of California. A UC researcher's laboratory has also undertaken studies characterizing the composition of flavonoids and procyanidins in date fruit at various stages of maturity. Recent efforts are focused on understanding how thermal processing (e.g. canning, microwaving and boiling) influence levels of flavonoids in broccoli and processed tomato products.

Impact: Their studies relating crop management practices with micronutrients in tomatoes help link agriculture with nutritional quality. The outcome of these experiments will be in the adoption of crop management techniques that can improve nutritional quality of food crops. Their studies of the impact of thermal processing (e.g. canning, microwaving and boiling) on the micronutrient levels of various fresh fruits and vegetables will help provide the framework for improving the nutritional quality of processed fruits and vegetables and ultimately mix foods.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.02 Human Health

Title: Drug and Disease Induced Trace Element Deficiencies

Description: The research investigated the effects of zinc and copper deficiency on fetal and early neonatal development. The UC researchers completed several studies on the effects of zinc and copper deficiency on oxidant defense mechanisms in the developing conceptus. They also completed studies on the effects of zinc deficiency on cell membrane integrity, the activation of certain key regulatory genes, and the effects of zinc deficiency on apoptosis. Finally, they completed two reviews on toxicant-induced zinc deficiency and disease-induced copper deficiency.

Impact: Their work provides evidence for the concept that a common cause of pregnancy complications is sub optimal maternal zinc and copper nutrition. Their work supports the concept that a common cause of developmental defects is excessive tissue oxidative damage. Finally, they show that diverse stressors can

induce a mineral deficiency in the conceptus.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.02 Human Health

Title: Effects of Nutrients and Toxicants on Human Health

Description: The research focuses on the regulation of neuronal cell signals by nutrients and toxicants. The UC researchers studied the regulation of transcription factor AP-1 in neuronal cells. They found that Zn deficiency leads to a rapid increase in neuronal oxidants that trigger the activation of AP-1. This can have a major impact in neurodevelopment since AP-1 participates in the decisions of cells to proliferate or die by apoptosis. Significantly, Zn deficiency caused a decreased cell proliferation and increased neuronal apoptosis. They have continued to work on the hypothesis that a combination of marginal Zn deficiency and lead exposure during gestation and infancy will have a serious impact on neurobehavioral and learning capacities later in life. In this regard, they have found that a condition of Zn deficiency increases the neurotoxicity of lead, leading to the activation of AP-1 and upstream events, and to neuronal death. Alterations in neuronal signaling can affect neuronal proliferation, differentiation, migration and death constituting one major mechanism underlying the deleterious effects of Zn deficiency on the nervous system.

Impact: Their studies indicate that zinc deficiency can have deleterious effects on the nervous system during development as well as in adulthood. A condition of zinc deficiency during gestation and infancy can increase the susceptibility of an individual to the adverse effects of select neurotoxic metals, which can affect neurobehavioral and learning capacities later in life.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.02 Human Health

Title: Gold Coast Collaborative

Description: The Gold Coast has a diversity of interest, cultures, geographies, communities and issues which offer opportunity and challenges in building healthier communities. The Gold Coast region reflects national trends towards increased obesity, less physical activity and reduced nutrition education in

schools, and competition from highly marketed, less nutritious food choices. The intent of the collaborative is to bring together community leaders and decision makers to be advocates for everyone in the Gold Coast to enjoy a community which supports healthful eating and physical activity. In reviewing national, statewide and county statistics, a collaborative group representing over a dozen organizations in the Gold Coast will promote policies that will reverse the disturbing childhood obesity trend. In times of reduced financial resources, it is better to organize actions that will prevent ill health than scramble to meet the far greater costs of treating intractable problems. In addressing the health of all Gold Coast citizens, the Collaborative has placed a special focus on the needs of children.

Impact: In less than two years, the Gold Coast Collaborative has received great press and media coverage. Their policy recommendations are intended to change the factors that contribute to children's overweight in their environment. Thus far, the Ventura and Santa Barbara School Boards have changed their vendor contracts, eliminated the sale of high sugar and high fat foods and beverages. The Forum in Ventura was attended by 250 and reported as a separate project, while the Santa Barbara Health Forum attracted 25 participants and the Youth Forum had 75 attendees. Salad bars and gardens are featured in every Ventura Unified elementary and junior high school. Children are eating crops they harvest. Each county is developing different outcome measures to determine effectiveness. School principals and food service staff see increased fruit and vegetable consumption. The Collaborative has three goals: 1) Convene a Forum of experts and stakeholders to identify strategies to address the obesity epidemic; 2) Address Children's Environments: Ensure children have healthy food options, quality physical education and facilities for active play, (eliminate marketing of high-fat and high sugar foods/beverages, discontinue exclusive soft drink and fast food contracts, promote safe routes for walking and biking to school, incorporate nutrition and physical activity education standards into core curriculum and develop and enforce nutrition and physical activity); 3) Implement and Enforce Laws for physical activity and safe routes to school.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Measurement of Cell Proliferation in Response to Nutrients: Role in Carcinogenesis and Atherogenesis

Description: Substantial progress was made toward the UC researchers' goals of understanding the role of nutrients in modifying cell proliferation and the risk for cancer and vascular disease. First, accurate, high-throughput techniques

were developed for measuring the proliferation rates of breast epithelial cells (BEC), colonocytes and skin epithelial cells (keratinocytes), both in rodents and humans. These techniques involve no radioactivity or other risks. Carcinogens increase the proliferation of skin epithelial cells in mice, while anti-mitotic agents such as the soy-derived peptide lunasin reverse this effect. Dietary carcinogens increase colonocyte proliferation in rats, and dietary curcumin or non-steroidal anti-inflammatory agents do not block this. Genistein, a phytoestrogen derived from soy, reduced BEC proliferation in rodents but only when provided in both pre-weaning and adult phases of life. Human BEC proliferation, measured from percutaneous needle biopsies or ductal lavage, exhibited higher values in premenopausal women than post-menopausal women and exhibited considerable variability among women, that could reflect effects of diet. Dietary caloric restriction (30% reduction) reduced the proliferation rate of keratinocytes and MEC in mice. Interestingly, feeding mice three times per week with only 5% caloric reduction reproduced most of the effects on cell proliferation of much more stringent calorie restriction, suggesting that intermittency of feeding may have potent impact on cell proliferation and may provide a feasible practical alternative to severe restriction in the clinical setting. The proliferation rate of cells in human skin was established indirectly by non-invasive sampling of skin keratin kinetics. Finally, high-fat diet interacts with genetics to alter vascular smooth muscle cell (VSMC) proliferation in the aorta of mice. The combination of apolipoprotein E knockout plus high-fat diet increased VSMC proliferation much more than either alone.

Impact: The ability to measure the proliferation and death rates of cells in vivo in animals and humans with accuracy and ease opens many research questions to experimental inquiry. The activity of agents proposed to have cancer-protective actions (e.g. estrogen modulators, soy-derived phytoestrogens or mitosis-inhibitors, caloric restriction, Brassica-derived agents) has now been tested in living organisms. Hypothesized health benefits or adverse effects of these factors can thereby be subjected to experimental testing. Improved understanding of the prevention, detection and treatment of disease may result from these new techniques that they have developed.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Improving Iron/Zinc Nutrition

Description: The UC researchers developed and validated a method to measure exogenous zinc absorption by using small doses of ^{65}Zn and its urinary excretion. This method opens the possibility of measuring zinc absorption in

populations. Double stable zinc isotopic methods are applicable only for clinical studies. They developed a method to measure total hemoglobin (Hb) mass and blood volume by inhalation of a measured small dose of carbon monoxide. This method will be used in studies of conditions where Hb concentration varies because of dilution with plasma (i.e. in pregnancy and possibly in the elderly). In collaboration with Mexican and Argentinean colleagues, have determined the advantages and safety of delaying cord clamping by providing additional iron to the newborn resulting in significantly greater iron stores at 6 months of age. This practice should be adopted as routine perinatal care to prevent iron deficiency during the first year of life. In collaboration with the Mexican National Institute of Perinatology, they have shown that routine administration of daily iron-folic acid supplements to pregnant women produces oxidative stress using the method they developed to measure breath ethane, TBARS, and hemoconcentration, starting soon after supplementation is started in a significant proportion of pregnant women. These conditions result in increased risk of low birth weight and prematurity. Data on the effect of total supplemental iron ingested during pregnancy in Indonesia confirm the above effect of iron on hemoconcentration. These undesirable effects are not observed when iron-folic acid is administered only every week, while having the desirable preventive effect on the development of gestational anemia. Infants at age six months born from mothers who received daily supplements had delayed brain transmission of auditory stimulus compared to infants born from mothers that received weekly supplements, suggesting defective myelination in the former group of infants. These results provide the scientific basis for interventions to reduce oxidative stress during gestation. Field studies on the interactions of zinc and iron supplementation in pregnancy (conducted at WHNRC at UC Davis) and in non-pregnant women consuming diets representative of Mexican urban and rural diets, in collaboration with the Mexican National Institute of Public Health have been finished. They used only stable zinc and iron isotopes. Analytical results are in progress in collaboration with a colleague from the California Department of Public Health. Iron absorption varies little between rural and urban diets. Zinc absorption is being measured. These studies provide information on interactions between zinc and iron on the regulation of their absorption in pregnancy. Bioavailability of zinc and iron from beans selected for being rich in these metals has shown that only total zinc absorption is improved. This has practical as well as basic information to be considered on the possible benefits from genetically modified beans. Studies on the mechanisms affecting the bioavailability of metals are in progress using in vitro digestions and dialysis, and Caco 2 cells. Chelation with EDTA improves both.

Impact: These studies have strengthened the concept that preventive iron supplementation administered on a weekly dose rather than daily is as effective, more efficient and safer, based on oxidative stress measurements. Now there are several countries that are adopting this strategy and WHO is recommending this preventive strategy for infants, children and women of childbearing age. They have developed methods that will foster the measurements of zinc absorption in

population groups and that will clarify the significance of low hemoglobin levels when hemodilution takes place. They have explored the interactions between iron and zinc absorption and metabolism in pregnancy and when diets vary, including the bioavailability of iron and zinc from bean cultivars that are rich in iron and zinc, stressing the importance of bioavailability measurements in order to evaluate the nutritional impact of such species.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Chemistry of Lipids in Foods and Tissues

Description: Research has sought to understand how lipids alter the mechanistic machinery of animals. Using a strategy of feeding animals diets varying in only the amount of long chain polyunsaturated fatty acids they have been able to define the various consequences on the metabolism of these animals. These studies found that the inclusion of polyunsaturated fatty acids to the diets of these animals had both acute metabolic effects, i.e. altered the membrane composition of cells and tissues, but also influenced the expression of families of genes in these animals (Mutch et al. FASEB J). Some genes were expected, e.g. those responsible for adding double bonds to fatty acids, but the overall metabolic machinery of the animals was altered as well. The gene encoding the enzyme stearoyl CoA desaturase 1 was down-regulated in response to feeding arachidonic acid. This gene has been implicated in the development of obesity and predisposition to diabetes that is a consequence of obesity. These results imply that arachidonic acid in the diet acts to alter the basic energetic machinery in cells and could represent a novel strategy for understanding and ultimately preventing the energy dysregulation that can lead to obesity. Studies have also examined the consequences of consuming milk. There are excellent scientific reasons to study milk since this is the only biomaterial that evolved for the express purpose of nourishing mammals. Therefore they have been interested in understanding how milk affects overall metabolism and in particular energy metabolism, a particular challenge to the young neonate. Milk has also proven to be not just a supplier of nutrients but is emerging as a model of how diet can be an important controller of overall metabolism, improving the storage of excess lipids as adipose and avoiding the inappropriate accumulation of energy intermediates in blood (Smilowitz et al. Aust. J. Dairy Tech.). Because metabolic dysregulation is emerging as such a problem to human health they have continued to develop the technologies necessary to measuring metabolism in a comprehensive manner and especially with the accuracy and precision necessary to be able to detect the normally subtle consequences of consuming dietary fats and other macronutrients

(Ninonueva et al., Electrophoresis, German et al., Metabolomics). They have also been requested to provide conceptual articles as the means to educate and recruit the larger nutrition community in the USA and around the world to the applications of this approach both for scientific research in Nutritional Sciences, but also to its ultimate applications as foods for human health (Zeisel et al., JN, Gibney et al. AJCN). It is also important to understand how the modern food consumer receives information about foods and diets, how the consumer interprets this information in terms of their own health and how these sources of information ultimately influence food choices. They have examined the internet as a very modern and potentially revolutionary information source for consumers about foods and diets, their risks and benefits (Moskowitz et al. CRFSN).

Impact: The lipid components of food provide desirable organoleptic properties to consumers, challenges to agriculture in quality and safety and are implicated in the overall health consequences of foods and diets. To improve the overall quality of foods and diets, it is necessary to build an integrated view on the lipids to understand simultaneously their benefits and liabilities. Polyunsaturated fatty acids exhibit metabolic effects but also influence the expression of multiple genes in animals (Mutch et al. FASEB J). Milk is a model of how diet can be a controller of overall metabolism (Smilowitz et al. Aust. J. Dairy Tech.). They have developed technologies to measure the consequences of diet (Ninonueva et al., Electrophoresis, German et al., Metabolomics), and been invited to recruit the nutrition community to this approach (Zeisel et al., JN, Gibney et al. AJCN). It is important to know how the food consumer receives and interprets information about foods and diets in terms of their own health and how these sources of information ultimately influence food choices (Moskowitz et al. CRFSN). Altogether the research is illustrating that critical knowledge of dietary fats is still lacking and designing optimal foods and diets will require the means to both understand the metabolic differences between individuals and to understand the metabolic consequences of consuming different dietary fats. Professional scientists such as dieticians will need to acquire a greater knowledge of how to guide individual consumers to optimal diets (German et al., JADA).

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Parent and Household Influences on Calcium Intake among Preadolescents

Description: This project recognizes that family knowledge and expectations play a significant role in young people's choice of food. It strives to create opportunities to strengthen nutritional knowledge and family ties. California

developed a set of parent/child joint food preparation activities and published them in a book, *Bone Appetit!*. The book includes food safety and nutrition pointers as well as directions for joint or individual preparation of calcium rich foods. An evaluation component is part of the product. Twenty-five teams participated with more scheduled. Response from parents and children has been very positive. This cookbook is available to other states as a thank you for completing the research instrument. It may also be used as central component of a follow up study on the effect of nutritional interventions. California also tested the parent intervention research instrument and the pilot test of the parent and child evaluation with Hispanic households.

Impact: The results of this project will be used to identify factors that influence the calcium intake of young adolescents. This information can be used in designing effective, tailored nutrition interventions for young adolescents and their parents. An improvement in calcium intake among young adolescents may reduce the future burden of osteoporosis. The book *Bone Appetite!* can be used to teach food safety and nutrition by the researchers in collaborative universities.

Funding Source: Multistate Research and State

Scope of Impact: AL, AZ, CA-D, CO, HI, IN, MI, MN, NM, OR, Utah Cooperative Extension, WA

Theme: 3.03 Human Nutrition

Title: Perceived and Actual Merit of Beer as a Component of the Diet

Description: Three elements of this research project have progressed substantially during the year. In addition, work continues on the assimilation of material for a database on "beer and health." A. fiber and prebiotics in beer. Methods have been developed for the assay of soluble fiber and prebiotic substances in beer. One method in particular has particular utility: it uses specific enzymes for the degradation of these substances. There is substantially more low molecular weight prebiotic material than soluble fiber (high molecular weight) in beer but the combined levels are sufficient to suggest that beers can contain useful levels of these substances. A further facet of this work has been their research upstream in the process in unraveling the enzymology of cell wall digestion during the malting of barley and the mashing of malt. They have made a characterization study of esterase enzymes that cleave ferulic acid and acetic acid from the wall polysaccharides, part of the process whereby molecules are solubilized (i.e. soluble fiber production). Other factors that impact the level of soluble fiber and prebiotics are exogenous enzymes added during mashing, and the relative efficacy of these has been explored. B. antioxidants in beer. A range of methods for assaying antioxidant levels has been explored to show that the ranking of beer in comparison to other beverages, including red wine, very much

depends on the assay selected. There is clearly significant antioxidant potential in beer. One of the molecules involved is the ferulic acid released by the esterases (see a above). Other contributors are the polphenolics, and they have been examining the extent to which these are removed from beer by different stabilizing agents. C. the perception of beer. Using questionnaires and study groups, they have demonstrated that the common preconception is that beer is inherently unhealthy and certainly less beneficial in the diet as compared to beverages such as red wine. However, when individuals are alerted to the beneficial components that are found in beer, including vitamins, antioxidants, fiber and the anti-atherosclerotic impact of moderate alcohol consumption, the ranking of beer improves. Their work in exploring the importance of consumer issues such as the use of genetically- modified materials and novel processing techniques has resulted in several publications in the general press. Of particular significance has been their debunking of myths to do with beer in the context of so-called "low carb" diets.

Impact: The work on fiber and prebiotics will inform brewers in respect of strategies to design beers with substantial levels of these useful substances. It will be of value also to users of barley in the production of other foodstuffs. The work on carbohydrates generally and their reminder to brewers that it is alcohol, not carbs, that is the primary calorie source in beer, will help them in the design of genuinely low calorie beers. The work on antioxidants reinforces the understanding that these materials cannot be compared for efficacy, content in food or benefit to the body simply on the basis of a single assay, as is too often claimed. It will help people select reasonable collections of assays to make judgments on antioxidants. The psychophysics work will be of value to consumers and brewers alike in helping to clarify beer's status in the context of an acceptable diet and lifestyle.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Characterization of the Nutritional Sensing Signal Transduction Pathway of Myxococcus Xanthus

Description: The long term goal of this project was to focus on understanding how M. Xanthus recognized starvation and utilize various nutrients. UC researchers focused on 1) role of omega-4469 and determined its role in nutrient sensing; and 2) the role of early developmental mutant on their ability to "predate" or utilize other soil bacteria and fungi as sole sources of nutrients. They developed a novel predation assay and determined the role of several

developmental and motility mutants on predation. They have entered into collaboration with the USDA/ARS to further these studies in the field.

Impact: These bacteria produce many antimicrobials including antifungals and antibacterials. These compounds are presumed to be used as predation agents, to kill and digest prey organisms. Many of these are controlled by the same regulators that regulate the developmental program. Their work has demonstrated a clear connection between stationary phase, development and predation. In addition, this work has aided in their understanding as to how cells regulate the production of these economically and agriculturally important compounds.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Nutrient Bioavailability - Phytonutrients and Beyond

Description: Optimizing folate status requires continued monitoring of erythrocyte (RBC) folate and folate intake. The accuracy of RBC folate assays remains a concern. Therefore, the researchers measured RBC folate with 4 different assays, examined the inter assay correlations, and compared RBC folate with folate intake as measured by an abbreviated folate-targeted food/supplement screener. Their design was a 4 x 2 x 2 factorial, 4 assays in pregnant and non pregnant women before and after each group received a folic acid supplement (1814 nmol/d) for 30-60 d. Folate assays included L. casei, chemiluminescence, GC-MS, and radioassay (RA). The screener had 21 questions (19 diet, 2 supplement) and measured usual and customary intakes of dietary folate equivalents (DFEs). Inter assay correlations were highly significant. RBC folate levels were highly correlated with folate intake when measured with their folate-targeted food/supplement screener that is now available on the internet. Their new LC-MS/MS method provides enhanced sample throughput as compared to their GC/MS methods. LC-MS/MS will enable accurate measurements of red blood cell (RBC) folate in nutrition surveys and clinical trials.

Impact: Their folate-targeted food/supplement screener that is now available on the internet (<http://nutritionquest.com>) when coupled with their LC-MS/MS analytical method for RBC folate will enable accurate measurements of folate nutritional status in nutrition surveys and clinical trials.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-B, CA-D, CO, CTS, IN, KS, ME, MA, MI, NE, NM, OK, OR, WA

Theme: 3.03 Human Nutrition

Title: Determinants of Early Lactation Success and Infant Feeding Practices, Growth and Fatness

Description: In 2005, UC researchers began work on two new projects: a) a prospective cohort study of primiparous women recruited prenatally whose lactation success is assessed at 0, 3, 7, 14, 30 and 60 days postpartum, and b) qualitative and quantitative studies of the relationship of infant feeding practices to child obesity in low-income populations. For the first project, they completed several pilot studies, developed and translated the interview questionnaires and assessment tools, and recruited and trained staff for the large cohort study. For the second project, they completed a small randomized educational trial to promote responsive feeding among bottle-feeding mothers in the WIC program, and began conducting focus groups on introduction of solid foods. In the educational trial, they had an impact on knowledge and attitudes of mothers regarding avoidance of over-feeding, but there was no effect on feeding behaviors or the amount of formula consumed by their infants. The desire for a quiet baby who sleeps through the night is a powerful barrier to behavioral change regarding infant feeding practices. Their qualitative studies are designed to develop strategies for overcoming such barriers.

Impact: Their project on early lactation success is aimed at increasing the percentage of women who are able to breastfeed exclusively during the first two months postpartum. Although the breastfeeding initiation rate in the US has now reached ~70%, there has been little progress regarding the percentage of mothers who are exclusively breastfeeding during the first several months postpartum. There are numerous societal and economic benefits to increasing rates of exclusive breastfeeding, primarily related to improvements in infant and maternal health. Their project on infant feeding practices in low-income populations is geared towards reducing child overweight, which is strongly related to excessive weight gain during the early months of life. They have developed and tested several educational messages to improve knowledge and attitudes towards appropriate infant feeding practices. Their long-term goal is to develop a comprehensive set of messages and educational tools, and assess their impact on child overweight.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Bioavailability of Vitamin A & Zinc from Selected Foods of Potential Use for Intervention Programs in Populations at High Risk of Deficiency

Description: During the project period, the UC researchers learned that: 1) micronutrient-fortified complementary foods are a suitable means to enhance iron and vitamin A status of infants at risk of deficiency; 2) zinc supplementation reduces the risk of diarrhea and pneumonia among children in low-income populations; 3) zinc supplementation increases growth of stunted (but not non-stunted) children; 4) multiple micronutrient supplementation increased the growth of Mexican infants; 5) NaFeEDTA enhances iron absorption from a fortified, cereal-based complementary food; 6) reduction of the phytate content of common cereals by genetic modification increases iron absorption; 7) zinc fortification does not adversely affect sensory properties of wheat products; 8) zinc is absorbed equally well from foods fortified with either zinc sulfate or zinc oxide; 9) spinach and orange sweet potatoes contribute to the vitamin A reserves of adult men, and vitamin A bioavailability from these sources is consistent with recently updated dietary reference intakes; 10) maternal nightblindness during pregnancy responds to food sources of vitamin A (liver, spinach or carrots) as well as vitamin A capsules; and 11) zinc intakes of a high percentage of US pre-school children exceeds recommended upper limits.

Impact: These results have important implications for developing strategies to enhance micronutrient intake and status of populations at risk of deficiency. Moreover, the findings emphasize the importance of selected micronutrients for maintaining children's growth and preventing common childhood infections. The results of the vitamin A absorption studies indicate that plant-derived sources of vitamin A can satisfy physiological requirements of this nutrient.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Biological Activity of Recombinant Human Milk Proteins

Description: Recombinant human milk proteins are being produced in the milk of transgenic animals and in plants. These proteins may subsequently be added to infant diets. The objectives of this project are to study: 1) the effect of different heat treatments necessary for manufacturing infant diets, and 2) the effects of low pH and proteolytic enzymes on the stability and physiological activity of recombinant milk proteins. The iron-binding protein lactoferrin and the enzyme lysozyme were chosen as model proteins, partly because they provide physiological functions, partly because the recombinant proteins are available in

significant quantities. Recombinant human lactoferrin (Lf), lysozyme (Lys) and AAT were subjected to different heat treatments, pH and proteolytic enzymes in solution and as a component in infant formula. The treated proteins were evaluated with regard to receptor-binding using human cells (Lf), and their ability to inhibit the growth of pathogenic bacteria (Lf, Lys). The stability of recombinant human milk Lf and Lys expressed in and purified from rice was studied in vitro and shown to exhibit similar characteristics to those of the native proteins. Recombinant and native Lf and Lys AAT were exposed to different temperatures, pH and digestive conditions mimicking those of the infants gut and their activities were investigated after these treatments. Lf and Lys resisted heat treatment, low pH and proteolytic enzymes and both proteins were able to inhibit the growth of enteropathogenic E.coli (EPEC) in vitro. Lf and Lys maintained their iron-binding and enzymatic properties to an extent similar to the native molecules. Thus, these recombinant human milk proteins are active and may remain so in the infant gut. The UC researchers evaluated this hypothesis by adding recombinant human milk Lf and Lys to oral rehydration solution (ORS) used to treat diarrhea. Children in Peru with acute diarrhea were treated with this experimental ORS, which in a double-blind design was compared to conventional ORS solution. Duration of diarrhea was significantly shorter in children fed experimental ORS and significantly more children had solid stool by 48 hrs. This demonstrates that recombinant human milk Lf and Lys can have health benefits in children with diarrhea.

Impact: Recombinant human milk proteins can now be produced in rice in large quantities. Proteins with biological function, such as Lf, Lys, alpha-1-antitrypsin, haptocorrin and lactoperoxidase may therefore be added to infant formula. They have already successfully produced recombinant human lactoferrin, lysozyme, AAT, haptocorrin and lactoperoxidase, which are present in breast milk, at high levels in rice. Addition of recombinant lactoferrin and lysozyme have now been shown to shorten the duration of diarrhea in children. Thus, a novel anti-infective formula may be developed that can protect formula-fed infants against infections. This may have significant health consequences in both less developed and industrialized countries.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: The Impact of Eliminating Sodas in the School Environment on the Calorie and Calcium Intake of Adolescents

Description: Initial work includes a phase for the development of a nutrition and health policy with selected schools and school districts to encourage the

establishment of a healthy school environment. A current challenge that this project addresses is the pressure on the school system to adopt established national and state academic content standards, align local curricula and student assessments with the standards, and be accountable for improved student outcomes as measured by standardized student examinations. Knowledge and skills are often considered appropriate primary outcomes. These include behavioral capabilities or the information and skills needed to eat a more nutritious diet and the critical thinking skills and procedural knowledge needed to analyze and make informed judgments on complex food and nutrition-related issues. As part of this project, the UC research group has developed a model program that incorporates agriculture into the school environment. It includes every part of the school environment, from gardens, to the cafeteria, to the classroom, as part of a consistent and repetitive message to students, that healthy eating habits can be learned through participation in the full cycle of life from seed to table and back again. California principals and teachers have been surveyed with respect to their use of gardens as part of the school environment. Results from these studies suggest that fourth grade teachers predominately use school gardens to enhance academic instruction, which is in strong agreement with principal responses obtained previously. The model program will be implemented and evaluated in selected schools in California and will include teacher and staff training to establish the following program components: 1) salad bars, 2) nutrition and gardening education, 3) composting and waste reduction and 4) development of a school food, nutrition and health policy. As part of the nutrition education portion of this project the UC research group is developing and assessing nutrition curriculum materials for multiple grade levels. Reading Across My Pyramid (RAMP) is a literacy promoting nutrition education curriculum targeting lower elementary students. Through the use of nutrition related books, RAMP aims to increase the nutrition knowledge of students while fostering the development of reading skills. As part of the evaluation, a short survey based on topics covered in RAMP lessons was developed and tested for clarity. Revisions were made accordingly and the survey was used in Contra Costa, Fresno and San Diego Youth FSNEP (N = 62) to evaluate RAMP. A parent survey was also used to determine correlations between the responses of children and their parents. Data showed RAMP to be effective at increasing the importance of exercise in the minds of children, knowledge that the heart pumps blood through the body, and knowledge that computer use and television watching are not exercise. A correlation was also observed between parent reported hours of television watching by their child and the child's knowledge that computer use and television watching are not exercise.

Impact: A comprehensive school health program, that includes involvement from families, communities, and health professionals, may be able to overcome obstacles, such as lack of parental involvement or classroom time, by bringing individuals together to support a common vision, therefore facilitating efforts focused on a sustainable healthy school environment. Their long-term project goal is to evaluate the efficacy of using the school environment to link schools

with families and communities to promote healthy lifestyles that will assist in the reduction of obesity prevalence among children. Specifically, they will introduce a comprehensive school health policy that envisions every part of the school atmosphere, from the playground to the cafeteria, to the classroom and then to the community, as part of a consistent and repetitive message to students; that healthy lifestyle habits can only be taught to children when there is participation of the entire community.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Obese Female Restrained Eaters: Two Treatment Options

Description: This study was done in collaboration with scientists at the USDA Western Human Nutrition Center. They studied restrained eaters. These are individuals (mostly women) who are chronically concerned about their weight and attempt to control or reduce their weight by reducing their energy intake. They studied obese female premenopausal women (n=78, ages 30-45 yrs) who were restrained eaters. Paper #1 (Bacon et al 2002), examined a non-diet wellness intervention. Subjects were randomly assigned to a control group (behavioral energy restriction) or an experimental group (non-restrictive program: reduce restrained eating, encourage eating in response to physiologic cues, improve body- acceptance). Paper #2 (Bacon et al 2004) measured bone mineral density (BMD) and content (BMC) of spine and femur with emphasis on the relationship between bone mineral content (BMC), determinants of bone mass, current eating behaviors, dietary intake, physical activity, and indices of calcium regulation, bone metabolism, stress and inflammation. Obese subjects are thought to be at low risk for osteoporosis due to increased body weight and estrogen on weight-bearing bone. Research involving eating behaviors identified an association between high levels of restrained eating and reduced bone mass. Women, 31%, had osteopenia/osteoporosis (osteo). In osteo women, 87.5% had osteo based on lumbar spine, whereas only 12.5% had osteo based on femur. No differences were observed between osteo women and non-osteo women for current eating behaviors, dietary intake, physical activity habits, bone turnover, calcium regulation, stress and inflammation. A significant positive correlation between BMC and energy expenditure ($r=0.256$), and a significant negative correlation between BMC and number of times on a weight loss diet ($r= -0.250$) and cognitive restraint ($r= -0.239$) were observed. P#2 (Bacon et al, 2005) reported on the two year follow-up of women in the diet group (control) and compared them with women in the health at every size nondiet group (HAES). Attrition was high in control group (41%), compared to 8% in HAES Group. The Diet Group showed initial improvement in many variables (weight, low-density lipoprotein,

systolic blood pressure, energy expenditure, hunger, disinhibition, bulimia, body dissatisfaction, interoceptive awareness, depression, self-esteem) although only the improvement in disinhibition was sustained at two year follow-up. The HAES group improved in all of the above variables except weight, which was unchanged, and sustained these improvements at two years. Fifty percent of both groups returned for two year evaluation. HAES group maintained weight, improved in all outcome variables, and sustained improvements. Diet Group lost weight and showed initial improvement in many variables at one year; weight was regained and little improvement was sustained.

Impact: Forty to seventy percent of US adults are trying to lose weight, yet obesity is on the rise. It is well known that weight loss (5-10% of initial body weight) can decrease blood pressure, decrease blood lipids and improve insulin sensitivity. If obese people are prediabetic, it can also improve glucose tolerance. Since dieting does not cure obesity for many people, they evaluated a program that encouraged healthful eating, self-acceptance and improving other health habits. Their hypothesis was that improved health for obese women does not have to include weight loss. They found that size acceptance which included a reduction in dieting and a heightened awareness of body signals enabled participants to maintain long-term behavior and health change. Finally, it is important to monitor obese women for osteoporosis/osteopenia including areas like the lumbar spine (which are not weight bearing).

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: California Cuisine: Historical Food Trends in California.

Description: Research on food patterns in Spanish, Mexican, and Gold Rush Era California has been initiated in central California archives/libraries/museums (Bancroft Library, Huntington library, Sacramento State Library, Santa Barbara Mission Archive, Sutters Fort Archive). The focus has remained on how and under what circumstances chocolate was used as both medicine and as food. Documents written by Father Junipero Serra reveal the widespread use of chocolate throughout the early California Mission Era. Diaries produced by General De Anza reveal the introduction of chocolate to California via Sonora, arriving at the San Gabriel Mission in 1776. More telling are the Gold Rush Era diaries examined that provide information on chocolate prices and use of chocolate as a common beverage of miners. Spanish and Mexican Era cookbooks housed in the Los Angeles County Library will be a focus of their efforts during the coming summer.

Impact: Understanding the historical basis of food patterns in Spanish, Mexican, and Gold Rush Era California provides insights on the current patterns of selected minority groups in California in the 21st century. The information generated from this project will be useful in developing culturally-sensitive nutrition education materials to professionals working in the US Department of Agriculture food assistance and nutrition education programs, including the federal Special Supplemental Nutrition program for Women, Infants, and Children, and the Food Stamp Nutrition Education program.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Improving Access to Health Care for Large-sized Women

Description: The UC researcher's study is the first one designed to gain insight into the perspectives of obese women, especially those with BMI greater than 55, concerning access to health care. The attitudes and practices of overweight women differ substantially along the spectrum of BMI, and the barriers increase in prevalence and severity with the size of the women. The design was purposeful sample of 498 women with Body Mass Index (BMI) from 25 to 122 kg/(m-squared), including 60 women with BMI greater than 55, who were surveyed concerning their access to preventive gynecological cancer screening and barriers to delay in gynecological cancer screening. Gynecological health care providers (N = 129) were surveyed concerning their education, resources, practices, and attitudes about providing care for obese women. Obese women reported that their weight is a barrier to receiving quality health care, and that weight-related factors influenced their delay in obtaining gynecological cancer screening tests. Women with a BMI greater than 55 had significantly less regular screening with Pap compared to those in other BMI categories. Women who reported that they delay health care because of their weight were significantly less likely to have timely pelvic examinations, Pap tests, and mammograms than the comparison group; even though, they reported that they were "moderately" or "very concerned" about cancer symptoms. These women were significantly more likely to have been on weight loss programs five or more times. The barriers that the women reported that negatively influenced their getting timely cancer screening tests included medical equipment that was too small, negative attitudes of providers, unsolicited advice to lose weight, disrespectful treatment, and embarrassment at being weighed. Many health care providers reported that they had little specific education concerning care of obese women and were not satisfied with the resources and referrals available to provide care for large women. The conclusion of the research is that a significant proportion of obese women delay routine cancer screening tests because of weight-related barriers.

These barriers increased in severity with the size of the woman and were especially severe for women who were BMI greater than 55. Strategies to encourage regular gynecological cancer screening tests must confront the reasons for reluctance for the women to undergo the tests.

Impact: This research proposes to investigate the barriers that obese women face when trying to access health care and nutrition information. Women make the majority of health related decisions for families; given the strong genetic contribution to higher body weight, empowering large women to obtain quality care could impact the health of their entire family.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Something Fresh and Juicy

Description: Between 2001 and 2005, the percentage of overweight and obese children and adolescents in California increased by 6%. This increase in obesity is largely due to poor eating habits and inadequate physical activity. In 2005 California spent \$28 billion on obesity-related costs. Obesity and related costs could be substantially reduced by serving more healthful school lunches. School lunch programs are designed to provide a substantial portion of age-appropriate daily nutrition, but many schools still rely on packaged foods and high-fat items that are not healthful for children. Often district and food service administrators are not convinced that students will accept more healthful selections. UCCE Monterey County Nutrition Education staff initiated a foto novela project, "Fast Food High School," with high school students. The students wrote three separate nutrition-related stories. They explored critical issues and pressures of life they experience living in a "supersized" environment. They also developed learning materials to address the key pressures they identified, such as popularity, familial diabetes, and quick weight loss schemes. In the third edition, UCCE staff and the Health Academy students at Alisal High School articulated their concerns about the healthfulness of school food. These concerns attracted the attention of school district administration and the Centers for Disease Control (CDC) "Steps for a Healthier Salinas School Health" consultant.

Impact: The school district was already discussing the feasibility of offering salad bars at three selected schools in the fall 2006 semester. Concurrently, but separately, Alisal High School (AHS) students began to develop their foto novela, voicing their concerns about the lack of healthful food choices. The project led to collaboration among UCCE staff, the AHS Health Academy educator, the Food Service Director, the CDC grant subcontractor and high school administrators to

build a salad bar in advance of the original plans. Students and farmers from the Agricultural Land-Based Training Program donated fresh produce. The joint effort resulted in students literally enjoying the fruits (and vegetables) of their labors. The decision to extend the fresh salad bars to all district high schools makes them available to 14,252 students, exceeding the original goals of all participants.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Changing the School Environment Increases Awareness about Healthy Habits

Description: In the past, people were aware of the important role farming played in their lives. Children, especially, have lost touch with how and where food is grown. They lack an understanding of the ecosystems, the land, the people, and even the plants that produce their food. Many school districts throughout California have shown an interest in “stepping out of the box” of traditional teaching methods to incorporate agriculture into several aspects of the school environment. This provides an excellent avenue in which to discuss food – where it comes from, its health benefits, how to choose healthy foods, factors contributing to human health, as well as concepts important to planetary health, such as, composting and recycling.

Impact: Kindergartners participating in this project learned to identify that MyPyramid is a tool to assist with dietary choices, what plants need to grow, why milk is important, and that dancing, not computer use or television watching, is a form of exercise. The kindergartners also decreased their soda consumption. Fourth and fifth graders participating in this project learned what foods are flowers, what nutrients provide their body with energy, why calcium is important, how many food groups are in a particular meal, messages from MyPyramid regarding grain and vegetable choices, what measuring your pulse tells you, what aerobic exercise is, what a healthy goal is, and how to identify food marketing schemes. The fifth graders also increased fruit and decreased cookie consumption. The results show that this school wellness program can be a successful means by which to increase awareness about the importance of proper nutrition and physical activity among participating students.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

NATIONAL GOAL 4

Greater harmony between agriculture and the environment. Enhance the quality of the environment through better understanding of and building on agriculture's and forestry's complex links with soil, water, air, and biotic resources.

Over the past year, UC ANR continued to address identified issues that are core to its programs. This process of issue identification strengthened the commitment of UC ANR to National Goal 4 through focused efforts on these Core Issues. The Core Issues pertinent to Goal 4 include Invasive Species, Sustainable Use of Natural Resources, Water Quality, Organic Production, Soil Quality, Waste Management, and Air Quality. ANR has made the commitment to provide additional resources, when available, to target these issues.

This focusing of effort resulted in significant progress by UC ANR in addressing a wide array of key themes within National Goal 4. The vast extent of this research and extension is indicated by the large number of publications produced and local extension programs conducted in this area over the last year. California academics published 483 peer-reviewed articles and 13 extension publications in the areas covered by Goal 4. Over 180 local extension programs delivered in this area. UC ANR funded 16 statewide collaborative workgroups and 3 continuing conferences comprised of both AES and CE academics that planned and conducted research and extension projects dealing with issues on a county, regional, and statewide basis. In addition, UC ANR has 11 Statewide Programs that bring together AES and CE resources and personnel that addressed critical issues in the state that are included within National Goal 4. Three patents were issued to UC researchers addressing this Goal.

FY 2005-2006 Allocated Resources

Extension Federal Funds (Smith Lever 3 b&c)	Extension State Match	Research Federal Funds (Hatch)	Research State Match
\$1,570,986	\$1,570,986 (37.60 FTE)	\$1,172,705	\$1,172,705 (92.20 FTE)

Theme: 4.01 Agricultural Waste Management

Title: CHROMOSOMAL MECHANISMS IN ENVIRONMENTAL CARCINOGENESIS

Description:

Important recent developments in UC research on chromosomal mechanisms in

environmental carcinogenesis are summarized as follows: 1) Using fluorescence in situ hybridization with rat chromosome-specific probes, UC researchers have shown that the administration of o,p-DDT to pubertal rats results in the induction of hyperdiploidy/polyploidy in the mammary gland of pubertal rats. These results indicate that at high doses this estrogenic form of DDT can cause genotoxic effects in vivo. 2) Their studies showed that at high doses, the rat carcinogen 1,4-dioxane was capable of exerting genotoxic effects in the bone marrow and liver of young rats. The induced micronuclei were formed primarily from chromosome breakage. Alterations in cell proliferation were also seen in the bone marrow and liver cells. 3) They confirmed that upon bioactivation, the benzene metabolite hydroquinone was able to inhibit topoisomerase II in vitro. These results support their hypothesis that inhibition of topoisomerase II may play an important role in benzene's toxic and carcinogenic effects.

Impact: Both benzene and 1,4-dioxane are important industrial and environmental chemicals. o,p-DDT continues to be a problem at many contaminated waste sites. An understanding of the mechanisms by which these agents cause their toxic and carcinogenic effects will allow more informed decisions to be made about the risks of occupational and environmental exposure. This information should permit more accurate determinations to identify safe exposure levels. Although not easily quantified, these determinations have major impacts on the economy, the environment and on human health.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.01 Agricultural Waste Management

Title: ANIMAL MANURE AND WASTE UTILIZATION, TREATMENT AND NUISANCE AVOIDANCE FOR A SUSTAINABLE AGRICULTURE

Description: Dairy Manure Treatment: Effects of anaerobic digestion and aerobic treatment on the gaseous emission reduction of dairy manure storage were evaluated. In this experimental study, screened dairy manure of about 2% volatile solids (VS) was either anaerobically digested or aerobically treated prior to storage in an air-tight vessel. Anaerobic digestion was carried out by using a mesophilic anaerobic sequencing batch reactor of 20-day hydraulic retention time (HRT) and 1 g/L/day VS loading rate and aerobic treatment was done by using an aerobic reactor of 10-day HRT and 2 g/L/day VS loading rate. The treated manure was put into the storage on daily basis for a period of 180 days. All the gases produced during this period were captured and analyzed for VOCs, VFA and methane. The liquid samples were also taken from the storage vessels and analyzed for these compounds. The untreated manure was also stored and

analyzed in the same way as the treated manure and used as the control for comparison. The six-month experimental results showed that both anaerobic digestion and aerobic treatment had significant effects on the reduction of VOCs, VFAs, CH₄, CO₂ and H₂S in manure storages. The anaerobic process performed significantly or moderately better than the aerobic on the reduction of these gases in terms of mass of individual gas per mass of volatile solid fed. Farm Emission Modeling: A process-based modeling approach was used to develop a comprehensive and predictive ammonia emission model for estimating ammonia emission rates from animal feeding operations. The ammonia emission model consists of a farm emission model (FEM) and animal allocation processor (AAP) and can be used to calculate ammonia emission rates both from an individual animal feeding operation (AFO) and from a group of AFOs and also allows predictions of different time-scale resolutions. The FEM covers six animal groups, including dairy, beef cattle, swine, layers, broilers, and turkeys. For each group, the FEM reflects different farm practices with regards to animal feeding, animal housing, manure collection and storage, and land application. Some computer simulation results for a finishing swine farm have been obtained. The predicted ammonia emission rates are variable during the day and over the period of the year.

Impact: The results of this research lead to development of effective dairy waste treatment and management systems, and air emission prediction tools and air emission mitigation technologies. Integrated animal waste treatment system will allow utilization of dairy manure for energy and fertilizer and remediate environmental pollution problems caused by confined animal feeding operations.

Funding Source: Multistate Research and State

Scope of Impact: AL, AR, CA-D, CO, FL, GA, GU, HI, IA, ID, IL, IN, KY, LA, MI, MN, NC, NE, OH, SC, TX, VA, WI

Theme: 4.01 Agricultural Waste Management

Title: Purification of agricultural drainage salt and its value-added applications in textile processing

Description: UC researchers working with researchers at Biological and Agricultural Engineering, on sodium sulfate, a drainage salt, has been purified and tested in textile dyeing. Agricultural drainage salt generated during irrigation of crops in San Joaquin Valley, California, exceeds 600,000 tons annually and cumulates in the field in a rapid rate. As a result, the waste is taking out more farmlands for salt storage and disposal, imposing serious concerns to environment and local agricultural industry. In searching for a potential solution to reduce or eliminate the waste, the research team has built a mobile solar system that can purify sodium sulfate from drainage waste water. The textile team

members have explored salt composition phase diagram and provided the engineers with theoretical prediction of purity of the products. This research demonstrated feasibility of producing a value-added product, sodium sulfate, from the waste and utilizing the product in textile dyeing. Magnesium sulfate that was found as a major impurity in recovered salt in several locations in the valley affect dyeing of cotton fabrics since it can form precipitates with reactive dyes. By analyzing phase diagrams of both sodium and magnesium sulfate They are able to find an easy method to remove magnesium ion and increase the purity of sodium sulfate to over 99%. The new method of purifying sodium sulfate produced from solar ponds is applied in a pilot system in the Department of Biological and Agricultural Engineering at UC Davis. The reactive dyed fabrics using the recovered salt showed high quality in colors.

Impact: Agriculture waste, drainage salt, can find applications in textile dyeing. With the new progresses in purification of the sodium sulfate they are able to produce sodium sulfate in 99% purity from a pilot solar evaporation system. The recycled salt was employed in reactive dyeing of cotton fabrics. This research further demonstrated that an agricultural waste can become a value-added chemical product for textile production.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.02 Air Quality

Title: ALTERNATIVE STRAW MANAGEMENT PRACTICES ON AVAILABLE SOIL RESOURCES IN FLOODED RICE FIELDS

Description: In 1991, the California Rice Straw Burning Reduction Act (AB1378) attempted to mitigate the negative impact of rice straw burning on air quality by requiring rice farmers to adopt alternative methods of straw disposal for the more than 500,000 acres of rice grown in the Sacramento Valley. Despite initial uncertainty over the impact of straw incorporation on rice growth and yield, in-field residue incorporation has transitioned from a burning "alternative" to the primary means of residue management. As a result, the amount of organic matter in the soil has increased and nutrient availability has been altered. From long-term experiments, it is clear that available soil N is increased after 3 years of residue incorporation and winter flooding; however, the impact on soil fertility in growers fields, where management options are frequently rotated to reduce pest and weed pressure, is uncertain. Survey results indicate that 29 percent of growers reported reducing fertilizer applications in fields where they regularly incorporated residues, while 9 percent of growers increased fertilizer rates and 52 percent reported no change following legislated reductions in burning. In an effort to address the need for improved fertility management guidelines, a

comprehensive evaluation of the impact of rice straw incorporation on nutrient cycling and fertility management by rice growers throughout the Sacramento Valley in 2003. The research included fertility trials conducted with 15 growers in 38 fields, self-reporting, extensive soil and plant sampling and monitoring of three different N rates across a variety of soils, under different management practices. When three year field histories provided by the growers were used to group the data for analysis, a comparison of relative yields within fields indicated that those fields with a history of residue incorporation had significantly greater yields under the reduced fertilizer treatment than those where residue was consistently burned or baled. In 2005 the specific objectives of the trails were: 1) To evaluate current starter fertilizer recommendations for flooded rice soils; 2) To further quantify the effects of alternative straw management on soil fertility recommendations; and 3) To improve critical N, P and K guidelines for mid-season tissue. Preliminary findings based on biomass accumulation through panicle initiation (yield data not yet available) from 2005 are: 1. In fields where the straw is burned there is less biomass accumulation and N uptake than when straw is incorporated. 2. There is a benefit to applying a complete starter (NPK) application. At all study sites and sample times above ground biomass yields were significantly higher when there was a NPK starter application than when no starter was applied. 3. At all sites there was a benefit to the application of starter N alone. Where starter N was applied biomass was higher at all sample times between 3 and five weeks after planting. 4. Based on the early season biomass data, the crop starts taking up the basal applied aqua N sometime before three weeks after planting.

Impact: Rice is grown on more than 500,000 acres in California. The ban on rice straw burning has been the single largest factor affecting rice management in these systems in the last 15 years. Farmers now incorporate rice straw in conjunction with winter flooding as the primary means of straw disposal. Incorporating these large amounts of residue has a large affect on nutrient cycling of N, P and K. With respect to N, it can be concluded that farmers can reduce their N fertilizer input by 25 kg N per ha per year if straw is incorporated in the previous year. On going research is evaluating the most efficient rates and times of N application to reduce losses and increase efficiency. With respect to P and K, soil and plant tissue tests need to be re-evaluated. All research is conducted on-farm and in collaboration with county extension agents. Presentations on straw and fertility management issues are given on a regular basis at the winter farmer or state wide meetings.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.02 Air Quality

Title: Improving Crop Yields Through Increasing Tolerance to Environmental Stress

Description: Plants can limit the damage caused by exposure to oxidizing environmental pollutants such as ozone by avoidance or tolerance. Avoidance involves limiting entry of ozone to the interior of the leaf through stomatal closure. Tolerance includes the detoxification of ozone typically by reactions requiring ascorbic acid (Asc). UC researchers examined whether increasing the level of Asc through enhanced Asc recycling using dehydroascorbate reductase (DHAR) would limit the deleterious effects of environmental oxidative stress. DHAR overexpressing plants had a lower oxidative load, lower level of oxidative-related enzyme activities, greater Chl a content, and a higher level of photosynthetic activity following an acute exposure to ozone despite exhibiting a larger open stomatal area. Reducing the size of the Asc pool size through suppression of DHAR expression had the opposite effect. Following a chronic exposure to ozone, plants with a larger Asc pool size had a larger stomatal area and a higher oxidative load but retained a higher level of photosynthetic activity than control plants whereas DHAR-suppressed plants had a substantially reduced stomatal area but also a substantially lower level of photosynthetic activity.

Impact: These data indicate that despite a reduced ability to respond to ozone through stomatal closure, enhancing Asc recycling in overexpressing plants provides greater protection against oxidative damage than does reducing total stomatal area.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.02 Air Quality

Title: Pedological studies of California soils: predicting soil quality, air quality, and landscape processes from soil survey information

Description: UC researchers' dust work continues with field-scale, side-by-side comparisons of standard and conservation tillage (CT) systems in the San Joaquin Valley. Test results showed CT reduced PM10 emission by 64 to 97% one year and by 53 to 88% the following year, by eliminating tillage operations. Quantifying reductions for specific tillage operations remain a challenge due to variable environmental conditions during sampling. Field experiments suggest that the thickness (generally in terms of a few centimeters) of the upper dry layer of soil is a major factor in determining dust production for a given operation. Aside from soil moisture, degree of soil pulverization, characterized by a weighted mean ped diameter (WMPD), is an important factor in determining the amount of PM10 produced by any tillage operation. Their results show that in

successive disking, the second disking always produced more PM₁₀, despite any change in soil water content, while WMPD decreased by 35-51% (i.e., more pulverized). With continued funding from the Almond Board of California, they began field studies to develop best methods for measuring in-orchard dust, especially during nut pick up. Their results show that PM₁₀ decreased rapidly with distance from the almond harvester, but PM_{2.5} concentrations were similar in adjacent tree rows. They continued to refine a soil dustiness index based on a weighted mean particle diameter derived from routine particle size analyses and on threshold water potentials at which dust production occurs in their lab dust generator. The soil K-fixation work in the San Joaquin Valley (SJV) showed that silt fractions from Sierran soils fixed the most K on a fraction mass basis, but in some cases, very fine and fine sands fixed the most K on a whole soil mass basis, because those are the dominant size fractions. The implications are that soil classification and mapping criteria may need to be modified in order to recognize K-fixation potential in SJV soils. Ongoing serpentinite research showed that xenoliths (foreign rocks) within the larger serpentinite body may weather to provide sufficient soil Ca to overcome low extractable Ca:Mg usually associated with serpentinitic soils, thereby affecting plant growth. They are beginning to expand this work to assess contributions of asbestos in dust from serpentinite-derived soils. The work on duripans showed that Tiron extracts less Si than NaOH, but both extract Al, suggesting that neither is a better extractant of pedogenic silica. Further, NaOH-extractable Si content was only very weakly correlated with duripan unconfined compressive strength, suggesting other soil properties (e.g., carbonate content, particle size distribution) may be at least as important as opal content in controlling strength and in affecting the quantification of cementation.

Impact: The dust research shows that conservation tillage clearly reduces dust production and that dust production is clearly related to soil texture, water content, and soil aggregation. The almond dust work is providing new practical orchard management methods to help reduce almond harvest dust.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.02 Air Quality

Title: Overcoming barriers to establishment and growth of salt-tolerant native plants in the Owens (dry) Lake Playa

Description: Establishing native salt-tolerant desert shrubs and grasses is one of the strategies being used to reduce fine particulate dust (PM-10) emissions from the dry playa at Owens Lake, Inyo County, California. The Owens Lake playa is the worst point source of PM-10 pollution in North America. Windblown,

saltating sand is the major generator of fine dust particles and plant cover both prevents initiation of sand movement and traps moving sand in a matrix of stems and leaves. This is based on knowledge of how plant cover reduces wind shear at the soil surface and observations of sand stabilization and reduced dust production that occurs naturally on a long time-scale with successional vegetation development in desert basins. Besides substantial human health benefits of dust control, successful and cost effective methods for establishing and maintaining native plants contribute additional aesthetic and habitat benefits, as well as relatively low long-term dollar and water costs. A major barrier to use of native plants in expanded dust mitigation efforts on the Owens Playa is the high capital cost for initial establishment of dense stands with cover that meets regulatory requirements. In addition, the high operations costs for maintaining current dust mitigation vegetation at compliance levels of cover need to be reduced to be sustainable. This project focuses on gaining plant and soil information needed to reduce both establishment and maintenance costs for sustainable dust mitigation. The project experiments test effects of fertilizer regimes, soil amendments, and irrigation reduction protocols on long-term growth, survival, flowering, and seed production of three native, salt-tolerant shrubs (Parry saltbush (*Atriplex parryi*), black greasewood (*Sarcobatus vermiculatus*), and bush seepweed (*Suaeda moquinii*)), and one native, salt-tolerant grass (saltgrass (*Distichlis spicata*)). In addition, competition experiments testing interactions among these species are being monitored. During 2005 the lowest irrigation levels appeared to benefit Parry saltbush and black greasewood relative to saltgrass in the competition experiments. These results support the importance of mixed shrub and saltgrass plantings for maintenance of dust control with reduced water input. Two experiments established in 2004 were monitored to determine effects of reduced irrigation on cover maintenance in previously established saltgrass monocultures and to determine nutrient limitations for growth of newly planted saltgrass in areas with extremely high salinity. Preliminary analysis of the nitrogen dose response of establishing saltgrass shows that maximal growth is attained with addition of less than 20 pounds nitrogen per acre per year.. The results of this study combined with results published this year on timing and magnitude of nitrogen demand resulted in substantially reduced nitrogen fertilization of the 5000 acres of established saltgrass. The saltgrass irrigation reduction experiments indicate that changing the timing of irrigation can result in less water use with no significant reduction in dust mitigation cover of well established saltgrass.

Impact: Sustainable reduction of particulate dust pollution (PM-10) in Owens Valley, Inyo County, California requires establishment and growth of native plant cover on extremely saline, alkaline soils. This research has determined the requirements of soil leaching, irrigation, and fertilization needed for reliable establishment, growth, and persistence of three native, salt-tolerant shrubs and a grass (saltgrass) useful for dust mitigation. Optimizing irrigation and fertilization is the focus of current research and results have contributed to substantial savings in operation costs of the dust mitigation plantings.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.02 Air Quality

Title: CONSERVATION TILLAGE PRODUCTION GENERATES LESS DUST

Description: The US Environmental Protection Agency designated the San Joaquin Valley (SJV) a serious non-attainment area for PM₁₀, particulate matter with an aerodynamic diameter less than 10µm. PM₁₀ can bypass the body's respiratory defense mechanisms and has been linked to cardiac and lung diseases. Because air quality violations occur during periods of intense tillage activity, row crop agriculture has been pinpointed as a major contributor of PM₁₀. Conservation tillage (CT) production systems that reduce or eliminate tillage have been developed in other regions. Less than 2 percent of California's annual acreage uses CT approaches. Do CT production practices reduce dust and can they be developed for California crops?

Impact: Because of this work, SJV farmers are becoming aware of potential air quality benefits that may derive from CT. While CT currently is used on less than 2 percent of SJV annual crop acreage, UC ANR's CT Workgroup has tracked increased use of CT practices during the past four years. The workgroup has been involved in more than 60 farm demonstrations, and its membership has grown from a handful of researchers in 1998 to over 540 UC, NRCS, farmer, private sector, and other public agency and environmental group members today. Access CT Workgroup information at <http://groups.ucanr.org/ucct/>.

Funding Source: Hatch, Smith-Lever and State

Scope of Impact: State Specific

Theme: 4.03 Biodiversity

Title: Biotic and Abiotic Factors Affecting the Biodiversity of Temporary Waters in California

Description: This is the termination report for this project. Over the past five years, a UC researcher and his students have made significant advances in understanding both biotic and abiotic forces that affect the biodiversity of temporary waters in California. One Master's thesis and one Ph.D. thesis were completed under the auspices of this project, along with three peer-reviewed papers and several presentations given at national meetings (e.g. the North

American Benthological Society and the Ecological Society of America). The Master's thesis showed that temporary streams have significant invertebrate biodiversity, and that the underlying geology and hydroperiod of the streams had strong effects on the abundance and diversity of insects. The dissertation includes a chapter demonstrating that mosquitofish reduce abundances of fairy shrimp, and a chapter showing that introduced mosquitofish impact an endangered native salamander. The former has been published and the student is preparing the latter for publication, along with other manuscripts showing that introduced trout have strong impacts on native long-toed salamanders in high-elevation lakes. In her work she is also researching how hydroperiod affects the persistence of the salamanders. In addition, the UC researcher co-authored a paper discussing how natural microcosms, especially small temporary-water habitats, can be used to advance the science of ecology (Srivastava et al. 2004). This paper complements an earlier publication on evaluating full-scale rice fields as a manipulable field system for studying seasonal wetlands (Lawler 2001, Israel J. Zool. 47:513-528). In that paper he reviewed how hydroperiod, growing techniques, and the presence of fish influenced the biodiversity of rice fields and their suitability as habitat for native species.

Impact: The research on invertebrates in temporary streams shows that even the smallest, temporary headwaters of California have a high diversity of invertebrates, and that there is considerable heterogeneity between sites, that makes conservation of a variety of sites crucial. The work on how introduced fish affect native amphibians has informed Mosquito and Vector Control Districts (MVCDs) that mosquitofish interfere with preservation of California Tiger Salamander populations in semi-permanent waters, and conservation of fairy shrimp in temporary waters. This information helps MVCDs and wildlife managers protect an endemic, declining amphibian, thus helping to preserve California's biodiversity.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: Microbial Ecology of Sap-Feeding Insects

Description: UC researchers attempted to simultaneously introduce within grapevines multiple mutant strains of *X. fastidiosa* that were not vector transmissible but which had an additional random mutation. Vector acquisition and transmission of strains in which the second mutation restored vector transmissibility would then identify bacterial genes needed for vector transmission. Experiments showed, that strain competition within plants precluded the use of this screening approach. Only one of an inoculated strain came to dominate in infected plants. While the movement of *X. fastidiosa* through

plants is an important trait for disease expression, the process is poorly understood. The researchers followed the movement of Xf cells within grape by determining the changes over time in the proportion of genetically distinct strains of Xf initially inoculated into plants. The results suggested a model of X. fastidiosa's sequential colonization of a plant's xylem vessels from the inoculation site. A mixture of two isogenic and virulent X. fastidiosa strains (Temecula and KLN61) that had been mechanically inoculated into Cabernet Sauvignon vines could be distinguished in culture by the resistance of strain KLN61, but not Temecula, to kanamycin. In plants sampled 50 cm from the inoculation point 12 to 18 weeks after inoculation, 46% percent were infected with only strain KLN61, 20% only with Temecula, and 34% of the plants not infected with either strain. Both strains were initially found at the site of inoculation, but only one strain or the other was recovered subsequently at distal sampling sites. These results suggest that X. fastidiosa cells moving from one xylem vessel to another confront a series of physical 'bottlenecks' during plant colonization. Competition between these two strains or other near-isogenic pairs of strains did not reduce the growth of either strain in culture medium. For example, a rpfF DSF-deficient mutant that does not adhere to the inside of the vector mouthparts (and is not vector transmissible) forms a reduced or no biofilm in vitro, but formed a biofilm when combined with a wild-type Xf strain. Growth of the DSF-deficient mutant was similar to the wild type in culture; neither strain outcompeted the other in two media, one of which promotes biofilm formation in the wild-type strain.

ENVIRONMENTAL EFFECTS ON VECTOR TRANSMISSIBILITY OF X. FASTIDIOSA. Environmentally-induced phenotypes of Xf that formed biofilms in culture were still not transmitted by an efficient insect vector (*Graphocephala atropunctata*) after the insects were fed on artificial diets composed of harvested X. fastidiosa biofilms. Further experimental manipulations will be needed to discover if phenotypic changes in cultured bacteria can render them vector transmissible.

Impact: 1. Competition between nearly genetically-identical strains of X. fastidiosa does not limit growth in culture of paired strains with similar growth characteristics, enabling studies of the effects of single genes on growth characteristics of this bacterium in strain mixtures. 2. Experimental data suggests that competition within grapevines among different strains of X. fastidiosa results from a series of bottlenecks that limit bacterial movement from cell to cell in the sequential process of the bacterium colonizing plants. The implications for biological control of Pierce's disease of grape with non-virulent strains of X. fastidiosa are that the protective (non-virulent) strains would have to be widespread within grapevines to preclude the colonization of plants with virulent strains.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: Characterization of Microbial Microhabitats on Leaves

Description: The foliar pathogen and ice nucleator, *Pseudomonas syringae* pv. *Syringae* B728a, demonstrates a high level of epiphytic fitness on plants. Using a promoter-trapping strategy termed habitat-inducible rescue of survival (HIRS), UC researchers identified genes of this organism that are induced during colonization of healthy bean leaf surfaces. These plant-inducible genes (pigs) encode diverse cellular functions including virulence, transcription regulation, transport, nutrient acquisition, and other known and unknown loci, some of which may result in antisense transcripts to annotated *P. syringae* genes. Prominent among the pigs was *ssuE*, a gene in the sulfate-starvation regulon, indicating that sulfate is not abundant on leaf surfaces. *inaZ* reporter gene fusion assays of the plant-inducible loci revealed up to 900-fold higher levels of pig transcriptional activity on plant leaves compared to minimal medium. However, the maximum levels of pig transcriptional activity were typically too weak to be measured using a *gfp* reporter gene. One exception was *orf6* in the *hrp/hrc* pathogenicity island which was highly induced in epiphytic *P. syringae* cells. Disruptions in the pigs did not affect epiphytic fitness of *P. syringae* thus confirming that epiphytic fitness is likely the cumulative result of many traits rather than due to individual genes conferring large effects. The spatial organization of cells within bacterial aggregates on leaf surfaces was determined for pair-wise mixtures of three different bacterial species commonly found on leaves, *P. syringae*, *Pantoea agglomerans*, and *Pseudomonas fluorescens*. Cells were co-inoculated onto bean plants, allowed to grow under moist conditions and the resulting aggregates examined in situ by epifluorescence microscopy. Each bacterial strain could be localized because they expressed either the green or cyan fluorescent protein constitutively and the viability of individual cells was assessed by propidium iodide staining. The degree of segregation of cells in mixed aggregates differed between the different co-inoculated pairs of strains and was higher in mixture of *P. fluorescens* A506 and *P. agglomerans* 299R, and *P. syringae* B728a and *P. agglomerans* 299R, than for two isogenic strains of *P. agglomerans* 299R. The fraction of the total cell population that was dead in mixed and monospecific aggregates of a *gfp*-marked strain of *P. agglomerans* 299R and a *cfp*-marked strain of *P. agglomerans* 299R, or of *P. fluorescens* A506 and *P. agglomerans* 299R, was similar. However, the proportion of dead cells in mixed aggregates of *P. syringae* B728a and *P. agglomerans* 299R was significantly higher than that in monospecific aggregates of these two strains, and increased through time. While dead cells in such mixed aggregates were preferentially found at the interface between clusters of cells of these strains, cells of these two strains located at the interface did not exhibit an equal probability of mortality. After 9 days incubation about 77 % of the *P. agglomerans* 299R cells located at the interface were dead while only about 24 % of the *P. syringae* B728a cells were dead.

Impact: An understanding of the small-scale spatial structure of bacterial cells on leaves as well as within plants enables us to better understand the potential for cell-cell communication that is expected to regulate expression of genes involved in virulence to plants as well as fitness on and in plants. Knowledge of the spatial structure of bacterial populations also helps explain how biological control of diseases might best be implemented. Their results suggest strongly that bacterial strains are highly segregated spatially on plants, thereby limiting the interactions that they may have with other bacterial strains such as those employed for biological control.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: Managing Plant-Microbe Interactions in Soil to Promote Sustainable Agriculture

Description: Work on the influence of various soil organic amendments on the dynamics of the colonization of roots by both pathogenic and saprophytic fungi is continuing. The long term studies have the long term effects on the soil ecology and disease suppression of organic amendments such as green manures. Changes in specific microbes which colonize roots compete with *Verticillium dahliae* and severely suppress its ability to establish epiphytic colonies. Both the number and size, but especially the colony are greatly reduced. This in turn, leads to a greatly reduced vascular invasion and associated wilt severity. The analysis of the data and the preparation of manuscripts and a book chapter describing and summarizing the results are in progress. These studies will provide information on how various cultural practices can affect the dynamics of the microbial community in the soil which, in turn, can suppress soil-borne diseases.

Impact: Information on which types organic amendments support disease suppression will be useful to growers practicing sustainable agricultural practices such as crop rotations, cover crops and organic farming.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: DEVELOPMENT, EVALUATION AND SAFETY OF

ENTOMOPATHOGENS FOR CONTROL OF ARTHROPOD PESTS

Description: For this project, UC researchers found out very early that the susceptibility of *H. zea* to infection is strain dependent; some strains are highly resistant and some are much less resistant to infection by AcMNPV. Because of this, they turned to a variety of AcMNPV insect systems to find general principles that were important in baculovirus infectivity. They found that oral infection directly proceeds from gut cells, then tracheal cells, then hemocytes and infection of all are extremely important in the outcome of the infection for the organism. For AcMNPV, *H. zea* hemocytes are the tissue that varies with regard to susceptibility to AcMNPV; gut cells and tracheal cells are just as susceptible as those of *H. virescens*. On the other hand, They also found that *S. frugiperda* gut cells are resistant to infection by AcMNPV, while the hemocytes of this organism are highly sensitive to infection. Evidence suggests that reason for the lack of susceptibility of gut cells is the host receptors and the viral attachment proteins p74, PIF1 and PIF2 do not interact properly. They also found that the time it takes for AcMNPV to infect gut cells of *H. zea* and *H. virescens* about 10 hrs for a dosage of 20 polyhedra and 4 hr for a similar dosage of HzSNPV, a baculovirus that specializes on heliothine larvae. It only takes AcMNPV 2 hr, however, to infect tracheal cells after the midgut cells have been infected and 8 hrs for HzSNPV. This is as expected because AcMNPV appears to use a parental nucleocapsid pass-through mechanism that is dependent on early GP64 expression and multiple parental nucleocapsids as a mechanism to hasten tracheal cell infection to avoid being sloughed with infected midgut cells. Sloughing of infected midgut cells is the primary method of defense of lepidopteran larvae against baculoviruses, and it can be exacerbated by the quality of food they eat in the field. This was demonstrated in the infectivity rates of AcMNPV in *H. virescens* fed cotton vs lettuce; the virus was significantly more infectious for the lettuce fed insects. In summary, the susceptibility of all three cell types, midgut, tracheal and hemocytes are important for baculovirus virulence and the surprise is that for many resistant hosts, two of three cell types are highly susceptible to baculovirus infection.

Impact: Understanding the basis of baculovirus pathogenesis and host resistance mechanisms is of fundamental importance for developing baculoviruses as safe, specific and effective pest control agents.

Funding Source: Multistate Research

Scope of Impact: AL, AR, AZ, CA-D, CA-R, CTH, CTS, FL, GA, IL, LA, ME, MN, ND, NJ, NYC, OH, PA, VT

Theme: 4.04 Biological Control

Title: THEORY AND PRACTICE OF BIOLOGICAL CONTROL

Description: A three-year study of the arthropod predators of beet armyworm, *Spodoptera exigua* (Hubner) (Lepidoptera: Noctuidae), in hay-alfalfa fields in northern California was completed. In field trials, predators typically exploited >50% of sentinel egg masses; mean predation rate ranged from ~40 to ~100% and percentage predation per individual egg mass was density independent (spatial context) for 16 of 17 sample intervals. The egg-predator guild consisted primarily of adults and nymphs of *Lygus hesperus* Knight & L. elisus Van Duzee (Miridae) *Nabis americanoferus* Carayon (Nabidae), and *Orius tristicolor* (White)(Anthocoridae); and adults of *Collops vittatus* (Say) (Melyridae) and *Hippodamia convergens* Guerin-Meneville (Coccinellidae). Sweep samples revealed that predatory bugs (especially *Lygus* spp.) were the most abundant. In laboratory feeding trials, these and other species readily fed on eggs, as well as on neonate larvae, of *S. exigua*. Density of *S. exigua* remained well below the established treatment threshold throughout the course of the study.

Impact: These results reveal how native predators can exploit an introduced pest and maintain it at relatively low levels. Alfalfa growers in northern California should conserve these natural enemies through judicious use of pesticides.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: PREDATOR AND PARASITOID BIOLOGY AND THE ECOLOGY OF BIOLOGICAL CONTROL

Description: The goal of this project is to develop a fundamental understanding of plant-insect, predator-prey, and parasitoid-host interactions, and to apply this knowledge to the development of sound pest management practices. Work was conducted in four areas. (1) First, I worked to develop a better understanding of the interaction of the herbivore *LYGUS HESPERUS* with its host plant, cultivated cotton. Manipulative field experiments failed to identify a causal role for factors that had previously been identified as correlates of plant 'sensitivity' to *LYGUS* feeding (petiole concentrations of phosphorus, sodium, and chloride). This result suggests that other factors correlated with phosphorus, including the crop rotational history for the field, may be important. A database built with information derived from private pest management consultants (time-series data on *LYGUS* densities in cotton fields), growers (yield data), and government records (pesticide application data) suggests that cotton's ability to compensate for *LYGUS* herbivory may be significantly greater than has been recognized heretofore. (2) Observational and experimental results suggest that

both the late nymphal and adult stages of LYGUS are capable of generating significant damage to cotton (abscission of young flower buds). (3) A comparative observational study has demonstrated that a great deal of variation exists in the opportunities for predators to generate non-consumptive effects (versus consumptive effects) on their prey. Some predators convert a high proportion of attacks into prey capture events (>90%), whereas others rarely attack the prey that they contact (<10%). Attacks that fail to capture prey may, however, interrupt feeding and trigger a variety of changes in prey behavior, morphology, and physiology that significantly depress population growth rates. (4) Finally, experimentation in the laboratory has demonstrated that not only herbivores, but also omnivorous predators can elicit induced resistance responses in their host plants by virtue of their plant feeding. This result will have major implications for the compatibility of omnivorous biological control agents and induced host plant resistance as complementary tools useful in IPM programs.

Impact: Uncovering the full extent of cotton's ability to compensate for herbivory by LYGUS HESPERUS has the potential to produce major decreases in the use of pesticides to control LYGUS in California cotton fields. Because insecticides directed at LYGUS can disrupt naturally effective biological control of other cotton pests (aphids, mites, whiteflies, worms), avoiding unnecessary sprays may substantially improve the overall profitability of cotton production.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: EFFECTS OF HERBIVORES ON CROP YIELDS AND AS BIOCONTROL AGENTS OF INVASIVE WEEDS

Description: A UC researcher has continued to study several aspects of plants and their interactions with damaging insect herbivores. He explored alternative strategies for increasing plant yields in the face of damage from insects. He continued work on a USDA grant from the NRI CREES program. His experiments this year had the following objectives: 1) To examine how induction after 1) mechanical damage to leaves, 2) application of methyl jasmonate to leaves and 3) application of methyl salicylate to leaves affects visitation to flowers by both injurious cucumber beetles and honeybee pollinators. They wish to determine whether damage from herbivores or disease makes flowers more or less attractive to pollinators and to injurious flower feeders. They also collected tissue from flowers and analyzed cucumber beetle response to petals and pollen from the four treatments (the three above plus controls). The larger aim of the experiment is to understand the degree to which damage from herbivores

interferes with services from pollinators, which promote compensation for damage. Another project continued this year was to determine the role of biocontrol agents in population regulation of the exotic pest, yellow starthistle. They are using a demographic approach to examine transitions from seed to seedling to reproducing adult in patches where they experimentally manipulate the presence/absence of the biocontrol agent. This approach will tell whether agents destroy sufficient seed to truly act as population regulators of invasive star thistle, or whether other agents focusing on different life stages may be more effective. They found that biocontrol agents destroy large amounts of seed, which translates to lower seedling densities in plots with agents. However, that self-thinning at the seedling stage across all plots makes plant densities in plots with and without biocontrol agents equivalent. Thus, self-thinning properties of thistle populations counteract the efficacy of seed predators and suggest that other life-history stages may be more important to target in the control of yellow starthistle. Finally, they also explored whether yellow starthistle has allelopathic effects on native plants, as does its congener, spotted knapweed. In the process, they found some methodological problems with standard methods investigating allelopathy (see below). All these objectives are important for the Agricultural Experiment Station mission

Impact: In the area of biocontrol, the researchers are collecting demographic data and using mathematical models to predict whether biocontrol agents that feed on seeds of yellow starthistle are effective in reducing population size. The data to date suggest that targeting life stages other than seeds may be more effective in controlling this invasive plant.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: UTILIZATION OF ENTOMOPATHOGENIC NEMATODES IN THE BIOLOGICAL CONTROL OF PESTIFEROUS INSECTS

Description: The attachment and infectivity of two entomopathogenic nematode species, *Steinernema carpocapsae* and *Heterorhabditis indica*, on soldiers and workers of a subterranean termite species, *Coptotermes formosanus* were investigated. With *S. carpocapsae*, more nematodes attached to soldiers of *C. formosanus* in the absence of workers compared to soldiers that were in the presence of workers. With soldiers alone, workers alone and mixture of equal numbers of workers and soldiers, soldiers in the mixed groups had lower mortality than soldiers alone after 1 and 4 days. Exposure of small groups of *C. formosanus* to *S. carpocapsae* resulted in higher mortality of soldiers after 1- and 4-days post exposure. Mortality in soldiers alone exposed to *H. indica* was not

significant compared to mortality in mixed groups at 1-day exposure, but was significant after 4 days. Termite soldiers experienced rapid mortality when exposed to *S. carpocapsae*. When soldiers alone or workers alone are exposed to the nematodes, there is a differential susceptibility of soldiers and workers to nematode infection with soldiers being more susceptible than workers. Most importantly, a high number of nematodes are needed to kill worker termites and *S. carpocapsae* and *H. indica* are not effective control agents against *C. formosanus*. The mechanism to avoid nematode infection is partly due to termite grooming behavior, but inability of the nematode to recognize termite as a host is being investigated.

Impact: Entomopathogenic nematodes should not be used against subterranean termites until a more virulent nematode can be isolated. In part, grooming behavior of the worker termites appears to be the mechanism to avoid nematode infection.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: POPULATION BIOLOGY OF NEMATOPHAGOUS FUNGI: MORTALITY, EFFICACY, AND FORMULATION

Description: Nematode-trapping fungi and insects parasitized by the entomopathogenic nematode *Heterorhabditis marelatus* are common in the soils of the Bodega Marine Reserve (BMR). Experiments determined whether nematode-parasitized insects enhanced the population densities of nematode-trapping fungi and whether the fungi trapped substantial numbers of nematodes that emerged and dispersed from the insects. When nematode-parasitized insects were added to laboratory microcosms containing BMR field soil, the prevalence and incidence of four nematode-trapping fungi increased substantially. The greatest increase in population density was by *Arthrobotrys oligospora*. *A. oligospora* population density increased about 10 times when insects were parasitized by the nematode *Heterorhabditis marelatus* (which is the dominant nematode parasite of insects in this soil) and about 100 times when insects were parasitized by the nematode *Steinernema glaseri*. Whether the fungi responded to nematodes, dead insects, or both, is unclear. The data suggest that the previously documented high incidence and prevalence of nematode-trapping fungi in BMR soil can be explained, at least in part, by nematode-infected insects. The strong bottom-up enhancement of nematode-trapping fungi was not matched by a strong top-down suppression of nematodes, i.e., the fungi trapped less than 30% of dispersing nematodes. In another study, soil cages (PVC pipe with mesh-covered ends) were used to determine how the

quantity of two organic amendments affected the nematode-trapping fungi *Dactylellina haptotyla* and *Arthrobotrys oligospora* in two vineyards. Each cage contained 80 cm³ of field soil (120 g dry weight equivalent), fungal inoculum (two alginate pellets, each weighing 1.9 mg and containing assimilative hyphae of one fungus), and dried grape or alfalfa leaves (0, 360, or 720 mg) with a C:N of 28:1 and 8:1, respectively. Cages were buried in the vineyards, recovered after 25 to 39 days, and returned to the laboratory where fungus population density and trapping were quantified. *Dactylellina haptotyla* population density and trapping were most enhanced by the smaller quantity of alfalfa amendment and were not enhanced by the larger quantity of alfalfa amendment. *Arthrobotrys oligospora* population density was most enhanced by the larger quantity of alfalfa amendment, but *A. oligospora* trapped few or no nematodes, regardless of amendment. Trapping and population density were correlated for *D. haptotyla* but not for *A. oligospora*.

Impact: Organic amendments to soil may suppress pest nematodes by several different mechanisms, and understanding these mechanisms may help farmers to use organic amendments to control plant-parasitic nematodes. One mechanism is the stimulation of nematode-trapping fungi. The current research indicated that trapping fungi may be more stimulated by crop residues containing abundant nitrogen (alfalfa leaves), that too much amendment may suppress the fungi, and that trapping activity and population density are correlated for some trapping fungi but not others. Moreover, noncrop detritus may be more stimulatory than crop residues: dead soil insects and other animals caused dramatic increases in the population densities of some nematode-trapping fungi in a nonagricultural soil.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: Development of plant pathogens as bioherbicides for weed control

Description: The relationship between soil C:N ratio, soil organic amendments and weed seed longevity in the soil is not clear. Addition of organic amendments such as compost or green manure may help foster conditions that reduce weed densities. This research tested the effects of potassium nitrate, compost and/or sawdust additions on seed longevity of two annual weeds; shepherds-purse and burning nettle, under controlled conditions of temperature moisture and light. Soil C:N ratios tested were 8:1, 10 or 13:1 (natural soil ratio), 25:1 and 40:1 with and without compost amendments. Dormant weed seeds (100 percent viable, with less than 15percent germination at 7 days) held in 3 by 3cm nylon mesh bags were buried 1 and 4 cm deep in 250 ml soil filled jars. Soils were moistened to 80

percent of field capacity and jars were incubated in a 12 hour 20 degree C light and 12 hour 10 degree C dark conditions for 1, 2 and 3 months. Seedling emergence and headspace carbon dioxide release rates were monitored continuously to measure microbial respiration. At the end of each incubation period, seed viability and extractable (1M KCl) and mobile (deionized water) C and N fractions in the soil were determined. After 2 months of incubation, viability of nettle seeds, at the 1 cm depth 1cm was reduced by 20 percent in compost amended soils (C:N =10:1) and by 57 percent in non-amended soils (C:N=13:1), respectively. No additional changes in seed viability were detected in the third month of incubation. Highest respiration rate were observed at a C:N ratio of 25:1, either with or without compost amendment. Similar respiration rates were observed at a C:N ratio of 40:1. Respiration rates in soils at all other C:N ratios were negligible.

Impact: The long-term profitability of the 6.0 billion dollar California conventional and organic vegetable industries is threatened by high weed control costs and potential loss of older herbicides (conventional only). Sustainable weed management inputs such as organic amendments may stabilize or reduce weed control costs

Funding Source: Multistate Research and State

Scope of Impact:

CA-D, CA-R, FL, IN, MA, MT, NYC, NC, PR

Theme: 4.04 Biological Control

Title: Development of Plant Pathogens as Bioherbicides for Weed Control

Description: Research has shifted from applying bio herbicides to working with cropping systems that have greater weed seed mortality, possibly due to increased weed seed pathogen activity. Many California vegetable crops are now routinely established with transplants. If soil pathogens attack weed seeds but do not affect transplants, UC researchers have a system for weed control with reduced herbicide and other inputs. They are nearing the end of their multiyear tillage experiment. They found significantly higher mortality of weed seeds when soil organic matter increased. It is hypothesized that the organic matter supports higher populations of weed seed pathogens. Current research centers on how increasing organic matter affects the diverse cropping systems of the desert region.

Impact: Research shows that organic amendments have benefits beyond soil fertility. They may also reduce reliance on pesticides. On farm use of organic amendments may also be a way of recycling urban yardwaste. The research appears to have shown reduced weed populations as yet another reason to encourage organic amendment of low organic matter soils.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, CA-R, FL, IN, MA, MT, NYC, NC, PR

Theme: 4.04 Biological Control

Title: BIOLOGICAL CONTROL AND ECOLOGY OF ARTHROPOD PESTS
ATTACKING AVOCADO

Description: Significant results have been achieved in the eighth year of work on the biological control avocado pests in California. First, the overwintering ecology of OLIGONYCHUS PERSEAE has entered the fifth year of fieldwork. Outbreaks of this pest are related to leaf retention rates by avocado trees in spring when new flush growth begins and leaves from the previous year defoliate. Understanding the outbreak ecology of this pest will greatly aid management strategies. The pest thrips SCIRTOTHRIPS PERSEAE, has been subjected genetic studies to determine its area of origin in Mexico. The results of genetic analyses are highly conclusive and the source region for this thrips pest was identified. A molecular key for identifying pest Scirtothrips was developed. Work has started on a new avocado pest that invaded California in late 2004, the avocado lace bug, Pseudacysta perseae. Natural enemy surveys, evaluations, phenology, and foreign exploration are underway for avocado lace bug.

Impact: Growers, grower cooperatives, and insectary managers are using the results of this and completed previous research for managing avocado pests with reduced insecticide usage. Reduced pesticide applications will slow resistance development by OLIGONYCHUS PERSEAE and SCIRTOTHRIPS PERSEAE which is a major threat to industry sustainability. The identification of donor regions for invasive avocado pests and potential conduits for entry into California has heightened awareness of biosecurity issues pertaining to mitigation of unwanted pest entry.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: Regional Analysis of Biological Control and Biotechnology in Sustainable Agricultural Systems

Description: Physiologically based model analyses of the ecological effects of Bt cotton has been completed, and an economic analysis of its efficacy is in

progress. Analyses of the the biological control of of vine mealybug on grape, oleander scale on olive, and the noxious weed yellow starthistle have been completed. Models imbedded in a geographic information system (GIS) have been developed and used to project pest severity across Arizona and California. An important analysis was to estimate the climatic limits of pink bollworm concluding that the pest cannot invade the Central Valley of California. Analogies between ecological and economic theory have been formulated and published. This has led to the development of a unified model of both fields.

Impact: The modeling/GIS methods developed in putting the field of biological control and IPM on a solid scientific basis. For example, the modeling analysis questions the efficacy of the transgenic Bt technology in California cotton, and the ongoing USDA pink bollworm suppression campaign in the great Central Valley of California. Other analyses suggest that past biological control efforts on yellow starthistle have been misguided, and shows how research guided by physiologically based model leads to better selection of biological control agents for the control of exotic pests.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control

Title: BIOLOGICAL CONTROL IN PEST MANAGEMENT SYSTEMS OF PLANTS

Description: Multiple genetic markers have clarified the host plant association of mealy aphids (*Hyalopterus* spp.) in the Mediterranean and the population structure of their associated parasitoid *Aphidius transcaspicus* for use in biological control of mealy plum aphid. Spain and Tunisia have been identified as likely sources of the invasion of California by this aphid and parasitoid biotypes are being screened for field release. A new white morph of the walnut aphid from the Sacramento Valley has a reproductive advantage and reduced susceptibility to parasitism. Research continued in the development of approaches to investigate the origins and demographic history of pest populations using molecular tools, symbionts, and computational methods. Many of these approaches are being developed using the olive fruit fly (*Bactrocera oleae*) and other tephritid fruitflies as models. Physiologically based models of tritrophic systems in a GIS context have been applied to the analysis of ecological effects of transgenic Bt cotton and to the analysis of potential geographic distributions and abundance of various pests species in California and Arizona (e.g. pink bollworm, olive fly, vine mealybug, yellow starthistle, etc) using observed and predicted weather under different climate change scenarios. Foreign exploration for parasitoids of vine mealybug continued in Europe and

South Africa, and *Coccidoxenoides peregrinus* was selected for host range testing and further evaluation prior to future field release. Field trials were conducted to evaluate several different approaches to reducing Argentine ants activity in vineyards as disruptors of biological control. Parasitoids of the olive fly continue to be imported from Europe, Pakistan and Africa, focusing on *Psytalia lounsburyi* and *P. ponerophaga*, and evaluated in quarantine for potential field release. Methods are being developed to rear *Psyllaephagus* sp. nr. *hirtus* in sufficient numbers for future release against the spotted gum psyllid. Studies on intercropping of broccoli with various selections of nectar producing flowers and the impact this resource subsidy on the abundance of cabbage aphids are continuing. Wild and cultivated sunflowers continue to be used as a model system of crop domestication and its influence on natural enemies with the development of molecular markers to elucidate the level of genetic variation between populations of the sunflower moth and its key parasitoids.

Impact: Biological control, or the use of natural enemies to suppress the abundance of insect and mite pests, is an approach to pest management that is designed to reduce pesticide use in food and fiber crops and thus the negative impacts of pesticides in the environment. Knowledge developed in this project has significantly improved biological control approaches to pest management.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-B, CA-D, CA-R, CO, DE, GU, HI, ID, KS, MT, ND, NJ, NM, NYC, OR, SAM, UT, WA, WY

Theme: 4.04 Biological Control

Title: BIOLOGICAL CONTROL IN PEST MANAGEMENT SYSTEMS OF PLANTS

Description: UC researchers continued to maintain colonies of both of the parasitoids that attack the whitefly *ALEURODICUS DUGESII*. They maintained the whitefly colony on *Hibiscus* sp., and used these whitefly colonies to maintain colonies of both parasitoids. During the year they began and completed a study of the behavior of *ENCARSIELLA NOYESII* when searching for and ovipositing in its hosts. They did this by recording the behavior of individual mated female parasitoids through a microscope fitted with a video camera. The camera was connected to a video recorder, and the behavior of each female was recorded for approximately one hour between 9:00 am and 12:00 noon. These data allowed us to determine the favored host stage for this species (the fourth nymphal instar), and also allowed us to quantify many aspects of the searching behavior of this species. This data is being written up for publication at this time. In addition to the study on behavior, they continued to distribute natural enemies throughout the nation to those who requested them, as the infestation of this pest whitefly

has spread throughout much of the southern united states and similarly into tropical greenhouses as far north as Michigan.

Impact: The studies into the basic biology of the parasitoids are critical in advancing understanding of species in these groups. Both parasitoids occur in groups the biology of which has never been studied, so these are the first insights into what may turn out to be very important natural enemy groups. In addition, the continuing dispersal of these natural enemies is having beneficial effects everywhere they are sent, as they establish easily, and bring the whitefly under control usually within 8-10 months.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-B, CA-D, CA-R, CO, DE, GU, HI, ID, KS, MT, ND, NJ, NM, NYC, OR, SAM, UT, WA, WY

Theme: 4.04 Biological Control

Title: BIOLOGICAL CONTROL OF WORMS IN WINEGRAPES

Description: Most winegrape growers must control worms from time to time. The most common worm pest of the grape bunches is the omnivorous leaf roller. Another occasional pest is the grape leaf folder. Traditional control of these pests is with insecticides. However, growers are always looking for more environmentally friendly ways to control vineyard pests. Cooperative Extension has been working on biological control of pests in grapes for over 25 years. The latest technology for controlling worm pests in the vineyard is mating disruption. Growers are beginning to place dispensers in the field that release a pheromone which interferes with the mating process. If no mating occurs, no eggs are laid to hatch into the larvae that cause the damage.

Impact: A chemical company is now in the process of bringing this technique to market as a commercial product that growers can purchase and use. Thus, growers now have another non-pesticidal, biological control to use in California vineyards.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.05 Drought Prevention and Mitigation

Title: UC RESEARCHERS IMPROVE DROUGHT TOLERANCE IN PLANTS

Description: Diminishing water resources, climate changes brought about by global warming, and drought conditions in many arid and semi-arid regions of the world are making it increasingly difficult to grow viable crops. Rainfall in California has been below normal for several years, raising concerns that the state may be experiencing another of its periodic droughts. And in the sub-Saharan region of Africa where many areas depend on rain-fed agricultural production, rain can be extremely scarce and the rainy season short. On top of this, there will be enormous needs for increased food production over the next 50 years. Current projections are that the global human population will increase from approximately 6 billion currently to between 8 and 12 billion around 2050. A UC biochemist and members of his research group, have developed technology that increases drought tolerance in plants by decreasing the amount of an enzyme that is responsible for recycling vitamin C. In the study, they reasoned that decreasing the amount of the enzyme DHAR would reduce the ability of plants to recycle vitamin C, making them more drought tolerant. The researchers accomplished this by using the plant's own gene to decrease the amount of the enzyme three fold. Vitamin C serves as an important antioxidant in plants as it does in humans and among its many functions in both, it destroys reactive oxygen species that can otherwise damage or even kill cells. Reactive oxygen species are produced in plants typically following exposure to environmental conditions such as drought, cold, or air pollution. Plants sense drought conditions by the buildup in reactive oxygen species and then respond by reducing the amount of water that escapes from their leaves. Reducing the amount of DHAR decreases the ability to eliminate the buildup of reactive oxygen species that occurs with the onset of a drought. This causes plants to be highly responsive to dry growing conditions by reducing the rate of water that escapes from their leaves. Thus, they are better able to grow with less water and survive a drought. The US Department of Agriculture and California Agricultural Experiment Station funded the six years of research that led to the findings.

Impact: This technology is expected to aid in the development of crops that conserve water resources. Assisting plants to be better water managers is important for crops growing in areas that experience erratic rainfall. This discovery will assist farmers who depend on rainwater for their crops during those years when rainfall is low. It will also assist farmers who irrigate their crops to conserve water, which is important in California where rapid population growth continues to increase the demand on this scarce resource. Finally, this discovery should help farmers who grow crops in arid areas, such as exists in many developing countries.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.05 Drought Prevention and Mitigation

Title: CONSERVATION TILLAGE CUTS COSTS IN TOMATO PRODUCTION

Description: Rising fuel and labor costs oblige growers to carefully cut production costs. Reducing intercrop tillage typically associated with bed preparation operations is a promising means to cut costs in tomato production systems. A variety of conservation tillage (CT) crop production systems have been developed in other regions for crops such as corn, wheat, soybean, and cotton. Since 1999, UC researchers have been evaluating CT practices for tomato production in Five Points, Calif. This work compares standard till (ST) and CT systems in terms of economics, profitability, soil properties, and dust emissions through a tomato-cotton rotation. The CT system reduced the total number of passes over the field by an average of nine per year, eliminating disking, chiseling, landplaning, and listing and shaping beds. CT system yields were comparable to those achieved by the ST approach, increasing profitability with CT because costs decreased and revenue remained unchanged

Impact: Although conservation tillage reduced the number of tillage passes by 50 percent, the total cultural cost of tomato production was reduced by only about 10 percent: 41 percent for harvest, 14 percent for seed, only 20 percent for preplant tillage operations. The value of the savings from reducing labor and fuel prices will increase as labor rates and fuel costs per gallon increase. [Example: CT reduced fuel use by 16 gallons per acre. At a price of \$1 per gallon, the savings is \$16; at a price of \$3 per gallon, the savings is \$39.] Reducing the number of ground preparation operations by adopting CT always will reduce resource use and cut costs; however, overall profit may not improve if CT leads to a decrease in income due to a crop yield reduction that is greater than cost savings. Even if yields are lower under CT, profit can increase if the reduction in costs is greater than the income loss due to yield reduction. Other environmental or ecosystem services result from reducing tillage. Dust generation in the CT systems was reduced by more than 60 percent and greenhouse gas emissions were lower, particularly when coupled with the use of cover crops. Elements of these systems are now being adapted and pursued by some processing and fresh-market tomato growers on the west side of the San Joaquin Valley.

Funding Source: Hatch, Smith Lever, and State

Scope of Impact: State Specific

Theme: 4.05 Drought Prevention and Mitigation

Title: NEW METHOD FOR MEASURING CANOPY SHADED AREA WILL IMPROVE IRRIGATION MANAGEMENT

Description: The irrigation crop coefficient relates vine water requirements to climatic conditions. Having an accurate coefficient allows farmers to estimate irrigation requirements accurately based on local weather data. Past UC research has demonstrated that the crop coefficient itself can be estimated based on measurements of the ground area shaded by the vine leaf canopy at midday. However, existing methods for measuring the shaded area have not been practical outside of research settings, so few growers used this irrigation management method. A novel method for measuring the canopy shaded area has been developed by a UC viticulture/soils farm advisor for San Luis Obispo and Santa Barbara counties. The device utilizes a lightweight solar panel as a shade meter. The panel is read automatically at high frequency by a datalogger while being moved through the measurement area by the operator. The method provides detailed information on the canopy shaded area with much less effort than previous techniques. The device (dubbed the "Paso Panel") is currently being used by Battany in research settings to measure irrigation crop coefficients and in evaluating irrigation management of commercial vineyards on the Central Coast. The advisor is introducing the Paso Panel to growers at field days and meetings.

Impact: A key step for bringing irrigation information to the commercial grower. Many growers base their irrigation decisions on past experiences or guesswork, rather than data, because a practical method for measuring an accurate irrigation crop coefficient hasn't been available. The new 'Paso Panel' fills that gap. Using the device, growers and irrigation managers can determine vine irrigation crop coefficients that are accurate and based on the conditions in their own vineyards. They can now use this more accurate information to manage irrigation systems more efficiently and to further optimize winegrape quality.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.05 Drought Prevention and Mitigation

Title: SOIL MOISTURE MONITORING IMPROVES IRRIGATION MANAGEMENT

Description: Alfalfa and pasture are the most extensively grown crops in the intermountain region. Irrigation is required for maximum yield and profit but future irrigation water availability in the intermountain area is in question due to competing uses, primarily for endangered species preservation. The region's entire agricultural economy is threatened if water supplies for forage production are reduced. Agricultural water use has come under increased scrutiny and is often singled out as a primary contributor to the decline in anadromous fish populations in recent decades. The general perception of many non-farmers is

that irrigation of pasture and alfalfa is a poor use of limited water supplies. Therefore, it is in the best interest of agriculture to use limited water resources as efficiently as possible. A five-year project funded by US Fish and Wildlife Service assessed current irrigation practices and evaluated the effects of early irrigation cut-off. The study showed considerable differences between ranches. Some fields were over-irrigated and many other were deficit-irrigated, indicating that there was significant potential in fine-tuning irrigation practices. Soil moisture monitors used in the trials were found to be very useful in improving irrigation management and water conservation. A brochure by a CE Farm Advisor and CE Specialists on improving irrigation management by monitoring soil moisture has been used throughout the state and the country. A downloadable Excel spreadsheet was developed by the authors and a programmer to graph the soil moisture readings.

Impact: This improved method of scheduling irrigations has been adopted by growers throughout Siskiyou County and other areas of the state. Nearly half of the producers in Siskiyou County's Scott Valley are now using soil moisture sensors. Educational materials developed during the project are used in irrigation training programs by other agencies such as NRCS, farm advisors in other areas and by irrigation specialists in other states.

Funding Source: Smith Lever, State and US Fish and Wildlife Service

Scope of Impact: State Specific

Theme: 4.06 Endangered Species

Title: Habitat fragmentation and biodiversity of aquatic habitats in California

Description: The project evaluated the population status and recovery potential of the federally threatened Valley Elderberry Longhorn Beetle (VELB) (*Desmocerus californicus dimorphus*). The sub-species is endemic to California's Central Valley and is vulnerable to extinction because it feeds only on patchily-distributed elderberry in riparian habitats. It inflicts a significant annual cost on public agencies through mitigation in response to incidental take of the species. Aims for the overall project were to identify factors that influence population viability, to determine the beetles distribution and abundance, and to assess the influence of factors influencing abundance. In 2005 determination of the extent of VELB populations within the American River Parkway (ARP), Sacramento CA was completed with all of the suitable habitat within the 23 miles of the ARP having been surveyed. Final statistical analyses of mapped shrub and beetle distributions were conducted showing that beetle occupancy and abundance increased with: proximity to the river and presence of adjacent elderberry; intermediate levels of canopy and shrub cover; and in larger elderberry clumps with more elderberry stems. Overall, habitat occupancy appeared to be highly

stochastic and clusters of host plants (elderberry) were on the order of about 200m diameter and beetles were clustered at similar spatial scales. A manuscript reporting this work has been submitted to Biological Conservation. In earlier parts of the project examination of mitigation site data showed that colonization of mitigation sites was highly dependent on beetles being brought to sites in transplanted shrubs, suggesting that the beetle is strongly dispersal limited. Transplanted elderberry shrubs were shown to be disproportionately valuable relative seedlings in mitigation sites because they achieve higher survival rates than seedlings up to the time where they are large enough to comprise suitable beetle habitat. In planted sites certain types of irrigation were shown to be most favorable for survival of shrubs. This work is in press at Conservation Biology. An additional activity was to use a natural experiment to assess the effects of dust from dirt roads on both the host plant and the VELB. A comparison of dirt and surfaced (control) roads showed that there were no significant impacts of dust on elderberry density, plant stress or VELB abundance. Mitigation for dust impacts is a significant source of cost to agencies. A manuscript reporting the dust results was accepted for the journal Environmental Management. Overall the project achieved all of its aims. The analysis of habitat suitability ended up being less predictive than they would have liked, but this reflects the highly stochastic dynamics of the species. It is valuable to know that the species does have highly variable patch occupancy and that it is highly dispersal limited. Both of these factors help us to select suitable areas for conservation and can be used to improve habitat mitigation and restoration practices.

Impact: The project has had a positive impact on both the conservation of a threatened species and on the ability of both US Fish and Wildlife Service (USFWS) and other agencies and companies to perform required activities while minimizing both their impacts on the species and their costs. The evaluation of mitigation reports shows that mitigation efforts are extensive, that transplanted shrubs are more valuable than seedlings, that mitigation reporting is inadequately monitored by USFWS, and that longer term monitoring for more than the current 10-15 years is needed to see whether the species utilizes planted seedlings. These activities will reduce public cost of habitat mitigation and may ultimately result in improved recovery potential for this threatened species. More directly, the results of these investigations have been conveyed to USFWS personnel in two 1 hour seminars, and meetings and seminars have been given to over 14 different public agencies or companies in the Sacramento Area (or statewide) that experience costs associated with the Valley Elderberry Longhorn Beetle. Hence the scientific findings have been used directly to improve current mitigation practices and to advise both public agencies and USFWS about how to best design new habitat and the scale of impacts on the beetle from things like dirt roads. The information is being used to help USFWS update the beetle's Conservation Guidelines and Recovery Plan, both of which will positively impact this rare and threatened species.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.07 Energy Conservation

Title: ESTABLISHMENT OF IRRIGATION STRATEGIES TO MAXIMIZE YIELDS AND FRUIT QUALITY OF GRAPEVINES

Description: The relationships among water use and the crop coefficient of *Vitis vinifera* L. cv. Thompson Seedless with several measures of canopy development were determined with the aid of a weighing lysimeter in the San Joaquin Valley of California. At various times during two growing seasons, vine leaf area, calculated leaf area index and the amount of shade cast on the ground directly beneath the canopy were determined. Leaf area was estimated by measuring the length of all shoots on the vines within the lysimeter and determining the relationship between length and leaf area per shoot and calculating total vine leaf area or by destructive harvests of vines of similar size surrounding the lysimeter. Shaded area was determined in 1998 using a grid (with 50 cm² individual sections) on the ground beneath the vine at solar noon and estimating the percent shade within each square. Total shade was calculated as the product of the area of all squares and the percent shade within each square. In 1999 shaded area was determined from an image of the shade beneath the canopy that was downloaded to a computer and the shade digitized with the use of a software program. Daily water use ranged from 4 to 60 L per vine across both years. Leaf area per vine ranged from 2 to 34 m² vine⁻¹ during the study. The amount of shade cast on the ground was a linear function of total vine leaf area although there were differences between years. The north and south curtains of the vines' canopies were raised for a two-week period in 1999 to simulate an overhead trellis system. The percent shaded area increased from 60 to 75% and vine water use increased from 42 L vine⁻¹ before the curtains were raised to greater than 60 L vine⁻¹ after being raised. The crop coefficient (Kc) increased from 0.9 to 1.3. Vine water use and the crop coefficient were linearly related to leaf area per vine, LAI and the amount of shade cast on the ground. However, the greatest R² value (0.95) of the relationships with the Kc was that for shaded area compared to a R² value of 0.87 for leaf area and LAI. The data indicate that due to the structure of a grapevine canopy the interception of light, as measured by the amount of shade cast on the ground, is a more important determinant of vine water use and the Kc than total leaf area or LAI.

Impact: Differences in trellis types and row spacing, both of which could affect the fraction or percent ground cover, are not presently accounted for in current publications listing crop coefficients for vineyards. The expression of the Kc as a function of percent shaded area as given in this paper could account for differences in water use requirements for vineyards having the same trellis

system but different row spacings or vineyards having the same row spacing but different trellis systems. For example, a VSP (Vertical Shoot Position) trellis for two different vineyards with row spacings of 1.5 and 2.5 m may have the same amount of shaded area per vine (assuming similar vine spacings) but the percent shaded area and therefore the calculated K_c , would be greater at the narrower row spacing. Therefore, water use per unit land area for a vineyard with narrower row spacings would be greater than one with wider rows. From a practical standpoint, managers could estimate their own individual vineyard K_c by simply measuring the width of the shade cast upon the ground and using the relationship between percent shaded area and the K_c from that given in this paper providing estimates of grapevine water use at 100% of ET_c .

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.09 Forest Resource Management

Title: CALIFORNIA HARDWOODS PROVIDE ECONOMIC DEVELOPMENT OPPORTUNITIES

Description: California hardwoods are an underutilized natural resource. California is a major consumer of hardwood lumber (20 percent of nation's production) but the hardwood lumber production industry in the state is almost non-existent; this is in spite of a sizable hardwood tree resource (12 billion cubic feet of timber growing stock). The economic viability of a native hardwood lumber industry depends on a thorough understanding of the lumber recovery and grade yield expected from the resource and a solid knowledge of wood properties and manufacturing characteristics. The focus of this effort is to encourage a sustainable California hardwood industry by identifying basic industry needs, raising the awareness of the potential for value-added products, developing good manufacturing practices, and providing technical assistance. The ANR wood resources group analyzed the structure of the existing hardwood industry in California, identified the needs of the industry to sustain growth, studied the properties and unique characteristics of native hardwoods, and through research developed recommended manufacturing techniques. Direct technical assistance for small businesses and a series of processing workshops were used to deliver this information throughout the state. Three regional meetings were conducted with the primary stakeholders and other interested parties. Research and training needs were assessed by meeting with collaborators and by conducting a formal survey of the existing and potential hardwood industry in the state. The information obtained was used to identify gaps in knowledge, design the research effort, and develop training materials.

Impact: This project clearly demonstrated that utilization of some of the native California hardwood species have potential to create new jobs. Presentations to forest product industry representatives, small business, and entrepreneur clientele sparked interest in new ventures. This led to a 5-fold measured increase in hardwood lumber production and a 500 percent increase in small businesses working with this hardwood resource during the past 4 years. The project was instrumental in cutting processing costs by 40 percent and dramatically increasing production in two new enterprises. In addition, the results were directly responsible for the best practices being implemented in a hardwood processing demonstration facility. By reducing losses to manufacturing defects these recommendations are directly responsible for a savings of \$ 2 million per year in a developing industry. The workshops and technical assistance efforts consistently receive excellent reviews by participants and peers, earning a reputation for the UC Forest Products Lab as the leading source for technical information/advice in hardwood processing. The delivery of technical information to more than 200 clients was responsible for increased efficiency in the production of hardwood lumber in California and the recognition that proper practices must be followed to succeed. Training was directly responsible for reducing manufacturing waste and lowering manufacturing costs at a new hardwood business by 20 percent, a savings of \$1 million per year. As new businesses are developed, the results of this project have the potential to create hundreds of new jobs in the depressed northern California economic regions. This project is expected to lead to the development of a sustainable hardwood lumber industry in northern California that meets environmental criteria for green certification.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.10 Global Change and Climate Change

Title: GLOBAL WARMING AND SURVIVAL OF DESERT BIGHORN SHEEP

Description: Bighorn sheep inhabit about 50 isolated mountain ranges in the California deserts. Their habitat occurs on mountaintops so global warming may cause their habitat to contract upwards with eventual extinction. UC research was conducted to characterize and model the current status and predict the future prospects for survival of desert bighorn sheep in southeastern California. Droppings of bighorn sheep were collected and analyzed. Mitochondrial DNA was extracted to infer population structuring. Fecal nitrogen was analyzed to determine diet. Measurement of fecal nitrogen content-which varies with growth and moisture content of forage plants-from the same droppings will indicate seasonal precipitation patterns. Areas with winter precipitation are expected to

show winter and spring peaks in fecal nitrogen, whereas summer precipitation is expected to show summer peaks with greater variation in amount and timing. Summer thunderstorms typically result in greater precipitation where they occur, but are much more variable in time and space. DNA information indicates that these populations showed a surprising degree of genetic differentiation and a large degree of spatial structuring of bighorn populations. Analyses of fecal nitrogen levels, an index of diet quality, showed that spring diet quality was significantly lower in low-elevation mountain ranges, as predicted by the climate-extinction model, and was positively correlated with lamb recruitment (and thus population growth) across ranges. Using a GIS model that includes the most important environmental variables, and data from 27 previous extinctions, they modeled the vulnerability of bighorn sheep to climate changes projected by global climate models. Lower elevation, drier, and more isolated ranges are most vulnerable. The researchers also used existing software (a population viability analysis model) to estimate error in their extinction in model. There may be cascading effects because the overall bighorn metapopulation is composed of smaller metapopulation clusters. Consequently, loss of certain populations affects the viability of the metapopulation cluster by loss of sources of dispersal necessary for recolonize following extinction.

Impact: The predictions from a survival model for desert bighorn sheep allows one to anticipate, and possibly mitigate, the impact of global climate warming. Data collected have established a baseline condition against which the consequences of actual future climate changes can be compared.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.10 Global Change and Climate Change

Title: Formation and redistribution of nanocrystalline products of biomineralization and chemical weathering during soil formation

Description: UC researchers investigated the coupled physical, chemical and microbial factors that determine the bioavailability of phosphorus in soils. Their prior studies showed that proton-promoted dissolution of iron phosphates is minor over a range of soil-relevant pH values and pointed to the roles of compounds such of oxalate and DFO-B in increasing mineral solubility and dissolution rate. This work also indicated that the rate of oxalate-promoted iron phosphate dissolution is strongly pH dependent, while DFO-B promoted dissolution is weakly- or non-pH dependent. They have extended these studies to explore the role of these and other organic ligands in apatite ($\text{Ca}_5(\text{PO}_4)_3(\text{OH},\text{F},\text{Cl})$) dissolution. This work focuses on the rates and mechanisms of fungally-mediated apatite dissolution in California grassland soils that have been

subjected to various rainfall manipulations to simulate two major climate change model predictions for northern California (sixth year of experiment by Dr. Blake Suttle). They isolated fungi from 20 to 40 cm deep soil horizons in a series of experimental plots in the Angelo Reserve. Active fungal isolates were identified by screening for their ability to dissolve tri-Calcium phosphate ($\text{Ca}_3(\text{PO}_4)_2$) (TCP) in solid media. Using liquid media, two pathways of TCP dissolution were identified among 14 active isolates: (1) Clearing of TCP by acidifying the medium and (2) Clearing of TCP without acidifying the media. All acidifying isolates were found to be Zygomycetes in the order of Mucorales. Non-acidifying isolates were all Ascomycetes, and cleared the media by altering TCP into hydroxyapatite and sequestering it within their mycelial spheres. Two different mechanisms by which soil fungi induce dissolution of apatite were identified. The isolates from the order Mucorales acidify their substrate mainly through production of oxalic acid, when phosphate is available. Acidification appears to be proportional to the fungal growth rate. The Ascomycete isolate, in the family Trichocomaceae, acidifies the growth media under conditions of phosphorus limitation and does not produce extensive amounts of oxalic acid. They conclude that oxalate production by Mucorales is an incidental side effect of metabolism whereas the Trichocomaceae isolate possesses a pathway for production of a compound that dissolves apatite, which is induced in response to phosphate limitation. Results of this work suggest that the apatite dissolution pathways depend on the composition and concentration of organic ligands. One of these compounds, oxalate, strongly etches apatite along channels parallel to [001], forming needle-like surface topography. In contrast, the non-oxalate ligand induces surface rounding, suggesting a distinct mechanism of organic ligand surface interaction. Further work is needed to identify specific compounds released in response to phosphate limitation and the effects of this compound on the apatite surface.

Impact: The results reveal relationships between soil conditions (especially water content) and fungal type and fungal type and apatite dissolution rates and mechanisms. Such work is providing insights to predict how climate changes impact soil fertility. The organisms able to regulate release of compounds that promote apatite release is particularly important, especially if observed changes in vegetation toward plants associated with nitrogen-fixing microbial communities relieve the ecosystem nitrogen limitation.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.10 Global Change and Climate Change

Title: Genetic Analysis of Recruitment and Dispersal in Coastal Marine Ecosystems

Description: Current research for this project primarily focuses on understanding the physical and biological processes that regulate marine populations, especially stock- recruitment relationships and range boundaries. For many commercially important marine invertebrates with sedentary adult phases and planktonic larval phases (e.g., urchins, crabs, sea cucumbers, mussels, and oysters), larval dispersal may be a critical determinant of both population dynamics and geographic ranges. The empirical challenge is to measure patterns and levels of dispersal in the sea. The UC researchers are continuing and extending a project that uses high- resolution microsatellite markers and mitochondrial DNA sequences to understand the population dynamics and dispersal patterns of several intertidal marine invertebrates, now emphasizing studies of a barnacle (TETRACLITARUBENS) that will complement their previous work on the barnacle BALANUS GLANDULA. The range of Tetralcita has been extending northward over the last several decades, suggesting that the well-documented increase in local seawater temperatures may be facilitating the northward range extension of this species. They are using genetic studies to identify source populations for newly established populations along the range boundary, and to characterize whether there is sufficient genetic variation in invading populations so that they can adaptively respond to novel environments at the range boundary. They are also collaborating with colleagues at Bodega Marine Laboratory to determine the physiological tolerances of these barnacles, and to characterize the relative contributions of genetic and physiological adaptation as populations expand northward.

Impact: Information on patterns and levels of dispersal of marine species with long-lived planktonic larvae provides the foundation for (1) developing sustainable management and conservation policies for most commercially important, coastal species and (2) understanding how global climate change will influence species distributions and ecosystem function.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.10 Global Change and Climate Change

Title: COVER CROPPING IMPROVES SOIL PROPERTIES AND REDUCES GREENHOUSE GAS EMISSIONS

Description: Diversifying crop rotations may be a means for reducing disease pressures and improving long-term productivity in California s annual crop production valleys. Using off-season or intercrop cover crops might be a useful crop diversification strategy that also could add organic matter to the soil and improve soil function and quality. In general, farmers have little experience with

cover-cropping practices and have been reluctant to use them. Over the past several years, UC scientists worked to evaluate the impacts of adding winter cover crops to annual crop rotations in California's San Joaquin and Sacramento Valley production regions. In a study initiated in 1999 at the UC West Side Research and Extension Center in Five Points, Calif., the use of triticale/rye/vetch cover crops increased soil carbon by an average of 4,000 pounds per acre after four years under standard tillage and by 4,456 pounds per acre in a conservation or reduced tillage system. When projecting these results into the future to take into account the storage and emissions of various greenhouse gases such as CO₂, CH₄, and N₂O, the cover-crop systems -- particularly when coupled with reduced tillage -- can reduce emissions significantly relative to today's standard systems in which cover cropping and conservation tillage are not used. In addition, the use of subsurface drip systems may enhance the effects of cover crops and conservation tillage in reducing greenhouse gases.

Impact: This initial research shows a number of potential benefits to using cover crops in Central Valley annual-cropping systems, including the improvement of soil properties and the mitigation of greenhouse gas emissions. Researchers and farm advisors are busy developing more grower-friendly practices and systems. They are studying the use of subsurface drip or overhead low-pressure irrigation systems in cover-crop systems, the evaluations of various new cover crops and mixes, the timing of cover-crop establishment and termination, how to efficiently manage irrigation water resources in cover-crop systems, and more efficient means for cover-crop incorporation or management systems.

Funding Source: Hatch, Smith Lever and State

Scope of Impact: State Specific

Theme: 4.11 Hazardous Materials

Title: Using Genetic Engineering to Enhance Phytoremediation of Toxic Trace Elements

Description: A UC research lab uses a multi-disciplinary approach to develop more efficient bioremediation technology for the clean up of selenium (Se) and other trace elements from agricultural and industrial wastewater. The narrative below highlights the most significant achievements. Phytoremediation Field Trial of Genetically Engineered Plants: In 2004, in collaboration with a USDA-ARS, Parlier, CA researcher, UC researchers followed the first-ever field study to evaluate the applicability of genetically engineered plants for phytoremediation (2003) with two field trials conducted in the same sediment with high concentrations of salts, Se, sulfur, and other trace elements, with the following plant lines: wild type (WT) and transgenic Indian mustard (*Brassica juncea*)

overexpressing the enzymes selenocysteine methyltransferase (SMT), chloroplastic selenocysteine lyase (cpSL), or methionine methyltransferase (MMT). Sample and data analysis in 2005 has revealed that both cpSL and SMT lines accumulated significantly more Se than WT plants on a concentration (per gram biomass) and total per shoot basis. CpSL plants were also more tolerant of the sediment and growth conditions than WT. As such, these lines hold promise for phytoremediation in the future. Although MMT plants did not accumulate significantly more Se than WT, they did accumulate more Se on average. Additionally, they had higher bioaccumulation ratios than WT, meaning that the final Se concentration in the plants vs. the soil Se concentration was higher.

Elucidating and genetically manipulating plants for trace element phytoremediation: 1) APSxSMT Indian mustard: The manuscript was completed and published in *Environmental Pollution*. 2) Other hyperaccumulator genes from *A. bisulcatus*: the researchers have initiated a project designed to detect and characterize other important genes in the *A. bisulcatus* Se hyperaccumulation mechanism. Their approach is to compare the transcriptomes of *A. bisulcatus* and its non-accumulator relative, *Astragalus cicer*. *A. bisulcatus* and *A. cicer* plants were grown on MS media in the presence and absence of selenate. Total RNA has been extracted for comparative transcriptome studies from all tissue (root/shoot) and treatment types (with and without Se). 3) Nickel (Ni) hyperaccumulation mechanism in *Alyssum* species: In collaboration with Dr. Leyla Acik of Gazi University, Ankara, Turkey, the researchers began a project to elucidate important genes involved in Ni hyperaccumulation in certain species of *Alyssum*. Fourteen *Alyssum* species (some hyperaccumulators, some not) were grown in both sterile and greenhouse conditions. Plants were exposed to external Ni in the as either nickel chloride or nickel sulfate at different concentrations. Total RNA was extracted from all plant tissue (roots and shoots, with and without nickel) and reverse transcribed into cDNA. *A. murale* shoot RNA (with and without Ni) was submitted to Seegene, Co. for differential display analysis. 63 genes were differentially expressed between the two treatments. Those overexpressed in the + Ni treatment were cloned, sequenced, and submitted to a BLAST search for annotation transfer. They are in the process of analyzing this data.

Impact: The multi-disciplinary research in the UC lab has allowed the researchers to develop innovative means of optimizing phytoremediation from the bench to the field. This bioremediation research will be used to efficiently and economically clean up trace element-contaminated environments.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Selective Management of Lepidopterous Pests in Orchard Ecosystems

Description: Development of alternative pheromone dispensers continue to show promise for disruption of long-range communication between male and female codling moths. Hollow fibers containing the codling moth pheromone that can be dispersed at 30,000-40,000 units per acre can currently be distributed by specialized application equipment affixed to either helicopters or fixed wing aircraft, whereas efforts to develop ground-based applications are underway elsewhere. The applications suppressed virtually 100% of the codling moth trap counts in 3 orchards using 2 applications of the fibers, but damage suppression was not equally dramatic. A similar result was obtained with low rates of puffer (aerosol style emitters) delivery devices. Trap suppression was easily obtained, but damage suppression did not follow. Therefore, different strategies targeting short-range location by codling moth need to be developed in conjunction with disruption of long-range disruption. Future programs will focus on multiple types of dispensers in combination to simultaneously target both long and short range orientation. A rapid means to assess a broad array of pheromone dispensers was tested using the antenna of codling moth to detect pheromone emissions from a unit. Using this approach, the duration of the fibers was determined to potentially exceed 10 weeks, whereas other units (laminated flakes) emitted for shorter durations depending on the level of sunlight striking the unit. The sprayable formulations of codlemone are not photo-stable enough to avoid breakdown in sunlight with the Suterra formulation no longer being detectable within 1 week, whereas the 3M formulation was detectable at 7 days, but not 14 days. These products have been shown previously to have much longer emission rates for applications made to shaded portions of mature walnut canopies.

Impact: New formulations of codling moth pheromone offer excellent promise for addressing the larger canopies of mature walnut orchards that are not suitable for pheromone mating disruption programs based on hand-applied dispensers. Two aerial applications of microtubules filled with the codling moth pheromone effectively suppressed traps for the entire growing season. Contrasts of dispenser technologies using direct assays of detectable pheromone emissions suggested significant differences in product longevity and stability to UV breakdown.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: ENHANCING BIODIVERSITY IN AGROECOSYSTEMS TO IMPROVE PEST REGULATION AND SUSTAINABLE PRODUCTION

Description: In a 17 hectare Sonoma biodynamic vineyard, an island of flowering shrubs and herbs located in the middle of the vineyard provided season-long flower resources and alternate preys/hosts for natural enemies, which slowly built up in the adjacent vineyard. The island and its mix of shrubs and herbs provides flower resources from early April to late September to a number of herbivore insects (pests, neutral non-pestiferous insects and pollinators) and associated natural enemies which build up in the habitat, with some of them dispersing into the vineyard. Clear population gradients were observed for thrips (the only pest species found in the insectory), which increased in abundance in vines farther away from the island . Responding to the abundance of habitat resources in the insectory, predators tended to decrease in abundance in vines 30 and 60 m away . Orius reached significantly lower abundances in vines away from the insectory, a trend that correlated with the densities of thrips .The island acts as a source of pollen, nectar and neutral insects which serve as alternate food to a variety of predators and parasites including Anagrus wasps.

Impact: Habitat management techniques are proving to be an attractive and effective strategy for organic wine producers to complement their ecological pest management schemes. Many farmers are learning about biodiversity enhancement through workshops organized by the California Sustainable Winegrowers Alliance and in which the project data is presented. Several farmers in Mendocino and Sonoma county are already applying habitat management in their systems based on the recommendations.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Engineering for Pest Control in Reduced Chemical and Organic Crops

Description: The project is addressing the reduced use of agrochemicals and the use of organic control materials through the integration of novel pest detection and treatment systems. Particularly in weed control, sensing the presence and location of target weeds within a crop area allows the treatment of the weed to be spatially localized on a leaf-by-leaf scale. This leads to a significant reduction in application rates of agrochemicals, the use of safer, chemically-nonspecific herbicides or the use of localized non-chemical treatment systems. Moreover, if successful treatment of weeds can be accomplished within the seedline where weeds and crops are in close proximity, non-chemical control means, such as mechanical cultivation, can be used in the non-seedline areas. Detection work has focused on using machine vision

techniques operating on images collected in the visible spectrum. For example, shape and pattern analysis has been successful in discriminating between broad leaves such as cotton and thin leaves such as grasses. However, uniformity of lighting is critical for success, occlusion can inhibit shape analysis and damage (wind, rain, pest) to crops can make these techniques difficult to implement in the field. Recent experiments have focused on the use of hyperspectral analysis for discriminating between crops and weeds with similar shapes (e.g. tomatoes and nightshade) and the use of 3-D cameras to address occlusion between crop and weed leaves. Once weed pests are located, the challenge is to selectively treat the weeds without damage to the surrounding crop. In seedlines of young vegetable plantings, spatial resolution on the order of 5 mm is desired. Additionally, if individual weed leaves are to be treated with liquids such as organic or conventional herbicides or heated liquids for thermal control, liquid volumes as low as 40 microliters must be delivered to the target during a 10 millisecond event. While these brief time periods and small volumes are not atypical in industrial coating processes such as ink jet printing, these design constraints are challenging when they must be integrated into agricultural field equipment that is operated in dirty ambient conditions and maintained by heavy equipment service organizations. A precision spray system was developed to apply organic food oils such as canola and safflower to weeds on a 12 x 6 mm grid. The system used an immersion heater and a high temperature pump to heat and circulate oils at temperatures up to 180 C. The sprayer was used in bioassay experiments against typical weeds such as pigweed, barnyardgrass and spurge. Efficacy of topically applied, heated oils was over 95% in most cases, indicating that precision thermal treatment is feasible.

Impact: Historically, pesticides have been applied on a broadcast basis without the ability to target application exclusively to areas requiring the pesticide. This leads to unnecessary release of agrochemicals into the environment, increased costs to growers and potential exposure of people to pesticides. Focusing application of pest control materials only on target areas can significantly reduce the use of chemicals and facilitate the use of lower risk and biologically-derived materials. This precision application can be achieved only if the target can be both sensed and treated. Sensing of plant targets such as weeds, especially when they lie in close proximity to a crop canopy, is technically challenging. High spatial resolution and high working speeds are necessary for commercial success. This project is investigating the use of machine vision and hyperspectral imaging for locating complex targets. Both methods are proving successful and have been investigated in field trials. For treatment, this project is developing robust, field-worthy microspray systems for integration into agricultural vehicles. A microsprayer has been developed to dispense heated oil for weed control. This thermal technique eliminates the need for chemical herbicides by killing plant tissue immediately. Additionally, the method may reduce the need for hand weeding, an operation of concern due to worker health issues. Bioassay tests have determined the feasibility of the method for control of common weeds species found in California vegetable production.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Alternative Approaches to Control Varroa destructor (Formerly, Varroa jacobsoni), An Ectoparasitic Mite of the Honey Bee

Description: Varroa destructor is recognized as the most serious pest of both managed and feral Western honey bee, *Apis mellifera* in the world. Because Varroa has developed resistance to many acaricides and residues of these acaricides have been found in the hive products, it is important to explore the feasibility of using biological control agents including fungi that may infect and kill the mite. Accordingly UC researchers have investigated the infectivity of entomopathogenic fungus *Hirsutiella thompsonii* on Varroa mite as well as host honey bee under laboratory conditions. Their scanning electronmicroscopy study revealed that the fungus infect the mite mainly through membranous leg suckers and the mite died from mycosis with LT50s ranging from 51.1 to 94.9 h depending of the fungal strains and isolates. Since *H. thompsonii* did not infect honey bee from larval to adult stage in their laboratory tests, this fungus may have the potential to be developed as a biocontrol agent for Varroa mite. <p> In 2004, they further collaborate with USDA laboratory to investigate several formulations of *H. thompsonii* in laboratory cage experiments. The experimental results showed that the fungus can kill mites in caged bees; however, the experiments also indicated that improvement on formulations would be needed to increase the application efficacy. None of these tested formulations had application value in field bee hive conditions

Impact: The results of the experiments report for the first time the possibility of using *H. thompsonii* as a biological control agent for honey bee parasitic mite, Varroa destructor, and showed the evidence of the infection mechanism. The research has a great potential to benefit the beekeeping industry with further research on formulations for the mite control applications..

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: BIOLOGY AND INTEGRATED PEST MANAGEMENT OF GRAPE PHYLLOXERA

Description: 1. Fields with damage to phylloxera-resistant rootstocks (with M.A. Walker, Vit. & Enol., UC Davis): Of the vineyard blocks identified as showing damage associated with nodosity phylloxera last year, the two Sonoma blocks were removed from experiments by the owners. One of the Napa sites was removed from consideration by discovery of AXR#1 in the block and some scion rooting. The UC researchers found one additional genuine 101-14 Mgt block in Napa with significant nodosity populations. One untested hypothesis for the cause of damage in this latter site was a root system too large to be supported by midsummer irrigation.
 2. Does phylloxera probing vector fungal necrosis to cause vine damage? The researchers set up greenhouse and field tests to determine if nodosity associated damage is caused by a spreading of fungal necrosis as a result of phylloxera probing on storage roots. 101-14 Mgt vines were treated with a virulent *Fusarium* strain or not. In addition the vines were infested with Type A phylloxera, a 101-14 phylloxera strain, or none. Ten of the greenhouse plants were evaluated in the fall. Increased fungal necrosis was not associated with the presence of the 101-14 Mgt adapted phylloxera. Rather than completing the test in the fall they let the vines overwinter in case the vectoring activity was enhanced by spring conditions. Similarly, the field-plants will be evaluated summer 2006.
 3. Bioassays and DNA fingerprinting: They used the nodosity bioassay method developed last year to test the virulence of 6 phylloxera colonies against up to 26 rootstocks and *V. vinifera* cv 'Chardonnay.' First, observations of activity on field growing vines and the bioassays suggest the phenotypes of 3 strains colonized from 101-14 Mgt roots caused strong nodosities on this root type unlike Type A or B phylloxera. Site conditions likely mediate this activity. Second, root sensitivity of strains is similar in June and August. Third, the three colonies which had a 101-14 Mgt host of origin responded to many rootstocks similarly. They tended to be more virulent on rootstocks with *V. rupestris*, *V. riparia* or *V. berlandieri* parentage while they tended to be inhibited on *V. vinifera* parentage rootstocks. The reverse response was seen with Types A and B. These parentage correlations are somewhat subjective since each plant parent contributes only half of its traits to hybrids. The mechanism for virulence on the *V. rupestris* and *V. riparia* hybrids appears to be ability to form the nodosity. Fourth, the 101-14 colonies had higher phylloxera survivorship, development, and fecundity on the 101-14 Mgt rootstock. However, these colonies were less strong in all three parameters on the *V. vinifera* and AXR#1. Conversely, for the Type A and B colonies *V. vinifera* susceptibility is seen clearly and the non-*V. vinifera* rootstock 101-14 Mgt retains resistance. These data indicate that *V. vinifera* has non-host traits within its genome and rootstocks have host traits. The researchers had difficulty with the DNA fingerprinting because of inadequate extraction. However, with 4 primers they saw a complete separation of 6 genotypes between AXR#1 and 5C field plantings.

Impact: This work investigates a previously unknown damage scenario for phylloxera. The past understanding was that vine damage was limited to storage

root (tuberosity) phylloxera populations. Since tuberosities are not seen on resistant roots, resistance of currently used rootstocks has remained durable. The researchers' observations of high feeder root (nodosity) infestations seemingly associated with vine damage question this understanding. The bioassays demonstrate a nodosity-virulent phenotype that is clearly associated with field populations on roots. The phenotypes select for rootstocks that previously have been resistant to nodosities, and preliminary data indicate that genotypes reflect this distribution. Their probing experiment will disprove or support the contention that nodosity populations cause damage via spread of fungal infections through probing. If the hypothesis is disproved, they will need to look for other reasons for poor vine health in some of the infested sites. If it is supported, they must then determine whether spread of the problem is occurring. The former outcome will minimize the impact and suggest that the nodosity virulence at this point is not of great significance. However it does not rule out the possibility that this virulence will lead eventually to damaging tuberosity virulence. On the other hand, if probing is damaging via spread of fungal infections, this will suggest that these nodosity strains of phylloxera are sufficient as they are to be very problematical for the grape industry, though further selection, would be even worse.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: REFINEMENT OF ARTHROPOD ECONOMIC THRESHOLDS ON FIELD CROPS CALIFORNIA

Description: The alfalfa weevil complex, comprised of the Egyptian alfalfa weevil (EAW), *Hypera brunneipennis*, and alfalfa weevil, *Hypera postica*, is the most damaging arthropod in California alfalfa. An insecticide application is commonplace in the late winter/early spring to control this pest.

Organophosphate, carbamate, and pyrethroid materials as well as other products are used. These treatments are generally effective and the effects on populations of natural enemies appear fairly short-term. However, the occurrence of organophosphate insecticides in surface waters, particularly chlorpyrifos (Lorsbanr), coinciding with the timing of treatment for EAW larvae, has placed added emphasis on refining IPM programs for this pest in alfalfa. Pyrethroid insecticides have also recently been implicated in some environmental concerns. UC researchers initiated studies in 2002 to re-evaluate the EAW treatment threshold under current production practices and to improve sampling strategies for this pest. Preliminary data were collected from one site in 2002-03 and 2004 and 2005 studies were expanded to several Central Valley locations. At the Davis location, first harvest yield losses from EAW larvae were very severe in

2002 (~50% from 10 larvae per sweep), moderate in 2003 (25% from 10 larvae per sweep), no losses from 35 larvae per sweep in 2004, and ~10% from 10 larvae per sweep in 2005. First harvest alfalfa hay quality (percentage crude protein, and digestibility) has consistently been unaffected by larval feeding. In 2005, square foot samples of alfalfa growth were sampled twice weekly during the larval feeding period in plots where the pest was controlled versus left uncontrolled. Biomass was separated into leaf tissue and stems tissue and dried. Weights and nutrient quality parameters on each component were recorded to gain a better insight on the effects of alfalfa hay quality.

Impact: Alfalfa is a commonly grown crop in California and is important as it supports the dairy industry. Insecticide treatments for the alfalfa weevil complex are made at a time of year where precipitation is common and pesticide run-off is possible. The occurrence of insecticide residues in certain waterways has been partially connected with use in the alfalfa system.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: PLANT-VIRUS-VECTOR INTERACTIONS: A BASIS FOR DISEASE CONTROL

Description: 1) Phylogenetic analysis of the thrips bacteria with 16s ribosomal DNA analysis, phenotypic tests, electron microscopy and cloning is complete. They have shown that thrips bacteria inhabit the thrips gut, are culturable and passed horizontally among thrips. The bacteria are *Erwinia*-like and at least two closely related types of bacteria are associated with the Western flower thrips, *Frankliniella occidentalis*. Thrips may be infected with one bacterial type at a time or both simultaneously. Presence of the bacteria in thrips populations from the Netherlands, Germany, California and Hawaii support the hypothesis that these organisms are likely facultative symbionts. A genetic approach is currently being used to study the impact of bacterial infection on thrips biology. Experiments with TSWV GN (formerly GP2) expressed from a baculovirus expression system show this protein binds thrips midguts and inhibits virus acquisition by thrips.. TSWV GC (formerly GP1) has been characterized and shown to be cleaved at acid pH and have the characteristics of a fusion protein. Evidence suggests these two proteins act in concert to mediate virus acquisition to the thrips midgut. Three papers on this thrips-tospovirus research have been published since the last progress report. 2) The UC researchers have biologically and molecularly analyzed segments of 30 Citrus tristeza virus isolates captured with aphids from commercial trees in the San Joaquin Valley. They have used microarray analysis to examine the genotypes of highly and poorly transmitted CTV isolates and to

compare trees from commercial orchards to their respective aphid transmissions. One paper is in press that reviews these results. Results from Yeast-two hybrid studies have revealed new information about viral protein- protein interactions and generated new hypotheses for the processes underlying aphid acquisition of CTV. In a model system they have used constructs of CTV genes to prevent infection via RNAi. One paper is in press since the last progress report.

Impact: The project findings provide a fundamental understanding of how insects transmit viruses, the role of other micro-organisms in mediating acquisition and the selective force insects place on viral epidemics. The researchers have shown that the bacteria associated with *Frankliniella occidentalis* have the hallmarks of facultative symbiosis. They have provided direct evidence for the roles of GN and GC in mediating virus acquisition by thrips and have shown that they can block transmission with GN. These findings provide a starting point for designing potential control measures to limit tospovirus spread by thrips. They have shown that aphids act as a strong selection pressure influencing CTV evolution and have focused attention on the importance of developing a mechanistic understanding of how aphids acquire the virus. They have shown the potential success of RNAi as a strategy for CTV management and the limitations that must be overcome before Mi-mediated resistance in transgenic materials can be stabilized for nematodes and aphids.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: The Biology and Management of Insects and Insect-Borne Virus Diseases of Field and Vegetable Crops

Description: Virgin female squash bugs produce a pheromone that is attractive to the male. Females release at two compounds, neither of which were seen in male extracts. Studies were conducted to determine if lygus bugs could be retained in alfalfa fields by leaving uncut strips as a habitat. Uncut strips were left in three field representing 5, 7, and 18% of the total area. All three fields retained lygus equally well. Blends of 75:25 new/old alfalfa had only a minimal impact on hay quality compared to 100% new growth alfalfa and in most cases quality did not differ. Acid Detergent Fiber, used to calculate several quality parameters, was generally not impacted by blends that included 25% or less of old alfalfa. Fresh market tomatoes were grown in using three production systems. In the spring planted/summer harvest crop, tomatoes grown over reflective mulch matured 10 days to 2 weeks earlier, yielded ca. 25% more mature green fruit, and were infested with fewer aphids and thrips than were plants grown in the other productions systems. In the summer planted/fall harvest crop, wheat straw was used as the cover crop. Yields between the three systems were not

significantly different. Reflective plastic mulch and wheat straw mulch delayed the onset of cucurbit viruses in zucchini squash by four to six weeks. Wheat straw mulch was superior to all treatments in delaying the onset of squash silverleaf induced by the feeding of silverleaf whitefly. The occurrence of aphid-borne virus diseases was significantly reduced in cantaloupe plants growing over reflective plastic and wheat straw compared to those growing over bare soil. Reflective plastic reduced the incidence of virus diseases to a greater extent than did wheat straw. The occurrence of silverleaf whitefly was reduced equally by plastic mulch and wheat straw. Plants growing over reflective plastic produced mature melons sooner and more cartons per acre than did the other production systems. The reflective plastic system also produced a greater number of large size melons. Plant growing over straw mulch produced higher yields, including large size melons, than did those growing over bare soil. Corn leafhopper populations were sampled from November to March using yellow sticky cards, D-vac suction samples and inspection of volunteer corn plants and spring planted corn. *S. kunkelii* presence was determined by sampling sentinel plants placed in the field during the winter, leafhoppers collected throughout the winter, evaluation of volunteer plants over the winter and the sampling of spring planted corn. Leafhoppers were collected on yellow stick cards in every month throughout the winter during all three years. They were also regularly recovered from alfalfa, winter forage and riparian areas. Females constituted the majority of leafhoppers recovered on sticky cards and from D-vac samples. *S. kunkelii* was recovered from leafhoppers throughout the winter, from sentinel plants placed in the field and in spring planted corn found to contain leafhopper adults shortly after seedling emergence. Volunteer plants were determined to be a critical key in leafhopper overwintering and the survival of *S. kunkelii*.

Impact: Squash bug pheromone will eventually be used in mating confusion. Leaving uncut strips of alfalfa is effective in managing lygus bugs. Reflective mulches can be used to manage aphids and aphid borne viruses in cucurbit crops as well as reduce and delay colonization by silverleaf whitefly. Studies show that the corn leafhopper and the spiroplasma pathogen can overwinter in the San Joaquin Valley.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Molecular basis of insect olfaction

Description: Using a newly developed binding assay and recombinant olfactory proteins from the navel orangeworm, UC researchers have observed binding of the major pheromone constituent, Z11Z13-16Ald to a pheromone-binding protein,

AtraPBP1. These experiments confirmed that this male-specific olfactory protein binds a pheromone and is, therefore, a pheromone-binding protein. They used this 'molecular target' to fish out other potential attractants for the navel orangeworm. They observed that AtraPBP1 binds (Z,Z)-11,13-hexadecadienyl acetate, Z11Z13-16Ac, with the same apparent affinity as that observed for Z11Z13-16Ald. With this 'molecular hint', they were able to isolate this compound from the pheromone gland of virgin females. Preliminary field and indoor bioassays suggested that Z11Z13-16Ac is neither an attractant nor an inhibitor for the navel orangeworm. However, field tests clearly indicated that Z11Z13-16Ac is a behavioral antagonist for *Pyralis farinalis*. In addition to Z11Z13-16Ac (and Z11Z13-16Ald), two other compounds, ethyl (Z,Z)-hexadecadienoate and ethyl palmitate, were also present in the fraction from gland extracts that contained Z11Z13-16Ac. An additional 'molecular hint' was the observation that (Z,Z)-11,13-hexadecadienol, Z11Z13-16OH, binds to the 'molecular target' suggesting a potential role in olfaction. As demonstrated in competitive binding assays, in which AtraPBP1 was exposed to the three ligands at the same time, AtraPBP1 showed slightly higher preference for the behavioral antagonist, whereas both the known Z11Z13-16Ald and Z11Z13-16OH showed apparently the same binding affinity. Z11Z13-16OH was also isolated from the pheromone gland extracts. Other EAD-active compounds produced by the pheromone gland were fully identified as the novel pentaenes, (Z,Z,Z,Z,Z)-3,6,9,12,15-tricosapentaene and (Z,Z,Z,Z,Z)-3,6,9,12,15-pentacosapentaene. (Z)-11-hexadecenal and (Z)-13-hexadecenal were also identified as minor constituents. All newly identified compounds were tested in the UC Davis experimental field where populations of the navel orangeworm are very low. Clearly, the new synthetic lure is active as significantly more males were captured in traps baited with the new synthetic pheromone blend than in virgin females-baited traps. When the synthetic pheromone was formulated in rubber septa, trap captures during the first night that the traps were deployed were high, but the captures decreased dramatically on the second night in the field. This was observed not only with NOW, but also with *P. farinalis*, which has a higher population in the location where the tested were conducted. The rapid decrease in activity of the NOW pheromone formulated in rubber septa suggests additional problem(s), which may be derived at least in part from exposure of the pheromone to sun light. Thus, for commercialization of the newly discovered pheromone mixture, long-lasting formulations need to be developed. Sun light exposure is not a problem when the pheromone is canned and applied by a 'puffer' for mating disruption.

Impact: Additional constituents of the sex pheromone of the navel orangeworm, the most serious pest of almond and pistachio in California, remained elusive for almost three decades. The discovery of eight new pheromone compounds opens new opportunities for pheromone-based, environmentally-friendly strategies for monitoring and controlling populations of this economically important pest.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Resistant Host Plants and Cover Crops for Management of Plant-Parasitic Nematodes in Sustainable Cropping Systems

Description: To assess potential cover crops for use in management of sugarbeet cyst nematode (SBCN), *HETERODERA SCHACHTII*, UC researchers have continued greenhouse experiments on potential cover crop plants that may be useful in California rotations to reduce SBCN numbers in soil. In two separate experiments, assay plants included a mustard blend, Arugula (Nemat. Gowan), Beta 8520N (as a control), cabbage (as a control), oil seed radish, oil seed radish (Diablo Gowan), and Phoenix. Plants that supported very limited reproduction of SBCN included the oil seed radish plants and Arugula, with Pf/Pi ratios that were less than 1. Given that the nematodes infected the plants but showed limited reproduction it is possible that they may have some potential for use in California. However, the reproduction that did occur is cause for some concern relative to long term use of such plants because they may act as selection pressure for SBCN isolates capable of increased reproduction on the cover crops. Additional trap crops were also evaluated for management of SBCN, including *BRASSICA NAPUS* (oilseed rape) Humus, *BRASSICA JUNCEA* (mustard), Horned Green, Red Giant, Erika, Green Wave, Southern Giant, Pacific Gold, ISCI 20, ISCI 61A, ISCI 61B, and ISCI 99, and *SINAPIS ALBA* (white mustard) Martigena and Ida Gold. Cultivars supporting the least SBCN reproduction (Pf/Pi 0.3) were Martigena, ISCI 99, ISCI 161B, and Red Giant. Evaluations of these latter cultivars is continuing. There have been numerous reports of bacteria as having potential as biocontrol agents of plant-parasitic nematodes, but none of the reports have assessed members of the genus *LYSOBACTER*. The *LYSOBACTER* are typically found in soil and water habitats, and characterized by having lytic activity against other microorganisms, including nematodes, presumably through the diverse array of antibiotics and lytic enzymes they can excrete, including chitinases, lipases and proteases. In the lab they assessed the influence of *LYSOBACTER ENZYMOGENES* strain C3 (LEC3) on *CAENORHABDITIS ELEGANS*, SBCN, *MELOIDOGYNE JAVANICA*, *PRATYLENCHUS PENETRANS*, and *APHELENCHOIDES FRAGARIAE*. Exposure of *C. ELEGANS* to LEC3 on agar plates resulted in almost complete elimination of egg production and death of 94% of hatched juveniles after two days. Hatch of SBCN eggs was about 50% on a lawn of strain C3 on agar as compared to 80% on a lawn of *E. coli*. Juveniles that hatched on a plate of LEC3 on agar died due to the cuticle and body contents disintegrating. *M. JAVANICA* juveniles died after four days of exposure to a seven-day-old chitin broth culture of LEC3. Immersion of *A. FRAGARIAE*, *M. JAVAINCA*, AND *P. PENETRANS*

juveniles and adults, and SBCN juveniles exposed to a nutrient broth culture of LEC3 strain C3 led to rapid immobilization and disintegration of the nematodes.

Impact: A few isolates of *Beauveria bassiana* were virulent against the glassy-winged sharpshooter, a devastating insect pest of grapes and other crops because of its efficiency as a vector of Pierce's disease. The use of this fungus may reduce overwintering populations of this insect.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: ALTERNATIVE WEED CONTROL OPTIONS FOR CALIFORNIA STRAWBERRY AND VEGETABLE GROWERS

Description: Strawberry herbicide program. All conventionally-produced strawberries in California are grown on soils that were previously fumigated. All fumigants, including methyl bromide, fail to control little mallow. However, oxyfluorfen herbicide effectively controls little mallow. In collaboration with several strawberry growers, and extension farm advisors, they developed an oxyfluorfen program for strawberry. Oxyfluorfen is applied at 0.25 to 0.5 lb ai/A 30 days before transplanting. Then, to avoid crop injury, a plastic tarp is installed prior to strawberry transplanting. By the end of 2003, 5 percent of California strawberry acres were treated with oxyfluorfen, up from 1 percent in 2002. Growers who have adopted this program like it because it reduces hand weeding costs by as much as 200 dollars per acre. Nutsedge management. In the Coachella Valley during 2003, UC researchers found that fallow applications of 1,3-dichloropropene plus chloropicrin (TC35) at 28 gallons/A (GPA) followed by (fb) EPTC at 7 pts./A resulted in better nutsedge control than EPTC alone. They initiated two follow-up studies in 2004, again in the Coachella Valley, to verify 2003 results. Treatments applied to fallow ground in 2004 were: shank injections of metam potassium or metam sodium at 50 GPA and TC35 at 20.5 and 26 GPA. Following fumigant application, all plots were treated with 7 pts./A EPTC that was disk incorporated. During the first 6 months after application, sequential applications of TC35 at 20.5 to 26 GPA fb EPTC at 7 pt/A provided better nutsedge control than EPTC alone, and metam sodium/potassium fb EPTC treatments suppressed nutsedge compared to EPTC alone. To look for long-term nutsedge control benefits greater than 6 months, they monitored these sites in 2005. In fall 2005 at site one, they found that the TC35 and metam fb EPTC treatments applied 15 months earlier, still controlled nutsedge better than EPTC alone. However, at the second site monitored 13 months after application, none of the treatments were better than the current commercial standard EPTC alone. They concluded that short-term benefits of TC35 fb EPTC clearly suppress

nutsedge better than EPTC alone, while long-term benefits are not guaranteed. Herbicide evaluations in celery. Celery growers are concerned about limited weed control options, and believe that they need additional herbicide tools. In 2005 they evaluated pretransplant applications of S-metolachlor at 0.63 lb ai/A, flumioxazin at 0.188, 0.25 and 0.375 lb ai/A, sulfentrazone at 0.125 lb ai/A, oxyfluorfen at 0.25, 0.5 and 0.75 lb ai/A, and V-10142 at 0.1 lb ai/A for celery tolerance and yield as well as weed control. Post transplant applications evaluated were V-10142 at 0.1 lb ai/A and commercial standards Iroxo at 1.0 lb ai/A and prometryn at 1.5 lb ai/A. All treatments were found to be safe on celery, with the exception of oxyfluorfen at 0.75 lb ai/A, which caused slight yield reduction, and V-10142 which killed the celery. A project request will be sent to IR-4 to pursue a celery tolerance for sulfentrazone. IR-4 projects are already in progress to pursue crop tolerances for flumioxazin.

Impact: California strawberry and vegetable producers sold about \$5.2 billion in produce during 2004. The long-term profitability of California vegetable producers is threatened by the potential loss of vegetable herbicides to regulatory action, as well as labor shortages and increasing energy costs. Integrated weed management strategies may allow reduced pesticide inputs and ease some of the regulatory concerns surrounding many of the older vegetable herbicides, as well as hold down production costs.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Horticultural crop genomics: genetic resources diversity and integrated pest management

Description: A project to develop a biocontrol yeast for control of *Aspergillus flavus* in pistachio was continued. Artificial wounding experiments were conducted in a organic orchard to determine if biocontrol yeast would control *A. flavus* on the wounded nuts and to evaluate persistence of the yeast on the wounded nuts. The ability of the yeast to control *Alternaria alternata* was also evaluated and preliminary results were promising. A project to evaluate published molecular marker genes for sex expression in pistachio was completed. The markers do not predict sex in diverse pistachio populations. Collection of data was continued on three pistachio genotypes identified for cultivar release and presently under advanced testing. A large scale budwood distribution was done for the two female and one male cultivars.

Impact: The development of biopesticides can reduce the use of hazardous chemicals for the control of plant pathogenic fungi, e.g. *Aspergillus flavus*. Use of

these biopesticides may also contribute to food safety by reducing the level of aflatoxin in pistachio. Biocontrol yeast may also be an effective control measure for *Alternaria alternata* in organic pistachio production systems. Presently there are no effective pesticides that can be used in an organic production system. The new pistachio cultivars being released are expected to provide growers with improved marketable yield and profitability, especially during seasons with low winter chilling which are expected to become more common as the environment becomes warmer. Earlier harvest will also help growers manage a heretofore short harvest window.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Disease Management in Ornamental Crops

Description: Over the past year, UC researchers have continued their work on *Phytophthora ramorum* in ornamental nurseries. They have been able to do work at several nurseries that were confirmed positive for *P. ramorum*. In one large southern California nursery, following a severe outbreak of disease on their camellia crop, they were able to evaluate *P. ramorum* survival in soil and movement within the nursery. After the crop was removed for destruction, they baited from the underlying bed soils. They found that 100 percent of the baits became infected when placed in soil samples collected as late as four weeks after the plots were cleaned off. They continued to detect *P. ramorum* in bed soils, albeit at lower frequency, up to 75 days after plant disposal. They lost control of the plot after 75 days and were unable to continue testing beyond that time. A rainfall event which occurred during this trial allowed us to also bait from runoff water that moved across the infested plot. They detected *P. ramorum* in water draining from the infested plot, in water draining into a collection ditch at the low end of the property, and in water pumped back up into the main recycling pond of the nursery. This shows that *P. ramorum* has the potential to spread with recycled irrigation water, and that effective water treatment is essential. They also have conducted tests at nurseries where *P. ramorum* was confirmed to be present, and where nurseries were subsequently following the APHIS Confirmed Nursery Protocol (CNP). At one nursery, Basamid was applied to bed soil at the maximum label rate, and the bed was then wetted to seal the surface. They conducted baiting before and after this treatment, and detected viable *P. ramorum* after treatment. The treatment was repeated, but using a plastic tarp to seal the soil on the second attempt. Following the second treatment, they were unable to detect *P. ramorum*. In another nursery location, they set up a replicated experiment using Clorox as a treatment. This replicated a treatment the grower had used the previous year, selecting Clorox because the beds were largely

gravel-over-soil, and Clorox is the treatment recommended in the CNP for non-porous surfaces. They found the Clorox treatment to be no more efficacious than water or no treatment at all. These tests may provide insight into the high rate of re-emergence of *P. ramorum* in nurseries that undergo the CNP in one year, only to have *P. ramorum* re-appear the following year. They presently are testing additional soil treatment chemicals to see if more efficacious materials or application methods can be developed so that re-emergence is reduced. This work is ongoing.

Impact: Growers of ornamental crops have been severely impacted by the emergence of *Phytophthora ramorum* on ornamental hosts. This work is aimed at helping growers understand the epidemiology of *P. ramorum* in the nursery environment, and at providing growers with more effective procedures for cleaning up nurseries following a confirmed detection.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Develop Management Practices for Recently Introduced Rice Diseases in California

Description: Rice Blast disease (*Pyricularia grisea*) has occurred sporadically in California since its introduction in 1996. UC researchers are continuing to monitor the races and to date only one race (IG-1) has been found. Study on the Bakanae disease (*Giberella fujikourii*) is being continued. They have found that infection from soil and or over-wintering residue may occur but at very low levels confirming earlier study that infested seed is the primary source of initial inoculum. A comparison of three seed assay methods on 198 seed lots including plating seed on *Fusarium* selective media, observations of 30 day old seedlings on germination boards and in a field grow out assay. Low Spearman correlations between the assay methods suggested the grow out assay is the most suitable of the methods tested for implementing management practices. Analysis of the population structure of *F. fujikourii* in California revealed three vegetative compatibility groups, both mating types, Mat-1 and Mat-2. AFLP analysis revealed 27 unique haplotypes with 53 % of 174 isolates representing a single clone. UPGMA analysis produced three clusters, each corresponding to a specific VCG. VCG accounted for 76.3 % of the observed AFLP variation. Thus while sexual reproduction has been observed, the low VCG diversity, predominance of a single clone and the lack of evidence for random mating suggest that clonal reproduction predominates in the population introduced into California.

Impact: Knowledge of *P. grisea* races in California allows breeders to proceed with logical attempts to produce blast resistant cultivars for California. Increased knowledge of the disease cycle of *Bakanae* and biology of the pathogen allows better management of the disease by altering some cultural practices and develop environmentally friendly seed treatments for control of the disease.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: MOLECULAR DETECTION, CHARACTERIZATION AND MANAGEMENT OF PLANT DISEASES CAUSED BY GEMINIVIRUSES

Description: UC researchers continued their investigation of the importance of curly top disease in melon. Their approach has involved 1) surveying melon fields for curly top symptoms (stunted growth and upcurling, crumpling and yellowing) and 2) inoculating various cucurbits, including cantaloupe and honeydew melon, with the three curly top viruses known to occur in California (Beet curly top virus, BCTV; Beet severe curly top virus, BSCTV; and Beet mild curly top virus, BMCTV) and determining their susceptibility compared with tomato and tobacco. In 2005, they also expanded their survey efforts to get samples from other states. Surveys were conducted in California failed to reveal obvious symptoms of curly top were observed in any fields, and curly top virus was not detected in any samples from any California melon fields. However, in late August/early September they received samples of melons (cantaloupe, honeydew and charentais) from Idaho that had curly top-like symptoms (leaf curling, crumpling and yellowing). Using the PCR technique they confirmed that most of these were infected with BMCTV. Thus, this appears to be a real case of curly top of melon, and it correlated with one of the worst curly top years in Idaho history. Results of CTV inoculation experiments using two inoculation methods indicated that melon can get infected by curly top viruses and even develop symptoms, but that melon is a poor host compared with tomato or tobacco. By agroinoculation, BCTV and BSCTV had very low rates of infection in melon; whereas 100% of inoculated tomato and tobacco plants were infected and showed severe symptoms. A similar situation was observed with leafhopper transmission of BMCTV; however, it was discovered that the host from which the leafhopper acquires the virus influences the ability of the insects to infect cucurbits. Thus, when leafhoppers acquired the virus from the highly susceptible host, Shepherd's purse, cucurbits get infected with BMCTV, and a number of pumpkin (8/17; 47%) and cantaloupe (2/20; 10%) plants even developed curly top symptoms (leaf curling, crumpling and yellowing). In contrast, no infections were detected when insects acquired the virus from sugar beet, a less susceptible host. Considered together with the finding of curly top in melons in

Idaho, their results indicate that under certain conditions curly top can develop in melons, which is in agreement with the early reports of curly top in melon. A threshold model is proposed to explain these results, in which high CTV pressure is needed for curly top to develop in less susceptible hosts (melons) and little pressure is needed to infect highly susceptible hosts (tomato and tobacco).

Impact: The curly top disease is known to be an important disease of crops such as tomato, sugar beet and common bean in California, and a statewide spray program is conducted to control the beet leafhopper vector. However, it has been a conundrum trying to reconcile old reports of curly top disease in melons and the more recent inability to find the disease in melon, even in areas having curly top in tomato. Their findings that curly top can develop in melons, but only under high virus pressure, may help explain this conundrum. Thus, when leafhoppers are fed on a host having a high titer of curly top virus, they deliver sufficient virus into melon for some plants to develop curly top symptoms. Consistent with this finding was the identification of curly top in melon in Idaho in 2005, when disease pressure was extremely high. It is therefore possible that the curly top spray program could benefit melons by keeping levels of the virus below the threshold needed for melons to develop the disease.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: EPIDEMIOLOGY AND MANAGEMENT OF DISEASES OF VEGETABLE CROPS

Description: Salinas Valley, the nation's salad bowl accounts for nearly 60 percent of the total lettuce production and soilborne diseases are a major impediment to production. Lettuce drop caused by *Sclerotinia minor* and *S. sclerotiorum* is one of the most important disease throughout California. Despite *Sclerotinia minor* being the dominant species in the Salinas Valley, losses caused by it are more predictable and at least one effective fungicide is available for managing it. In contrast, the more dramatic losses are caused by the airborne phase of *S. sclerotiorum* that hitherto was restricted to the central and desert valleys in California with limited management options. This decades-old geographic delimitation is likely to be altered by the evolving production practices such as the 80 inch bed configuration largely being driven by the consumer preference for ready-to-eat salad mixes. This in turn has the potential for the establishment of the explosive airborne phase of *S. sclerotiorum* in the Salinas Valley. This year, UC researchers concluded the studies comparing the effects of 40 inch and 80 inch bed configuration on lettuce drop development caused by both species. Data obtained over the past three years suggest that lettuce drop

caused by both species is significantly greater on 80 inch beds than on 40 inch beds; the aerial infections from *S.sclerotiorum* are at least 50 percent higher on 80 inch beds with significantly greater inoculum additions to soil than on 40 inch beds. Another aspect of their work on this disease has been to develop new methods of managing this disease. As part of this, they evaluated several biocontrol treatments along with the standard fungicide in the desert production areas over the past three years and consistently, Contans (*Coniothyrium minitans*) provided the greatest reductions in lettuce drop caused by *S. sclerotiorum* that essentially obviated the need for fungicides. They continued monitoring the spread of *Verticillium* wilt on lettuce to new areas of production in coastal valleys. The most significant discovery was the existence of two races in *Verticillium dahliae* populations infecting lettuce. Race 2 of the pathogen is virulent on all of the existing cultivars of all lettuce types. The relative distribution of the two races along with methods to rapidly identify the two races is being developed currently. They are also continuing with studies to determine the efficacy of methyl bromide + chloropicrin at different soil depths and the rapidity of recolonization of fumigated soil by *V. dahliae* microsclerotia is currently being explored.

Impact: Because of the applied nature of this work, the results always have a direct impact on disease management in many vegetable crops. The researchers have identified the production practices that would have a major impact on soilborne diseases on lettuce in the Salinas Valley. A number of lettuce breeding lines with resistance to *S. minor* and *V. dahliae* have been developed and being evaluated. How well these sources of resistance hold up against race 2 of *V. dahliae* will have a significant impact on how soon lettuce cultivars from these sources can be developed. Nearly all of the research conducted as part of this project is directed towards developing disease management strategies with the twin purpose of increasing sustainability and reducing the pesticide burden in vegetable production systems. These strategies are rooted strongly in the principles of ecology, epidemiology, soil microbiology and sustainable agriculture.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Stone Fruit Diseases: Etiology, Pathogenicity Mechanisms and Host Resistance

Description: Approximately 337 peach genotypes were evaluated in laboratory assays for resistance to brown rot disease caused by *Monilinia fructicola*. Mean lesion diameters and incidence (proportion of infected fruit) were determined in inoculated fruit for each genotype, and from these values disease severity values

were calculated. Fruit color, an indicator of quality and ripeness, also was estimated by color image analysis and light transmittance. Due to the favorable conditions for naturally occurring brown rot disease in the field this year, latent infections complicated interpretation of results for some genotypes, including several from previous analyses that have shown promise for further development. UC researchers continue to find selections that display a significant level of disease resistance in the laboratory assay, with a significant number (50) of the genotypes showing very high levels of resistance with a disease severity value less than 0.2. This year's evaluation included material carried forward from previous years, including some of the advanced lines with heritage from cv. Bolinha and a number of USDA lines. Of particular interest is identifying promising early and late maturing genotypes, since these are often the most vulnerable to brown rot disease and present the most difficult challenge for disease management. The number of genotypes they have screened in the program during the past 11 seasons now totals approximately 2400. Their evaluations indicate that the disease resistance of some of the lines, which have been evaluated over several seasons, is stable. Studies on *Monilinia* pathogenicity mechanisms continued, and certain aspects concluded with the completion of M-H Lees Ph.D. dissertation. Principle discoveries include the development and characterization of a DNA transformation method for *M. fructicola*; a description of different appressorial morphotypes in *M. fructicola*; the regulation of appressorium formation and the role of appressoria in pathogenesis; the isolation and characterization of the genomic sequence of a cutinase gene *Mfcut1*; the demonstration of the expression of *Mfcut1* during pathogenesis; and a detailed analysis of the influence of extracellular and intracellular redox status on expression of cell wall degrading enzymes by the pathogen.

Impact: These findings have advanced their ongoing efforts to select promising peach genotypes for further development within the stone fruit breeding programs, with a goal of developing cultivars with improved fruit chemistry and resistance to brown rot disease. The methods developed for studying *Monilinia* at the molecular level will enable mechanistic studies of fungal pathogenesis and quiescence.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Etiology, Epidemiology, and Control of Virus Diseases of Grapevines, Fruit and Nut Trees, Roses, and Strawberries

Description: The ability of rose cuttings from virus-infected stock to root was studied by UC researchers on Rosa hybrida Dr. Huey, a commonly used rootstock variety. Stock was infected with Apple mosaic virus ApMV, Prunus necrotic ringspot virus PNRSV and a mixed infection of both ApMV and PNRSV; stock which has indexed negative for virus was used as the control. Virus infection reduced total percent rooting by an average of 35% as compared to healthy. Root vigor was also negatively affected by virus infection. The diameters of the cuttings from one virus treatment consisting of a mixed infection of ApMV + PNRSV were significantly smaller than healthy, but not in the other two virus treatments. It is possible that in some cases, rooting reduction is an indirect effect, due mainly to a decrease in stem diameter, stored carbohydrates and vigor. Double-stranded RNA (dsRNA) was extracted from roses that showed rose spring dwarf disease symptoms on (RSD) Rosa multiflora indicator host and negative on Shirofugen cherry. The dsRNA was used as template for making a cDNA library. A virus which was closely related to members of the family Luteoviridae was identified. The virus was found to have five open reading frames (ORFs), similar to the genomic organization of luteoviruses. Similarities were observed in different coding regions for RNA- dependent RNA polymerase (ORF 1 and 2), coat protein (ORF 3), movement protein (ORF 4), and readthrough protein (ORF 5). A specific reverse-transcription polymerase chain reaction (RT-PCR)-based detection method was developed. They are currently in the process of characterizing this virus.

Impact: As commercial garden rose production in the United States is moving toward a greater use of own rooted plants, the effects of virus infection on the ability of a cutting to root could have a significant role in propagation efficiency. These experiments have demonstrated the importance of using virus tested stock in the production of garden roses. Rose spring dwarf causes rosetting or a balled appearance in the new growth following bud break. The leaves first emerge in the spring are recurved or very short, and show conspicuous vein clearing or a netted appearance. Previous studies have been conducted to determine the causal agent associated with RSD but without success. Since detection and identification of the rose virus diseases is an important part of rose maintenance program it is essential for formulation of control measures that can be recommended to rose growers. This work should provide a laboratory test for Rose spring dwarf.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Disease Mechanisms and Management Strategies for Pierce's Disease

Description: During 2005 UC researchers continued basic and applied research on Pierce's disease (PD) of grapevines which is caused by the bacterium, *Xylella fastidiosa* (Xf). A second inoculation of approximately 40 putative avirulent mutants found that only 3 of these remained avirulent, the other produced PD symptoms that were similar or slightly less than the wild type strain. These three avirulent mutants are now being further characterized. Research published in 2005 described a number of mutants with hypervirulent phenotypes, i.e. grapevines inoculated with these mutants developed more severe disease sooner and died faster than vines inoculated with the wild type parental strain. Sequence analysis showed these insertions to be in a hemagglutinin (HA) gene, 2 LPS genes, an iron transport gene and several genes of unknown function. A second HA gene homolog was disrupted by site directed mutagenesis and this mutant also showed a decrease in cell/cell attachment as did the HA mutant identified by the random screening process. They are now further characterizing the cellular and in planta location of the HAs. They are also attempting to identify and sub-clone those regions of HA proteins that mediate Xf cell-cell interactions. If the binding domains can be identified they want to determine if their expression by transgenic grapevines or grapevine bacterial endophytes can slow the movement and colonization of grapevines by Xf, potentially offering a novel form of PD resistance. They also determined that small Xf plasmids replicate via a rolling circle mode and evaluated the potential of these native plasmids to be Xf/*E. coli* shuttle vectors. They found that engineered plasmids were stable in vitro under antibiotic selection however they were quickly lost without selection or when cells harboring these shuttle vectors were inoculated into plants. In spring 2003 they inoculated vines each with 6 bacterial grapevine endophytes that showed antagonism to Xf in vitro. One month after inoculating the vines with endophytes they were exposed to Xf-infectious sharpshooter vectors. In the fall, 2003 these vines were rated for PD symptoms and tested for Xf by PCR. All of the endophyte-inoculated vines tested positive for Xf however the severity of the symptoms in vines inoculated with *Bacillus* and *Cellulomonas* endophytes was less than the Xf-inoculated controls. In spring, 2004 these vines were taken out of the greenhouse and planted in the field. In fall, 2004 and 2005 disease symptoms were rated and 9/10 of the control vines were dead from PD. All of the *Cellulomonas*-inoculated and 8/10 of the *Bacillus*-inoculated vines appeared healthy without any symptoms of PD. Even though the vines appeared healthy and no Xf was detected by PCR, attempts to re-isolate the endophytes from vines in fall 2005 were unsuccessful. They plan to repeat and expand this study and test additional endophytes for their ability to protect vines against PD.

Impact: The UC researchers identified 8 genes that function to moderate Xf pathogenicity, thus providing novel insights in Xf pathogenicity mechanisms. They showed that hemagglutinin (HA) proteins mediate cell-cell interactions and they hope to use recombinant Xf HAs to provide a novel form of resistance against PD. These discoveries offer hope that some of these virulence genes can be suppressed and possibly offer a cure for PD. Xf/*E. coli* plasmid shuttle vectors were constructed and shown to be stable in vitro but they were lost

without antibiotic selection and thus were not suitable vectors for gene complementation studies in planta.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Detection of Inoculum Potential, Latent Infection, and Fungicide Resistance of Fungal Pathogens of Fruit, Nut, and Vine Crops in California

Description: 1) To develop and implement molecular systems for the detection and quantification of spore inoculum potential and latent infections of *Monilinia fructicola* and *M. laxa*, the pathogens causing brown rot in stone fruits and almonds, and *Botrytis cinerea*, causing Botrytis gray mold of grapes, kiwifruit, apples, and stone fruit in California. 2) To develop and implement molecular systems for the detection and quantification of spore inoculum potential and latent infections of *Botryosphaeria dothidea* causing panicle and shoot blight of pistachio and band canker in almond and *Alternaria* species causing late blight of pistachio and leaf spot of almond. 3) To develop molecular systems for the detection of fungicide resistant pathogens of the above mentioned crops in California. Objective 1: Disease levels in orchards depend on pathogen spore inocula. A pair of species-specific primers for *Monilinia fructicola* and *M. laxa* was used to detect the DNA of these pathogens. Using real-time PCR with samples from spore traps, they quantified spore densities in six orchards. A large number of isolates of *Botrytis cinerea* from various fruit, nut and vine crops used to study their genetic structure. Although accurate, the conventional techniques are time-consuming and only provide results after 5 to 21 days. Molecular methods offer the possibility of faster, more reliable and efficient tests. They have developed such methods to monitor, diagnose and quantify crop pathogens. UC researchers have also used these new molecular techniques to answer complex questions on the biology of tree fruit and nut pathogens, the origin of their inoculum sources, and changes in their population structures. Objective 2: Protocols for conventional techniques have also been developed for diseases of nut crops (pistachio and almond). Specifically, for pistachio they used BUDMON to detect latent infections and disease risk by *B. dothidea* in pistachio orchards. ONFIT, which is performed during the growing season, was very accurate in estimating disease incidence at harvest. *B. dothidea* from almond, walnut, and pistachio had similar DNA fingerprints, suggesting possibility for cross infection. *B. dothidea* from almond trunk and upper canopy had similar DNA fingerprints as those from walnut, suggesting also similarity of the almond and walnut *B. dothidea*. They are developing now a protocol for a real-time PCR technique with fruit, leaf, bud, and bark tissues from nut crops. Objective 3: They have

completed a real time PCR assay, established standard curves for both azoxystrobin sensitive and resistant DNA in *Alternaria* spp. Different azoxystrobin resistance levels were detected in *Alternaria* spp. using this technique. Samples from more than 30 pistachio and almond orchards are being processed now to quantify levels of azoxystrobin resistance in *Alternaria*. A real time PCR assay has been also used to determine the frequency of benzimidazole resistant allele in *M. fructicola* in stone fruits. Results of these real time PCR assays were consistent with those of the conventional methods. In addition, the molecular assays were more efficient, less costly, less labor intensive, and showed lower variation.

Impact: In this project, the researchers developed protocols for conventional and molecular techniques for detecting accurately and efficiently fungal spore inocula and latent infections. In addition, these techniques can provide answers to epidemiological questions, identify the sources of disease inoculum, and determine the population structures of the fruit/nut and vine fungal pathogens. Specifically, the molecular techniques are very quick and can provide results in ample time so that fruit/nut and vine growers make timely decisions on managing fungal diseases in their orchards. Especially, the real time-PCR technique can provide results on levels of fungicide-resistant pathogens of stone fruit, nut crops, and vines in a very short time allowing growers to make proper adjustments for selecting the right fungicide and implementing fungicide resistance management programs. Although private diagnostic laboratories have been using a number of these conventional techniques, contacts have been made so that the protocols of some of the developed molecular assays are adopted by these private laboratories.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Management of Vascular Wilt Diseases

Description: Strawberry production in California has benefited from the use of pre-plant fumigation with methyl bromide and chloropicrin. One such benefit has been the suppression of soilborne pathogens such as *VERTICILLIUM DAHLIAE*, which causes a wilt disease of strawberries and many other crops. As a result of regular fumigations, soil populations of the pathogen have remained low but if fumigations are discontinued or if they are not fully effective, populations of *V. DAHLIAE* can be expected to once again build-up to damaging levels. In the future management of *Verticillium* wilt, it will likely rely heavily on the use of genetically resistant cultivars. In screening for resistance to *Verticillium* wilt, UC researchers have used root-dip inoculations to induce disease development in

susceptible genotypes. This is a standard procedure for breeding programs in many crops and it is predicated on two critical assumptions. First, that plants appearing resistant to root-dip inoculations will respond to the pathogen in a similar manner when challenged with soilborne inoculum, and second that the isolate or isolates used are representative of the population of the pathogen to which the crop will be exposed. They have undertaken experiments to test the validity of these assumptions. With respect to the first assumption, they compared cultivars and breeding lines known to differ in susceptibility to Verticillium wilt when they were subjected to a standard root-dip inoculation or grown in soil with a high level of *V. dahliae*. The results showed a good correlation between the two methods, with the root dip procedure providing more consistent results. To confirm that pathogen strains used to identify resistant strawberry cultivars are representative of the broader population of *V. dahliae* (second assumption), they evaluated the reaction of eight strawberry genotypes when challenged with eight different isolates of *V. DAHLIAE*. Three isolates originated from strawberry and one each was associated with: potato, watermelon, eggplant, mint and cauliflower. Each isolate x genotype combination was replicated twice in the experiment, which was conducted in 2003-04 and again in 2004-05. Known susceptible genotypes developed typical symptoms of Verticillium wilt in both years. Although the eight tested isolates manifested a wide range of virulence, differences were only significant on the most susceptible strawberry genotype. Two isolates from strawberry were among the most aggressive of the eight tested, whereas the least aggressive isolate was obtained from cauliflower. Six strawberry genotypes that were regarded as resistant to Verticillium wilt based on previous tests, also appeared resistant in the present study, regardless of the isolate used. Overall, strawberry genotypes represented the largest source of variation in these experiments, with variance components approximately ten-fold greater than those associated with either isolate or the isolate x genotype interaction. The results of this study suggest that it should be possible to develop resistance to Verticillium wilt in commercial strawberries that is broadly effective against isolates of diverse host origin.

Impact: The strawberry industry will soon need to rely primarily on genetic resistance for management of Verticillium. The UC studies have confirmed the utility of the inoculation method used to identify genetic resistance and established that resistance can be broadly effect against strains of VERTICILLIUM DAHLIAE of diverse host origin.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Biology of Pathogens and Insects in Natural Forest Ecosystems of

California

Description: UC researchers have shown that a new canker disease of oaks and tanoak caused by *P. ramorum* has reached epidemic proportions in oak forests along approximately 300 km of the central coast of California during the past eight years. Their work continues to focus on the developing ecological models and on impacts of the disease in natural ecosystems. They have established 500 permanent plots in mixed-evergreen (dominated by coast live oak), redwood/tanoak and Douglas-fir/tanoak forests in from Big Sur to the Oregon border. Over 20,000 trees and shrubs have been permanently mapped, tagged, and sampled for *P. ramorum* in these plots. Using these plots, the researchers have collected baseline data on pathogen spatial distribution and spread over several years. On each plot, they monitored leaves, rain water, soil and stream water year round for *P. ramorum* to determine survival in these substrates and sources of inoculum. The winter of 2004-2005 was found to be very conducive to production of *P. ramorum* spores than the previous year. The rainy season extended into June 2005 and resulted in very high pathogen numbers as compared to spring 2004. This resulted in very high numbers of new infections on most host plants including a number of plants previously not considered to be hosts. These include two species of fern, pacific yew and vine maple. They have also initiated a number of experiments designed to determine the survival of the pathogen in soil and leaves during the summer drought period in California.

Impact: The information they have gathered on sudden oak death has played a significant role in the past year in the continued development of management and regulatory practices for this disease. Their data continues to be used by many national and international government agencies (APHIS, CDFA, DEFRA) to write regulations for quarantines.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: The Epidemiology and Control of Crown Gall on Walnuts, and the Detection and Ecology of its Pathogenic Agents

Description: Walnut trees on *Juglans hindsii* x *J. regia* Paradox rootstocks are highly susceptible to crown gall, caused by *Agrobacterium tumefaciens* and *A. rhizogenes*. Plants that are infected on the trunks when the trees are young have decreased growth and yield. UC researchers' previous results indicated that infections on young orchard trees are often the result of either contamination or pre- symptomatic infections of transplants. Here, they evaluated several potential

points of infestation and infection in nurseries. They used an antibiotic (rifampicin)-resistant strain (2516R) to monitor the population of *A. tumefaciens* on walnut seedlings in various stages of the nursery operation. In their negative controls, rifampicin-resistant colonies were not recovered from either potting or field soil, or from mock-inoculated walnut roots. Their experiments indicated that the pathogen can be disseminated in soil from the tips of the roots to the rest of the root system in the absence of any visible galls. To first determine if *Agrobacterium* can be transmitted from one plant with a rhizoplane population to another clean plant, a plant with a rhizoplane population was potted with a pathogen-free plant and incubated for four months. Although there were no visible galls on any of the plants during this time period, seven of the eight (88%) of the pathogen-free plants became infested; populations on the previously non-inoculated plants were 0 to 104% of the population on its partner. They next demonstrated that in densely-planted seedlings as in a nursery where roots from adjacent plants have contact, inoculum spread throughout a field, presumably from root-to-root of adjacent plants. After digging of seedlings in a nursery, there are other opportunities for dissemination during bare-root storage. They mixed infested trees in a storage pile with clean plants. No rifampicin-resistant, *A. tumefaciens* colonies were detected in samples from the negative control transplants, i.e., clean trees at time 0 of the storage experiment. In two years of trials, the population on the infested trees in the pile declined. Also, in both years, transmission from infested to non-infested trees occurred, in 18% of the trees in the first year and 50% in the second year. In the second experiment, they tested whether there was a difference between transplants that had a thin film of soil, i.e., that presumably retained some of their microflora with those that presumably had more of their microflora removed. In both treatments, approximately 50% of the transplants had acquired a rhizoplane population of *A. tumefaciens*. However, trees that were pressure-washed and chlorox treated had significantly higher population densities than trees that retained a thin film of soil. Finally, they demonstrated that when bundles of seedlings were stored in sawdust healing-in beds, *A. tumefaciens* moved from inoculated seedlings to clean seedlings, and some *A. tumefaciens* survived in the sawdust, although populations declined during the study period.

Impact: The data support the hypothesis that the growth and dissemination of *A. tumefaciens* on the rhizoplane (root surface), particularly in the nursery, are important in the epidemiology of the disease in both nurseries and orchards. More specifically, the researchers' observations support the following. One, *A. tumefaciens* moves presumably via flagella, multiplies, and persists on the root and crown surface. Two, *A. tumefaciens* moves from tree-to-tree via root contact in settings in which the trees are closely planted, as in a nursery. Three, the pathogen can survive to a limited extent on the rhizoplane and can be disseminated in either bare-root cold storage or in sawdust healing-in beds. However, in a commercial facility with good temperature control, transmission and growth were limited. In the experiments in bareroot cold storage, trees that retained a thin film of soil and presumably a rhizoplane population of competitors

of *A. tumefaciens*, supported lower populations of *A. tumefaciens* than trees which were more thoroughly washed and then chlorox-treated. This suggests that the rhizoplane microflora affect *A. tumefaciens* population dynamics. This is consistent with previous data that indicated that *Agrobacterium* is less competitive in natural soil than in fumigated soil, and that seedlings with an *A. tumefaciens* rhizoplane population that are planted into fumigated soil will tend to have a higher incidence a gall than seedlings planted in unfumigated soil.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Alternatives to Methyl Bromide Fumigation of Soil for Strawberry

Description: Replicated field experiments on alternatives to methyl bromide for soil fumigation in strawberry production were conducted in 2002-04 near Watsonville, CA. Selected beds were fumigated with shank-applied methyl bromide/ chloropicrin (MBC, 67/33) at 325 lb/a (rates per unit treated bed area) and covered with black standard polyethylene or virtually impermeable (VIF) plastic. Chloropicrin at 200 and/or 300 lb/a, InLine (Telone C-35) at 283 and 425 lb/a, or iodomethane (33% methyl iodide/ 67% chloropicrin) at 300 lb/a were drip applied in water to beds under plastic and there were non-treated controls. The use of VIF plastic as compared to standard plastic improved the control of buried inoculum of *Verticillium dahliae* significantly where chloropicrin or InLine was used. The ranking of the five varieties used for the final incidence of plants with *Verticillium* wilt on nontreated soil (highest incidence 25-85%) was Camino Real, Aromas, Diamante, Camarosa, and Ventana. All of the fumigation treatments controlled *Verticillium* wilt adequately in Camino Real and Aromas, while only iodomethane and InLine at the high rate generally gave wilt control equivalent to MBC in Diamante, Camarosa, and Ventana. Control of *Verticillium* wilt by chloropicrin was generally less than by MBC or InLine with standard plastic, but was improved somewhat with VIF plastic. Most of the chemical fumigation treatments more than doubled total yields and the highest yields in all varieties were most often obtained with InLine. While the effects of the various chemical treatments on the yields of Camino Real, Aromas, and Diamante were generally similar, Camarosa and Ventana usually yielded significantly less on soil treated with chloropicrin. Bacteria were isolated from the bulk soil, rhizospheres and root tissues of strawberry grown in field plots with MBC-fumigated and non-treated soils. Following fumigation, fluorescent *Pseudomonas* species quickly reached high populations in soil and on roots. Isolates were identified and tested for antibiosis in cultures of pathogenic fungi isolated from strawberry. Several bacteria, especially *Pseudomonas* species from rhizospheres in fumigated soils, had antibiosis to one or more fungi. Among bacterial isolates, there was a

correlation between antibiosis to fungi and growth promotion of inoculated strawberry plants grown in natural soil under controlled conditions. Bacterial isolates giving consistent growth benefits under controlled conditions were tested in the field for 3 years. Bacterial growth promotion of strawberry following inoculation of bare-root transplants in the field was variable and depended on soil background treatment, strawberry variety, and isolate. Among the combinations of four soil treatments (non-treated, MBC, chloropicrin, and metam sodium) and five *Pseudomonas* isolates used, 1-2 isolates applied to Camarosa or Aromas on chloropicrin- and/or metam sodium-treated soils gave significant and repeatable yield increases. A marked strain of one bacterial isolate colonized strawberry roots at high populations for at least 6 months after inoculation in the field.

Impact: California produces over 80% of the nation's strawberry fruit and California nurseries produce nearly 1 billion strawberry runner plants each year. The California strawberry industry relies heavily on methyl bromide fumigation of soil to control soilborne plant pathogens and obtain profitable yields in high-cost production systems. This research project has further identified and optimized some chemical and non-chemical alternatives to methyl bromide for strawberry production. This project also has increased their understanding of microbial mechanisms by which soil fumigation increases the growth and yield of strawberry.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Exploiting *Xylella Fastidiosa* (Xf) Proteins for Control of Pierce's Disease and Other Xf Diseases

Description: The Gram-negative, xylem-colonizing bacterium *XYLELLA FASTIDIOSA* (Xf) is the causative agent of Pierce's disease (PD) of grapevine, citrus variegated chlorosis (CVC), almond leaf scorch, alfalfa dwarf disease, and others. PD has had a significant economic impact in southern California. Host resistance against Xf probably is the most effective long term strategy for management of Xf diseases, but natural sources of strong resistance have proved to be elusive. UC researchers discovered that MopB is a major outer membrane protein of Xf and is displayed evenly over most of the cell surface. Their strategy for engineering host resistance to Xf is to express a Xf-inactivating protein chimera in a xylem-targeted form in the rootstock, expecting xylem flow to transport the protein into the otherwise unmodified scion where it will be able to inactivate glassy-winged sharpshooter (GWSS)-vectored Xf. The Xf-inactivating protein chimera will be composed of a protein (XfSBP) that binds tightly to a Xf surface protein, a xylem-targeting sequence, and possibly a bactericidal peptide

or protein sequence. In one approach to creating a XfSBP for MopB or other Xf surface factor, they have applied a bacteriophage M13 (M13) library whose members have a 12-mer random peptide sequence linked to the amino end of M13 protein P3 by a flexible tri-glycine sequence. Members of the M13 library capable of binding to Xf cells recovered from solid agar medium were recovered using a procedure that employs 4-6 cycles of binding, 8 washes with non-ionic detergent in buffer, elution at low pH, and amplification of the M13. Selected M13 clones were assayed for their ability to bind to Xf cells immobilized in wells of plastic plates. Detection of M13 was with fluorescently labeled anti-M13 IgG. 14 of 20 clones generated a fluorescent signal. The assay procedure included 12 washes between the initial incubation of M13 clone with immobilized cells and the assessment of fluorescence, suggesting that any fluorescence that was detected would represent tight binding of the selected M13 peptide to the Xf cells. A second assay, based on immunoprecipitation with fluorescent IgG, identified the same set of 14 M13 clones. None of these 14 M13 clones reacted with Xf cells grown in liquid culture (i.e., planktonic Xf), suggesting that planktonic Xf cells and Xf cells from solid agar medium have distinct surface characteristics. Whether the form of Xf injected by GWSS resembles agar medium-derived Xf cells or planktonic Xf cells, or neither, is unknown. Selections are in progress for M13 clones with peptides binding to planktonic Xf or to an ESCHERICHIA COLI (liquid culture) strain in which they have replaced the major outer membrane protein OmpA with a MopB-OmpA chimeric protein designed to display those parts of MopB that are displayed on the Xf cell surface. Single Xf-surface-binding peptides derived by M13 selection probably will not serve as a XfSBP directly because of insufficient affinity, and the selected peptides will be incorporated into appropriate protein scaffolds to create a XfSBP. They also continue more direct selections of gp38 variants for binding to MopB as described in their new project plan.

Impact: Creation of grafted plants capable of resisting Xf will provide a means to prevent or greatly reduce losses due to the infection of economically important hosts of this bacterium. Limiting production of the proposed anti-Xf protein to the rootstock should preserve the valued quality and agronomic traits of the scion.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: DEFENSE-RESPONSE GENES: ROLES IN INSECT INFESTATION AND PATHOGEN INVASION

Description: The LAP-A was further studied by characterization of 35S:LapA silenced (LapA-SI) and over-expression (LapA-OX) plants. LapA-SI lines were

characterized by 2D-PAGE immunoblots and RNA blot analysis with several early and late wound genes. LapA-SI show that LapA regulates only late wound responses and not early wound responses. LapA acts downstream of jasmonic acid. UC researchers have examined the role of jasmonic acid in trichome development and induced defenses in *Datura*. They continue to study the role of aminopeptidases and transferases, which modify the N-terminus of proteins, in *Arabidopsis* growth, development and responses to abiotic and biotic stress. LAP1, LAP2 and LAP3, as well as DAP1 and DAP2, have been over-expressed in *E. coli* and characterized. LAP1 has been sent for characterization by combinatorial peptide libraries. To understand changes in gene expression in response to phloem feeding insects, microarrays were performed to examine changes in gene expression in response to feeding nymphs. The role of the salicylic acid and jasmonic acid signaling pathways are being dissected by the use of defense signaling mutants. In a collaborative project with a UC colleague, they characterized citrus TFL, LFY and AP1 gene expression and juvenility.

Impact: Identification of genes activated by tissue damaging herbivores and by phloem-feeding insects is the first step in strategies to enhance herbivore tolerance using biotechnology. Future studies to identify the mechanisms that regulate these genes will aid in the development of cogent transgenic strategies for broad-based resistance to herbivores. Investigation of mechanisms that regulate the processing of the N-termini of proteins by LAP and other hydrolases and transferases may have significant impacts on biotechnology.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: ECOLOGY AND MANAGEMENT OF ARTHROPODS IN POULTRY SYSTEMS

Description: Northern fowl mites, *Ornithonyssus sylviarum*, (NFM) are the worst ectoparasite of caged layer poultry in North America. Other serious pests include the chicken body louse, *Menacanthus stramineus*, and the chicken mite, *Dermanyssus gallinae*. Sampling system development for NFM is ongoing using both hen and egg infestation data. NFM orient and are activated by heat and vibration cues and this is being studied in detail. Control seems to be idiothetic (internal control program), as opposed to allothetic (externally guided). Mites that lose a heat cue begin to execute larger turns that ultimately return them to the vicinity of the cue. NFM economic impact has been studied in both commercial and university facilities. Egg size and feed conversion efficiency, and sometimes hen-day production, are significantly reduced by high infestations. This results in significant economic impact. The body louse was shown to

displace NFM on dually-infested hosts over a 5-8 week period, and presence of lice prevents anything beyond transitory establishment of mites. The mechanism(s) are being investigated. Hen immune responses to NFM are being described. Tissue inflammation increases the distance mites must probe to reach capillaries, is evident in higher proportions of starving mites, and partially explains the drop in NFM numbers after infestations peak. Influences of temperature and humidity on off-host survival of lice and NFM are being determined. House flies in poultry operations often lack what was thought to be a key pheromone component, muscalure.

Impact: Detailed knowledge of mite orientation may allow the researchers to interfere with it for control. Sampling plan development is necessary for producers to detect and treat infestations before they get out of control. Economic impact is necessary to put control efforts into an economic context and allow producers to treat only if and when benefits exceed costs. Knowing how long ectoparasites survive off-host governs how long a chicken house must remain empty to eliminate residual infestations. Knowledge of hen immune system function may be useful in developing mite vaccines. Knowledge of the natural role of muscalure in house fly biology may affect its use in baits and traps in the field.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Ecology, Behavior, and Integrated Management of Insects Affecting Woody Ornamental Plants

Description: Research focused on the ecology and management of introduced insect pests on woody ornamental plants. Populations of the redgum lerp psyllid, *Glycaspis brimblecombii*, the spotted gum psyllid, *Eucalyptolyma maidenii*, the lemon gum psyllid, *Cryptoneossa triangularis*, and associated natural enemies were continued in inland Riverside and coastal Tustin locations to establish the effectiveness of biological control and to provide baseline data prior to the introduction of additional natural enemies. Studies of the sequence of behaviors of host location by the parasitoid *Syngaster lepidus*, a larval parasitoid of *Phoracantha semipunctata* and *Phoracantha recurva*, have continued to determine if the wasp relies on airborne sound or surface vibration. In a comprehensive evaluation of the records of introduction of insects on eucalyptus, several patterns emerged. The trees were introduced approximately 140 years ago but no insects were introduced into the state until 1984, at least 14 insects from 4 feeding guilds have been introduced in the last 22 years, the introductions have occurred in four discrete twelve month periods, insects within each

temporal cluster are all found in a single geographic area in Australia, all but one has been first detected in southern California, only three of the insects introduced into California have been introduced world-wide, and, because there are very few other insects that have been introduced to other parts of the world on eucalypts, California is accumulating insects in a unique, unexplained pattern. Studies on the competitive interactions of red imported fire and Argentine ant at different population levels have been completed. Results show that reduction of fire ant colony size by application of insect growth regulator insecticides can make them susceptible to elimination by competing ant species. Further research on the toxicity of fire ant venom on different ant species are continuing. In other studies, the presence of a specific resistance gene in tomato (Mi) confers resistance to tomato psyllid. In choice tests, psyllids prefer to feed and oviposit on plants lacking the gene and nymphal survival is higher on plants without the gene. Data on the specific induction of RNA following psyllid feeding are under evaluation. The influence of plant community structure and standard nursery pest management practices on natural enemy populations are under investigation. Systemic insecticides applied for control of nursery pests concentrates in floral nectar and may have significant impacts on foraging adult parasitoids. Cerambycid borers can be responsible for mortality of drought stressed trees in unmanaged and managed forests. The short- and long-range chemical communication of a longhorned borer in white fir is under investigation.

Impact: The research blends fundamental and applied elements of insect-plant interactions, biological control, behavior, and insect population and community ecology in efforts to develop comprehensive integrated pest management programs that reduce insecticide applications. The nursery, arboriculture, and landscape industries have been adopted the results from the multidisciplinary approach. The biological control programs become the cornerstone of the efforts. These have been expanded to include studies of parasite-host interactions, competition/predation, and host plant resistance. Biological control efforts in integrated management are supported by modifications in plant cultural practices, manipulation of behavior using semiochemicals, judicious use of selective insecticides, and host plant selection.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: TRITROPHIC INTERACTIONS IN NATURAL AND MANAGED ECOSYSTEMS

Description: DATURA WRIGHTII is dimorphic for trichome morphology, and the two morphs are differentially susceptible to several species of herbivorous

insects. Glandular plants produce an exudate containing esters of glucose and several organic acids. Plants with glandular trichomes are resistant to several species of insect herbivore, but they are more susceptible to the mirid bug, *TUPIOCORIS NOTATUS*. Plants with glandular trichomes are equally susceptible as plants with non-glandular trichomes to the chrysomelid beetle, *LEMA DATURAPHILA*. In series of controlled laboratory feeding studies to disentangle the effects of differences in trichome morphology from the differences in the defensive chemicals that they produce, consumption of *D. WRIGHTII* foliage by *EPITRIX HIRTIPENNIS* was reduced by adding glucose esters to plants with non-glandular trichomes and was increased when those esters were removed from leaves with glandular trichomes by washing. Consumption by *TRICOBARIS COMPACTA* was increased by removing the esters from leaves with glandular trichomes but was not reduced by adding the esters to leaves with nonglandular trichomes. Consumption by *L. DATURAPHILA* was not affected by any of the ester addition or ester removal experiments. The responses of plants to the plant hormone, methyl jasmonate, were determined and compared to other related plant species in the same plant family. Exposure to methyl jasmonate increased the activity of proteinase inhibitors and polyphenol oxidase, similar to other species. Exposure to methyl jasmonate did not increase the concentration of leaf alkaloids. Both trichome types were equally inducible. Exposure of plants to methyl jasmonate during the period of trichome differentiation did not affect either final trichome type or the density of either type of trichome but did increase the concentration of glucose esters produced by glandular trichomes. Because trichome type was not inducible and both trichome types were equally inducible for the production of defensive proteins, inducible responses probably do not contribute to the variation in frequencies of plants with glandular and non-glandular trichomes in natural populations.

Impact: This research continues to document the costs and benefits of the production of glandular trichomes for plant defense against herbivorous insects. Results demonstrate a large pleiotropic or linkage cost so far but no clear, offsetting benefit. The result that trichome morphology is not inducible demonstrates that trichome type is a stable, genetically-determined trait that is itself not a plastic response to herbivory. Benefits seem to be variable in both space and time based upon differences in the composition of the community of herbivores and their natural enemies that infest *D. WRIGHTII*. Results are useful to help define why herbivore resistance polymorphisms exist in natural plant populations. These specific results also may be useful in designing plant breeding programs for cultivated solanaceous plants, such as tomato and potato.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: BIOLOGY, BEHAVIOR, AND ECOLOGY OF VECTORS OF PLANT PATHOGENS

Description: UC researchers continued studying the epidemiology of Pierce's disease (PD), a disease of grapevines resulting from infection of *XYLELLA FASTIDIOSA* (Xf). This bacterium is vectored by sharpshooters and recent outbreaks have coincided with the glassy-winged sharpshooter (GWSS), *HOMALODISCA COAGULATA*. Their work has focused on the spatial distribution of Xf within grapevines and within vineyards. At the grapevine scale they found that most visual symptoms of disease were unreliable indicators of Xf infection; only the 'matchstick' symptom was a consistent indicator. They also found that leaves from the most basal nodes of infected canes had the highest probability of Xf detection by ELISA. At the vineyard scale, the spatial structures of PD distributions were characterized with geostatistics and spatial analysis with distance indices (SADIE). In the Coachella Valley, their surveys over 4 years found 97 diseased grapevines from seven vineyards. Fine-grid sampling showed 82% of the diseased vines were adjacent to two to six consecutive dead, missing, or replanted grapevines in a row, suggesting a 'PD-signature.' With remote sensing (natural color and IR images from 2000, 2002, and 2004) they identified 122 signature areas. Ground truthing revealed 57 of the signatures existed and they confirmed the presence of PD- infected vines in 14% of them. This process can be used to prioritize vineyards in large geographic areas for PD sampling. In Kern County, census data from 215 vineyard blocks showed a total of 52 blocks with PD. 82% of the infected blocks were within 1/4 mile of citrus, an important criterion to consider when sampling for PD in this area. Analyses showed that the distribution of diseased grapevines was dependent on the overall PD incidence in the vineyard. When the incidence was < 0.1%, there was no spatial structure to the infection. Vineyards that had 0.1 - 1% incidence showed a 'trend' distribution pattern, with areas of low to high infection. When the PD incidence was between 1% and 5%, the pattern of disease was random, and it was aggregated when disease incidence was > 5%. In these aggregations, PD-infected vines were spatially correlated within ca. 23-28 m, suggesting an appropriate size for grid sampling plans to find diseased grapevines. They have concluded analyses of a 4-year monitoring study of GWSS and the smoketree sharpshooter (STSS), *H. LITURATA*. Temporal trap catches of these insects showed two peaks per year, and the peaks of the two species coincided. All patches of GWSS were located near citrus and major patches of STSS and major gaps of GWSS were located in desert saltbush scrub and urban areas. In general, there is a poor relationship between infected fields and numbers of GWSS. Research on the carob moth, *ECTOMYELOIS CERATONIAE*, a severe pest of dates, showed high moth mortality in dates (up to 99%) that are shaken from the bunch to the ground. They have developed a tool that is effective for removing waste dates from bunches. Studies also showed that moth development and fitness was directly related to the amount of moisture

in dates.

Impact: The researchers' work describes the spatial distribution of PD at the vine, vineyard, and areawide levels, providing the foundation for a comprehensive sampling program. This program impacts three areas of PD management and research. First, it enables growers to locate PD-infected vines that can be rouged. Second, growers will be able to identify problem areas in their vineyards and design local strategies within their vineyard for these areas. Third, the sampling program provides a method for standardizing PD sampling statewide for researchers and policy makers. In other research, they determined that densities of GWSS and STSS in the Coachella Valley were most abundant from January through March and again from May-September. GWSS abundance was highest near citrus while STSS densities were highest near desert saltbush scrub and urban areas. These temporal and spatial relationships should be utilized for the areawide management of the two vector species. Finally, they developed a date bunch cleaning tool that effectively removed abscised dates from bunches. This resulted in up to 99% reduction of carob moth, providing an effective in-season management alternative to insecticidal dust.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: INTERACTIONS AMONG BARK BEETLES, PATHOGENS, AND CONIFERS IN NORTH AMERICAN FORESTS

Description: 1) determine the influence of fungal associations on fitness of sibling beetle species with non-overlapping host ranges in normal and novel host trees. 2) determine if mycangial fungal associates change the nutrient quality of host and non-host tissue. Dendroctonus bark beetles cause significant mortality to the nation's forests each year. Several of the most serious pests (e.g., *D. ponderosae*, *D. brevicomis*, *D. jeffreyi*, and *D. frontalis*) are associated with one or more species of fungi transferred by the beetles among host pines in mycangia, specialized fungus-bearing structures on the pronotum or on the maxillae. Recent phylogenetic analysis of *Dendroctonus* species and their ascomycete mycangial fungi suggests that there has not been extremely close co-evolutionary relationships between some pairs in these mutualistic associations. While there has been a significant amount of research on the nature of the initial interactions of beetles and their associated mycangial fungi with the defenses of host trees, there has been limited work on the subsequent interactions between beetles and fungi which may prove to be critical to beetle fitness. The program was successful in generating unanticipated results during the year. It is estimated that the forests in southern California have been subject

to the most severe drought conditions in the last two centuries. As a result of overstocking of the forest and historically unprecedented drought, there has been significant mortality of conifers from both bark beetle attacks and dehydration. The UC researchers monitored beetle activity in two forests, one subject to very high levels of nitrate and ozone pollution and the other relatively free of pollution effects. Tree mortality and beetle activity were significantly higher at the high pollution site. Differences in beetle activity between sites were significantly associated with ozone injury to pines, while differences in tree mortality between sites were significantly associated with both ozone injury and fertilization level. Tree mortality was 9% higher and beetle activity 50% higher for unfertilized trees at the high pollution site compared to the low pollution site. Tree mortality increased 8% and beetle activity increased 20% under the highest rates of nitrogen additions at the low pollution site. The strong response in beetle activity to nitrogen additions at the low pollution site is evidence that atmospheric nitrogen deposition increased tree susceptibility to beetle attack at the high deposition site. While drought conditions throughout the region were a major factor in decreased tree resistance, both ozone exposure and atmospheric nitrogen deposition further increased pine susceptibility to beetle attack.

Impact: The overall project goal of the proposed research is distinguish between the potential nutritional benefits and ability to utilize specific host trees in the mutualistic associations of beetles and fungi. The results from this research will provide a better understanding of the relations between key forest insect pests and their host trees as mediated by a mutualistic association with vectored fungi. Understanding the interactions among these organisms can contribute to better sustainable ecosystem management of the nation's forest resources.

Funding Source: Multistate Research and State

Scope of Impact:

Theme: 4.12 Integrated Pest Management

Title: Genetic control of crop pests by transgenesis and paratransgenesis

Description: The development of transgenic conditional lethal pink bollworm is virtually complete except for regulatory approval. The USDA-APHIS lab in Phoenix developed the ability to make transgenic pink bollworms themselves. Before the end of 2005 one of the lethal plasmids supplied by Oxitec, UK was inserted into pink bollworm in Phoenix and proved to be 100% lethal in the egg stage, or exactly what they wanted. This transfer of technology and production of a lethal strain is a very successful University-USDA development project bringing new biotechnology into crop protection. UC researchers are still involved because the issue of open field release under permit from the BRS part of APHIS has not yet been approved; in fact, it is stifled by inaction on the part of the

regulators. They have been asked to help generate a Workshop Conference in Washington, DC scheduled Oct-Nov 2006 on the topic of improving regulatory actions on recombinant organisms used in crop protection. Both the transgenic pink bollworm and their Symbiotic Control of Pierce's disease projects will be prominently featured. Indeed, these projects are the most advance towards practical application of this type using insects. The genetically altered the endophytic bacterium, *Alcaligenes xylosoxidans* var. *denitrificans*, was found not to express a single chain antibody to control the pathogen causing Pierce's disease in grapevines in high enough titer to disrupt the disease cycle. Their collaborator at Duquesne University, decided last summer to switch to a new strategy of developing a soluble antibody. They continued to develop methods to test his products in disruption of the disease cycle. New genome analysis shows the *Alcaligenes* endophyte to be another bacterium closely related to *Pseudomonas fluorescens*. Originally they thought this would ease regulatory concerns about side-effects of the organism, however, last summer their field project to test the genetically marked *Alcaligenes* was cancelled by the State CDFA PD program, unexpectedly. At the same time their request for field trials with the marked symbiont for multiple years without burning the grapevines was denied by EPA-TOSCA (who had oversight). A risk assessment study of possible horizontal gene movement from *Alcaligenes* to other bacteria continues with support from USDA-CSREES and with two collaborators at Duquesne and at University of New Mexico, Medical School.

Impact: The UC researchers developed a new pest control strategy called ABC, Autocidal Biological Control. The first practical example of this new strategy using pink bollworm is now ready for field release and was developed as a team effort with a colleague at Oxitec in UK providing the lethal genes, and UC providing the genetic transformations and USDA-APHIS in Phoenix, AZ doing the testing. Gradually APHIS in Phoenix took over and this year finally achieved the ability to do transformations on their own, so the project continues between Oxitec and APHIS, as an outstanding example of technology transfer. The UC researchers continue helping with regulatory matters, since they are a sticking point. They identified a symbiotic organism to deliver a cure for the Pierce's disease that currently threatens grapevines in California. The approach is termed 'Symbiotic Control' (SC), and is a form of biological control using symbiotic microorganisms. This is a major breakthrough since the only current method to protect crops from pathogens transmitted by insects is by treating the vector insect with insecticide or quarantine of the uninfected plant coupled with expensive removal of infect plants and installing a repressive and expensive quarantine program to prevent movement of vector insects on alternate hosts or on produce shipped from infected areas. Symbiotic Control is selective acting only on the pathogen and employs symbiotic microbes already in the ecosystem. The federal regulatory system appears unable to deal with this new strategy (thus the Workshop mentioned above).

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: DEVELOPMENT AND USE OF SEMIOCHEMICALS IN THE MANAGEMENT OF INSECT PESTS

Description: UC researchers' recent work with the pheromone communication of moths has emphasized how the temporal-spatial structure of pheromone plumes influences their peripheral perception. These studies have used electroantennogram measurements followed by Fourier analyses to document how well moth antennae can resolve rapidly encountered filaments of pheromone. Their studies with female *Culex* and *Aedes* mosquitoes have two aims. First, they are using wind tunnel observations to see how the structure of plumes of carbon dioxide and other host-emitted kairomones influences the flight path of these mosquitoes as they progress upwind and to see how exposure to carbon dioxide alters the threshold of response to other host-emitted kairomones. Second, they are documenting the kinds of orientation maneuvers that female *Culex* mosquitoes use to locate a site for favorable for egg deposition, based on odors released from the water and from the egg-raft pheromone. These studies also involve development of new traps for surveillance. A final project documented the mechanisms that northern fowl mites use to orient to host birds based on thermal gradients.

Impact: Understanding how the structure of pheromone plumes modulates orientation in moths may contribute to improving a new type of direct control, the so-called 'attract-and-kill' method. Formulations relying on this technique lure the male to the precise locus from which the odor is emitted. Therefore, it is crucial to duplicate the female's complete attractive blend and to mimic the structure of the naturally emitted plume. Their work with mosquitoes has two potential benefits. First, by optimizing the structure of kairomone plumes, they expect to improve the efficacy of sampling traps that are based on carbon dioxide and possibly other host-emitted odors. Similarly, their work with oviposition attractants is directed toward improving the reliability and sensitivity of traps that are baited with such semiochemicals.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Insect-Plant Interactions and Plant Resistance to Phloem-Feeding Insects

Description: This past year, UC researchers conducted a field study on stage-specific survival of silverleaf whitefly, *BEMISIA ARGENTIFOLII*, on upland cotton, *GOSSYPIUM HIRSUTUM* and its wild relative, *G. THURBERI*. This is the last in a series of experiments that will soon be submitted for publication. Briefly, *G. THURBERI* shows very high levels of resistance against silverleaf whitefly in naturally infested field plots (4 years of data). However, in experiments where they manipulate whiteflies to gain insights into the mechanism of resistance (stage-specific survival tests and choice and no-choice oviposition preference tests), the whitefly seems to perform just as well on either cotton species. They will follow up on this paradox in future experiments. They also have initiated electrical penetration graph (EPG) studies on beet leafhopper, *CIRCULIFER TENELLUS*, the only known vector of curly top virus in North America. Curly top virus causes an economically important disease that affects many crop species, primarily in arid and semi-arid regions of the western US. The main goal of these studies is to determine the mechanism of resistance to curly top virus in the few varieties of tomato possessing resistance. Previous work by other labs indicates that resistance in these tomatoes is due to an effect on the leafhopper that interferes with its ability to inoculate the virus. Virus inoculation by insect vectors is intimately related to the vector's feeding behavior, and the most powerful technique for studying feeding behavior of piercing-sucking insects, like beet leafhopper, is the EPG technique. Essentially, EPGs record electrical signals from the feeding insect and, analogous to how a cardiologist can observe details of heart function or malfunction by recording electrical signals in an EKG, details of piercing-sucking insect feeding behavior can be observed with EPGs. Before EPGs can be used to observe these behaviors, studies must be conducted to correlate different details of feeding behavior with different patterns of electrical fluctuation. In this past year, they have been conducting the necessary correlation studies. They have established behavior-electrical fluctuation correlations for pathway phase (advancement of the stylets in the plant tissue) and xylem sap ingestion. They also believe they have identified the correlation for phloem sap ingestion, but need more replicates to confirm this. After establishing the correlation for phloem sap ingestion, the one remaining important correlation they need for virus inoculation and acquisition studies is salivation into phloem sieve elements. Then they will be able to compare the feeding behavior of beet leafhopper on resistant and susceptible tomatoes and determine how the resistant varieties interfere with the leafhopper's feeding behavior and its ability to inoculate curly top virus. Finally, they have conducted field studies on potential non-toxic repellents against beet leafhopper in tomato fields. The potential repellents include silver reflective plastic mulch, white plastic mulch, green plastic mulch, and sprays of kaolin. Of these, only the silver reflective mulch showed promise in the first year of study.

Impact: The intended outcome of the silverleaf whitefly studies is development of a whitefly resistant cotton variety. This would be a very valuable contribution as silverleaf whitefly is one of the most serious pests of cotton in most cotton-growing regions of the world, and there are no resistant varieties available. The potential impact is to reduce pesticide use for whitefly control in cotton. The intended outcomes of the beet leafhopper studies are 1) to determine the point in the feeding behavior of beet leafhopper where curly top virus is inoculated and acquired, 2) determine the mechanism by which the resistant tomato varieties interfere with inoculation and acquisition, and 3) develop environmentally friendly strategies (resistant tomatoes and/or non-toxic repellents) to manage curly top virus in tomatoes. The potential impacts are to reduce the incidence of curly top virus in tomatoes, and provide tomato breeders with information to help speed the incorporation of resistance into more than just the few resistant tomato varieties currently available.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Mosquito and Agricultural Pest Management in Riceland Ecosystems

Description: An integrated mosquito management (IMM) strategy including both source reduction (isolating emergent vegetation to narrow raised planting beds) and the addition of larvivorous fish was studied in a 10 hectare wetland used to process secondary-treated municipal effluent. The distribution and abundance of mosquitofish (*GAMBUSIA AFFINIS*) and the efficacy of mosquitofish for reducing mosquito production from 20-meter (wide) versus 3-meter (narrow) bands of emergent vegetation (*SCHOENOPLECTUS CALIFORNICUS*) was studied on 4 dates. Transects perpendicular to the path of water flow through the vegetation bands were established at 3 positions (1.5 meters, 5 meters and 10 meters from the open water-emergent vegetation interface) in replicate wide bands of vegetation, in the center of replicate narrow bands of vegetation and in the open water. Thirty sites in each of two marshes were sampled per date. Samples were taken in June (2 dates), July, and September 2005. Mosquito production was measured using emergence traps. Mosquitofish and large mobile aquatic insects were sampled using minnow traps lined with fiberglass window screen. Mosquitofish were not distributed uniformly across the transects in the two marshes. In inlet marsh 1, significantly fewer fish were collected at the 5-meter and 10-meter positions in the wide band of vegetation than were collected in the narrow band of vegetation and in the open water during June-July. In inlet marsh 5, significantly fewer fish were collected at the 10-meter position than were collected at the other positions during June-July. In contrast to the summer collections, the trends for the number of mosquitofish collected at the 5 positions

were consistent in the two inlet marshes in September. Significantly more mosquitofish were collected in the narrow bands of vegetation than were collected at positions towards the interior of the wide bands of vegetation in both inlet marshes. Nearly 10-fold more mosquitofish (N = 3189) were collected in September than were collected in June-July. Mosquito production in the center of the wide vegetation bands was comparatively greater than at positions closer to the open water-vegetation interface in inlet marsh 1 and at all positions in the wide vegetation band relative to the narrow band in inlet marsh 5 in June-July. In inlet marsh 1, nearly 200 CULEX were emerging daily from each square meter of vegetation in the center of the 20-meter bands despite an ongoing IMM program using larvicides and adulticides. The benefit of using narrow vegetation bands in wetlands containing larvivorous fishes is evidenced by the comparatively lower mosquito production from the narrow bands of vegetation within each inlet marsh. Mosquito production from the open water zones did not differ statistically from zero during June-July. The combination of ongoing IMM activities and water management that reduced the harborage for immature mosquitoes probably lowered mosquito production during late autumn. The results to date indicate that the utilization of thin bands of emergent vegetation enhances mosquito control efforts in IMM programs for wetlands stocked with larvivorous fishes.

Impact: The results of this study will help to provide criteria for the management of pest and pathogen-transmitting mosquitoes that utilize rice fields and constructed treatment wetlands as developmental sites. Mosquito abatement and resistance management of mosquitoes to control agents must be included as part of any comprehensive plan for the design and operation of multipurpose constructed treatment wetlands, particularly where human residences are situated near wetlands. The work summarized here will assist a multiagency effort to develop criteria for the construction of large-scale wetlands systems that will be designed to conserve precious water resources, promote the biodiversity of endemic wetlands organisms, and protect the public from mosquitoes and the diseases that they cause.

Funding Source: Multistate Research and State

Scope of Impact: AR, CA-D, CA-R, FL, IL, KY, LA, TX

Theme: 4.12 Integrated Pest Management

Title: Invasive insect pests and biological control agents in California: Impact on agriculture and conservation

Description: The project on the recognition of different species/biotypes of *Gonatocerus ashmeadi* is concluded with the conclusion that all *ashmeadi* in the USA indeed are a single species where the different populations are reproductively compatible. UC researchers have also completed a project on a

closely related group of egg parasitoids *Gonatocerus morilli* and several species have been discovered by crossing experiments and the use of molecular methods. They have finished the work on the citrus peelminer from the central valley and have concluded that they cannot prove that the citrus peelminer found in the central valley necessarily originated from Mexico. They have found that the Coachella citrus peelminer differs from the citrus peelminer found in the central valley, but when they extended their search for peelminers to include areas in Arizona, they found that around Yuma the peelminer is of the Coachella type, but around Phoenix, they find the same citrus peelminer as in the central valley and in Mexico. Consequently the range of the central valley peelminer simply extends from Mexico, though Arizona to the central valley of California. They have concluded their work on the impact of *Wolbachia* on the biocontrol agent *Aphytis*, most of the wild and insectary populations are infected with this bacterium and little or no negative impact of this bacterium on the biocontrol effectiveness of this scale parasitoid is expected.

Impact: The studies on invasive species help in the determination of the origin of these pests, which may help in the prevention of future invasions from these sources. For biological control it may also be helpful to know where the pest originated in order to collect the natural enemies. The work on *Wolbachia* has made it clear that the researchers do not have to take specific precautions when they release insectary reared wasps in field populations. The studies on the identification of the parasitoids of the Glassy Winged Sharp Shooter help in determining which natural enemy may be useful for additional releases to suppress this pest to a non economic level.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Management of Arthropod Pests Impacting Perennial Fruit and Nut Crops in California's Central Valley

Description: 1) Previous laboratory studies showed that summer temperatures (> 37°C) severely reduced survival (> 95%) of female olive flies (*OLF*), *Bactrocera oleae*, over 3 to 5 days if no water or carbohydrate source (e.g., 50% honey-water) were accessible. Five-day field tests on caged flies conducted from August-October 2005 at Parlier (mid-San Joaquin Valley) and Hayward (coastal influence) showed that adult mortality was greater than 90 and 50% when access to water and honey-water were denied or only water was available, respectively, and temperatures surpassed 32°C for 2 or more days. However, half-life longevity of adults, held in mesh bags within olive trees in the San Joaquin Valley, provided with excess water and honey-water was greater than 4 months

over the period from February through June 2005. Some adults lived 8 months. Honeydew of black scale, *Saissetia oleae*, was found to be a suitable carbohydrate source to enable OLF to survive 5-day periods of 36.4o C (daily high) with less than 5% mortality when water was available. GIS analysis of summer temperature data from California suggests that adults will experience little mortality from high temperatures along the coast, but in the inland valleys mortality should be significant if access to food and water are limited. Lower frequencies of 3- and 5- day sequences of high temperatures (i.e., > 37o C) in the Sacramento Valley versus the San Joaquin Valley may result in greater survival of adults in the former. 2) Further analysis of field longevity of the fruit fly pesticide bait GF-120 (with Spinosad) under varying climatic conditions suggests that although high summer temperatures (mean daily temperature > 34o C, and no dew) may reduce effectiveness of the material after 7 days, increased frequency of dew (95% of test dates) in October with cooler daily highs (mean temperature = 28o C) resulted in much lower efficacy 4 days after application. 3) Greenhouse studies on tenlined June beetle, *Polyphylla decimlineata*, showed that third instar grubs significantly reduced rootstock weight of young almond transplants about 35% over a 60 day period as compared to rootstocks not exposed to feeding grubs. Interestingly enough, above ground growth of root-infested versus grub-free plants was not significantly different. 4) Laboratory studies showed that survival of glassy-winged sharpshooter (GWSS), *Homalodisca coagulata*, adults was severely reduced when temperatures were at and below 10o C, which resulted in insect death in 25 or less days. At 20o C and above, survival was greater than 80%. Feeding studies showed that adult GWSS stop ingesting xylem fluids (as indicated by xylem excretia levels) when temperatures are at and below 10o C. This information will be used to estimate potential establishment of GWSS in California using GIS temperature data. 5) The parasitoid *Anagrus epos* is under consideration for management of GWSS populations in California. Studies showed that this parasitoid can be easily reared on beet leafhopper eggs to obtain large numbers for biological control introduction efforts against GWSS. Rearing methods for the parasitoid are being refined and its host specificity evaluated.

Impact: 1) Olive fly (OLF) poses a great economic challenge to table olive growers in California's Central Valley because it requires weekly applications of bait insecticide from June to November. Refinement of control methods and adoption of alternative controls could reduce growers' costs via reduced management inputs. If impacts of high summer temperatures on adult OLF populations can be accurately predicted in areas where high maximum temperatures (> deg 37 C) frequently persist for several consecutive days, growers may be able to halt insecticide applications for 1 to 4 weeks until temperatures decrease in early Fall. 2) Understanding climatic influences on GF-120 efficacy is important to obtaining maximum control with minimal cost. Potential reduction of GF-120 in the fall months due to cooler temperatures or moister conditions was unexpected and needs to be further investigated. 3) A better understanding of the impacts of TLJB on tree growth is needed so that

growers will not let infestations accrue for a long time (while yields may be affected) before control options are implemented. 4) Understanding the impact of winter climate on glassy-winged sharpshooter (GWSS) populations in the Central Valley will allow management efforts to be focused on problem areas where GWSS survival will be highest in the springtime. This will reduce the need to chemically treat areas where overwintering GWSS mortality is heavy. 5) GWSS are difficult and expensive to produce and alternative hosts to support natural enemy colonies may provide a less expensive protocol for parasitoid production.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Management of Nuisance Flies in Confined Animal Agriculture

Description: The production and dispersal of nuisance flies is one of the most challenging problems for animal agriculture in California. With the changing landscape favoring a reduced separation between residential homes and animal operations significant conflict between animal operations and neighbors will increase unless appropriate methods of monitoring and controlling nuisance fly populations can be developed. Further, a fly nuisance threshold that can be held as an industry standard must be developed in order to protect animal operations from encroaching urbanization and increases in the perceived nuisance by residential neighbors. The UC researchers are making significant progress toward meeting their listed objectives to 1) develop and evaluate new techniques of manure management for control of nuisance flies, 2) investigate the dispersal behavior of nuisance flies, and 3) evaluate the role that nuisance flies may play in the maintenance, dissemination, and transmission of pathogens. Recently, composting of poultry manure has been proposed as a means to control flies and produce a marketable product from manure that is too high in nitrogen to be used directly as fertilizer. Funding was secured to evaluate composting of poultry manure as a means of reducing the production of nuisance flies (house fly and little house fly). They found that properly composting poultry manure with municipal green waste reduced the development of nuisance due to the high internal temperature and low external moisture content of the compost resulting in the death of young fly larvae before they could complete development. This work has been presented at the National Livestock Insect Workers Conference, at the California Conference of the Directors of Environmental Health conference, and at the California Association of Pesticide Applicators Continuing Education meeting. The UC researchers have recently completed a study funded by an ANR Core Issues Grant to compare monitoring techniques for house fly on a large dairy operation. Standard monitoring systems such as spot cards, sticky tapes, and alsynite traps were placed at multiple locations at three participating

large dairies in the Central Valley of California. Trapping was also conducted 1/4 mile from each dairy to examine the relationship of fly abundance at the dairies to fly abundance at a typical urban setback. Results are being analyzed and will be presented and published over the next year or so. Flies are known to mechanically carry a number of common disease agents like Salmonella bacteria. There is some evidence that flies may also carry epizootic disease agents like exotic Newcastle disease (END) virus which can cause significant mortality of infected poultry. As part of a funded UCIPM Exotic Pest Grant, they are currently examining whether flies may carry END virus mechanically or biologically (within the insect body) and to determine if they might play a role in the transmission of this disease agent from one poultry operation to another. They are currently conducting laboratory trials (in conjunction with the USDA Poultry Research Lab in Athens,GA) to examine the length of time that infected insects will continue to harbor virus.

Impact: New methods for fly management are being investigated; techniques that exploit the biology and behavior of nuisance fly species may complement currently practiced IPM techniques. Techniques including physical or chemical manipulation of the manure in which flies breed as well as changes to current cultural practices of animal facility operators should provide permanent reductions in numbers of flies produced without the need for additional insecticides. The researchers' work has made excellent progress in testing options for the control of nuisance flies. Coupled with recent studies to measure the dispersal ability of nuisance flies and ongoing studies to determine appropriate fly monitoring strategies and nuisance thresholds, they hope to provide the knowledge and tools that animal agriculture in California will need to work with state and local regulatory agencies in order to ensure compliance with nuisance laws. A number of presentations on the subjects above have been given to dairy operators, cooperative extension farm advisors, county health departments, and private pest control operators. This extension of research is having a direct and immediate impact on how insects are controlled and monitored on animal agriculture operations in California.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Insect and Manure Management in Poultry Systems: Elements Relative to Food Safety and Nuisance Issues

Description: UC researchers are making significant progress toward meeting the listed objectives for understanding the biology, phenology, and control of nuisance flies. In collaboration with UC Cooperative Extension, research funding

was secured to evaluate composting of poultry manure as a means of reducing the production of nuisance flies (house fly and little house fly). They found that composting poultry manure (rich in nitrogen) with either municipal green waste or horse bedding material reduced the development of nuisance flies. Properly composted manure had high internal temperature and low external moisture content resulting in the death of young fly larvae before they could complete their development. The results of this work were presented at conferences including the National Livestock Insect Workers Conference, the Annual California Conference of Environmental Health Directors, and at the Continuing Education Conference of the California Association of Pesticide Applicators. A scientific publication for this work is in preparation. They have recently completed a study funded by an ANR Core Issues Grant to compare monitoring techniques for house fly on a large dairy operation. Standard monitoring systems such as spot cards, sticky tapes, and alsynite traps were placed at multiple locations at three participating large dairies in the Central Valley of California. Trapping was also conducted 1/4 mile from each dairy to examine the relationship of fly abundance at the dairies to fly abundance at a typical urban setback (1/4 mile from an agriculture operation). Results are being analyzed and will be presented and published over the next year or so. Exotic Newcastle disease (END) virus was found infecting a number of southern California poultry operations in 2003. This virus can cause severe disease to poultry and may result in the death of even vaccinated birds. A research study was developed by their laboratory to determine the role that insects might play in the maintenance and transmission of this virus in nature. Flies were collected from premises that contained infected poultry in order to test these flies for the presence of END virus, and laboratory studies have been initiated that will look at the ability of flies to carry this virus over a period of days or even weeks. Results should help to determine the need for fly control to be performed at the same time as other END virus eradication measures are initiated at locations with END infected birds. This research is funded by the UCIPM Exotic Pest Grants and is currently underway. In collaboration with the USDA Poultry Laboratory in Athens, GA, laboratory procedures have been developed to infect and disinfect insects with END virus. They are currently finishing the first round of deliberate insect infections to determine the persistence of END virus in flies and beetles.

Impact: The production and dispersal of nuisance flies is one of the most challenging problems for animal agriculture in California. With the changing landscape favoring a reduced separation between residential homes and animal operations significant conflict between animal operations and neighbors will increase unless appropriate methods of monitoring and controlling nuisance fly populations can be developed. Further, a fly nuisance threshold that can be held as an industry standard must be developed in order to protect animal operations from encroaching urbanization and increases in the perceived nuisance by residential neighbors. Their work has made excellent progress in developing options for the control of nuisance flies and in determining the dispersal ability of little house fly. Coupled with ongoing studies to determine appropriate fly

monitoring strategies and nuisance thresholds, they hope to provide the knowledge and tools that animal agriculture in California will need to work with regulatory agencies such as county health departments in order to ensure compliance with nuisance laws. Work on END virus will provide important information about the role that insects might play in the persistence and transmission of this virus between poultry operations. With the cost of eradicating this virus from California (millions of dollars for each eradication effort), failure to understand the role of insects in the maintenance and transmission of this virus could be very costly considering that insects are not controlled as part of the eradication effort.

Funding Source: Multistate Research and State

Scope of Impact: AR, CA-R, FL, GA, IN, KS, MN, NYC, NC, TN

Theme: 4.12 Integrated Pest Management

Title: Development of an IPM framework for implementation of methyl bromide alternatives into orchard and vineyard replant settings.

Description: UC IPM-based guidelines for replanting perennial crops without methyl bromide (MB) remain on-line and receive updating. Alternatives to MB are somewhat different for each different crop and create greater complexity for management. Sandier soils containing less than 12 moisture can be effectively treated with 1, 3-dichloropropene (1, 3-D). Prior to this work, nursery crops grown on clay loam soil could only be effectively treated with MB. Where soil moistures range between 12-15% one must rip the soil to 1.3m depth and then apply 280kg/ha 1,3-dichloropropene (1,3-D) at 65-75cm depth in addition to 280kg/ha at 45-50cm depth. The field surface must be covered with a plastic tarp or receive 110kg/ha metam sodium (MS) throughout the surface 15 cm. Lesser treatment rates will not guarantee nematode-free plants even for a 14mo nursery crop. The key requirement for treatment of clay loam soils is attachment of 2 delta wings on each shank to scrape soil into the chimney that remains after each shank passes through. The shanks are followed by the usual disc and cultipacker. At higher soil moisture contents, 15-19, the initial soil preparation must reach 1.6m depth and 1,3-D treatment rates increased to 370kg/ha from each of the two chisel ports on each shank. Application rates at the deeper chisel port can be substituted by the same application rate of chloropicrin. In orchard replant settings there is a 95 reduction of *Meloidogyne incognita* from roots 60 days after the tree trunk receives a Roundup application. However, root dwelling life stages of *Pratylenchus vulnus* can be extracted from these roots 2 years later. If no other root-killing soil treatments are combined the value of Roundup is to provide significant relief from the rejection component of the replant problem. When Roundup is combined with soil fumigation the value of the Roundup treatment is hidden. Complete kill of walnut roots with Garlon provides 99 reduction of *P. vulnus* in old roots collected 9mo later. Five years later the soil

dwelling populations of *P. vulnus* have finally achieved 95% reduction, still too many nematodes to be considered an alternative to MB. This nematode apparently achieves an inactive, non-feeding, cryptobiotic state. With walnuts the only occasion where significant growth improvement was due to Garlon was where the subsequent fumigation reached only 1.3m deep. In the absence of soil pests the plant growth benefits from Garlon plus one year of fallow were typically 85% of that achieved with MB. Against *P. vulnus* there was little benefit to a rotation crop of sudan grass compared to leaving the ground fallow except that sudan grass serves to dry the soil profile. A drench of sodium azide proved to be effective at 560kg/ha against nematodes as deep as 1.6m. However, this product does not adequately penetrate roots of walnut or grape and 1/3 of treated plants survive. A drench of Propylene oxide did not out perform sodium azide and a greater number of nematodes survived within roots and soil. Switching rootstocks from Nemaguard to Peach almond hybrid can remedy the rejection component.

Impact: There is greater complexity for the manager when soil fumigants cannot be used because all replacement tools are generally less effective. Loss of Methyl Bromide (MB) will shift interest to 1,3-dichloropropene (1,3-D), then to metam sodium (MS), and finally to some of the approaches being tested here. Grower assuredness declines as these transitions are made, largely because MB does a great job on 95% of occasions. To replace methyl bromide the use of 370kg/ha 1,3-dichloropropene will suffice for deeply dried, coarse-textured soils. Tree growth is further improved if 170 kg/ha of chloropicrin is also placed down each planting rows. In finer textured soils at higher moisture contents (12 to 15%) the treatment rates of 1, 3-D must be increased 50% or doubled where soil is 15-19% moisture. Broadcast applications in excess of 370kg/ha 1, 3-D have not been permitted in California since 1990 but UC researchers have found that shifting half the active ingredient to chloropicrin and placement at two different depths can perform if soil is properly prepared. Killing of old roots with Roundup or Garlon and waiting one year can remedy the rejection component of the replant problem but not the soil pest component. Any growth benefits using this tactic are less than that achieved from fumigation. MS can be a very useful product if properly applied; a difficult task for tree and vine growers. Additionally, *Prunus* spp do not grow well after MS unless there is a one-year wait before replanting or a completely different rootstock is chosen.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Development of sustainable strategies to manage plant-parasitic nematodes

Description: Much of the time (from 10/2004-9/2005) covering this progress report was spent on a sabbatical leave in Madrid, Spain. During the sabbatical leave, the UC researcher participated in research projects on the effects of biofumigation and soil amendments using different types of organic residues, such as agro-industrial waste products, crop rests, manures, city-green wastes, on population dynamics of plant-parasitic nematodes. Results from these (mostly) field experiments, located in commercial greenhouses or farmer's fields indicated that biofumigation with different types of organic materials caused strong declines in population levels of plant-parasitic nematodes (root-knot and dagger) in different crop types such as tomato, swiss chard, cucumber, and grapes. It was however observed that plant-parasitic nematode populations usually rebounded at the end of the growing season to levels similar to untreated plots. In spite of this, effects on crop yields were generally positive and significant. Thus, results from these trials suggest that biofumigation for management of nematode problems is not limited per se to using Brassica-type crops, but can be achieved using various organic materials, that are locally available and cheap. A second-year of field trials at Irvine, CA, on effect of biofumigation using different fall/winter-grown crops followed by the main tomato summer crop indicated that broccoli was more effective as a biofumigant crop than carrots, tomato, strawberry, or marigolds. Laboratory experiments on the effect of volatiles released during biofumigation of broccoli material indicated that volatiles play only a limited role in the root-knot nematode-controlling action of biofumigation.

Impact: Multi-year field trials in Spain show that plant-parasitic nematodes can be maintained below damage thresholds using soil-incorporation of different types of non-composted organic residues. Results from 2-year field experiments in Southern California show that a fall/winter crop of broccoli, followed by spring biofumigation with crop residues is more effective than carrot, strawberry, tomato, marigold, or a fallow control.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: MECHANISM OF RESISTANCE TO ROOT-KNOT NEMATODES IN TOMATO

Description: The tomato gene *MI* confers resistance against root-knot nematodes (*MELOIDOGYNE* spp.), potato aphid (*MACROSIPHUM EUPHORBIAE*) and whitefly (*BEMISIA TABACI*). *MI* was cloned and shown to belong to the largest class of resistance genes encoding proteins with nucleotide binding site and leucine-rich repeat motifs. Resistance gene-mediated responses

involve global changes in gene expression mediated by multiple signaling pathways. These defense pathways are mediated by a number of small molecules including salicylic acid (SA), jasmonic acid (JA) and ethylene. UC researchers questioned whether SA and JA have a role in MI-1-mediated resistance to either nematodes or aphids. To address this question, they generated Mi-1 tomato lines with mutations in LeCOI-1 defective in JA signaling. They have also generated tomato with mutation in the SA signaling by introducing the NAHG transgene in MI-1 tomato. Screening MI tomato with the NAHG transgene indicated a role for SA in MI-mediated resistance to aphid and nematodes. Currently, they are investigating a role for JA in MI-1-mediated resistance to both pests. Resistance signal pathways of diverse resistance gene seem to converge downstream of the R genes. Based on this observation, obvious candidates of the MI-1-mediated resistance signaling are genes involved in other R gene-mediated resistance signaling. To identify these candidate genes, they used virus-induced gene silencing (VIGS) to address the role of mitogen-activated protein kinases (MAPKs) in MI-1-mediated resistance to aphids. VIGS is a reverse genetic tool that allows rapid and transient suppression of host genes, by targeting sequence-specific degradation of their transcripts. Using VIGS in MI tomato, they identified a role for MAPK kinase (NtMEK2) and three MAPKs (SIPK, NTF4, and WIPK) in MI-1-mediated aphid resistance.

Impact: MI-1 is the only plant gene that confers resistance to pests from distinct groups, aphids and nematodes. Understanding how MI-1 works, will lead to engineering broad-spectrum resistance.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Nematode management in annual crops with emphasis on host plant resistance.

Description: Host plant resistance to root-knot nematodes (MELOIDOGYNE spp.) is being studied as a primary means of nematode management in annual field and vegetable cropping systems. Analyses of resistance genes are being conducted in carrot, cowpea, cotton, tomato, and lima bean. The Rk resistance gene in cowpea is a complex locus with multiple specificities to different nematode populations. Infected and non-infected roots of resistant and susceptible plants were harvested and used for preparing cDNA libraries during the period of resistance expression, as an approach to develop markers for the Rk genomic region. Cowpea RNA was micro-arrayed on the Affymetrix soybean GeneChip, and SFP markers identified. A series of near-isogenic lines in a blackeye cowpea background produced by recurrent backcrossing was

compared for a second year to determine the value of each Rk gene form in protecting cowpea from nematode infection in field experiments. Field experiments were conducted comparing the four near-isogenic lines over a series of replicated inoculum densities of three nematode populations (avirulent and virulent *M. INCOGNITA*, and *M. JAVANICA*). Results of cowpea yield and nematode multiplication rates provided a relative index of the protective effect of each resistance gene, using regression analysis. Recombinant inbred lines developed from crosses between root-knot susceptible and resistant Lima bean genotypes were screened to determine the relationship of resistance genes effective against nematode reproduction on roots, nematode induced root-galling, or both. One Lima genotype (L-136) was shown to be a donor of three resistance genes. These genes were compared in the field in subsets of recombinant inbred lines possessing the three genes singly and in different combinations. The relative protective value to grain yield of each gene or combination was determined. A second Lima genotype with two resistance genes was confirmed to be highly effective against *M. INCOGNITA* and *M. JAVANICA* in greenhouse pot tests. A set of recombinant inbred lines from a cross of the two resistant genotypes was screened to study the relationship between the two sets of resistance genes. The genes appear independent between the two resistance donor sources. Nematode infested field nurseries in the San Joaquin Valley of California were used in 2005 to advance two hundred breeding lines of fresh market type carrots with resistance to *M. JAVANICA* and *M. INCOGNITA*. Analysis of *M. INCOGNITA* and Fusarium wilt race 1 resistance in cotton was continued using crosses between resistant and susceptible genotypes of both pima and upland cottons. Both AFLP and microsatellite (SSR) molecular polymorphisms detected between resistant and susceptible genotypes were found to be linked to a major nematode resistance gene, *rkn1*, in NemX cotton. The gene was mapped to linkage group A03 of the cotton genome, and linked markers were developed and tested for use in marker-assisted selection.

Impact: The identification and characterization of resistance genes in crop plants will lead to effective and safe approaches to managing root-knot nematodes by developing resistant varieties. The use of the resistance in crop production systems as alternatives to nematicides is aided by understanding the nature and specificity of resistance genes. Characterized resistance with genetic markers can be more easily selected for in breeding programs and deployed in cropping systems.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Replace Methyl Bromide combine tactics root kill, fallow, resistant rootstocks,

strtr nutrients, and environmtly friendly post-plnt nematicides.

Description: In 2004 and 2005 a UC researcher began development of a Nematode/Rootstock profile for Prunus spp. Although 2 more years will be required a large data set is already available. Forty Prunus rootstock selections were collected from Russian, Italian, Spanish, French, and US sources. Twenty rootings of each selection were planted into sandy loam soil along with *Pratylenchus vulnus*, *Meloidogyne incognita* nematodes. Eighteen of the selections were placed into large sand tanks containing *Mesocriconema xenoplax*. Three standard trees were used for comparison, including Nemaguard, Lovell and *Pistacia atlantica*. The pistachio selection is resistant to *P. vulnus* and *Meloidogyne* spp. Nemaguard is the rootstock of choice in 90% of California's peach, plum, prune, nectarine, apricot and almond orchards. Nemaguard peach is quite sensitive to the rejection component when it is the replant, so they are searching for an alternative rootstock with comparable or improved nematode resistance. The overarching goal is to replace soil fumigation using a strategy of five steps and one of those steps is to plant on a rootstock having parentage different from Nemaguard. Thirty of the 40 Prunus rootstocks exhibited resistance to *M. incognita*; or fewer than 0.2 nematodes/gram of root. Apparently scientists from around the world have recognized that resistance to *Meloidogyne* spp is essential. Unfortunately, a number of these 30 selections had Nemaguard in their parentage, but not all. The only rootstocks offering resistance to *P. vulnus* were *Pistacia atlantica*, Krymsk 1 and Krymsk 2. The latter two did exhibit susceptibility to *M. incognita* but Krymsk 1 may be a useful reduced vigor alternative following Nemaguard. Two rootstocks exhibited moderate resistance (0.21 to 0.6 nematodes/gram of root) to *P. vulnus* plus resistance to *M. incognita* and they included Garnem (Garfi almond x Nemared) and Bright's Hybrid-4 (Titan almond x Nemaguard). Rootstocks exhibiting a *P. vulnus* host status similar to or less than Nemaguard but without Nemaguard parentage included Hansen's 536, Flordaguard, Emphyrean 2, and Torinel. Viking also fit into this latter group but has a small level of Nemaguard parentage. These are the findings of a two-year evaluation. Of 18 selections placed into soil infested with *M. xenoplax* no rootstock thus far has out-performed Lovell but Guardian, Pumiselect, and Bright's Hybrid -1 have come closest. In 2006 several of the stocks listed above and others are being planted into long-term studies involving numerous trees with and without nematodes. This will be an effort to confirm original findings while evaluating fruit and tree size imparted by each rootstock. Five field trials were initiated for evaluation of several new post-plant nematicidal agents. What is learned from these 3-year trials will broaden their capabilities for solving replant situations that involve a nematode component but rootstock resistance is unavailable.

Impact: The replant problem of perennials is complex and they have previously identified four components including: 1) rejection component, 2) soil pest and disease component, 3) soil physical and chemical component and 4) a nutritional component. Proper soil ripping and fumigation solves all these components but

future costs and availability of these tools makes them unsure. Their proposed alternative to soil fumigation is: a) systemic herbicide to old trunks, b) wait one full year, c) soil ripping, d) replant with rootstock of different parentage and e) a fertilizer program. Although their interests include all perennials their main focus has involved replanting of *Vitis*, *Prunus* and *Juglans*. Their efforts to improve rootstock availability in *Prunus* should provide us with the compliment of strategies and tactics needed to solve the replant problem of *Prunus*. The industries based on *Prunus* will become their model system to test the five-step program indicated above. They do not envision successes everywhere but through

proper diagnosis of prevailing field settings they will determine where the 5-step program has the potential for success. Success with post-plant nematicides would further enlarge their capabilities by providing a useful sixth step.

Funding Source: Hatch

Scope of Impact:

Theme: 4.12 Integrated Pest Management

Title: PHYTOBACTERIOLOGY AND BACTERIAL DISEASE CONTROL

Description: A multi-primer polymerase chain reaction (PCR) based diagnostic method was developed to distinguish among three main subspecies of the bacterium, *Xylella fastidiosa*, that causes Pierce's disease in grape, almond leaf scorch, and oleander leaf scorch is a. Three PCR primer sets were developed to amplify DNA fragments specifically from each group, and then the three primer sets were combined to allow the simultaneous distinction between the groups with one PCR reaction. The UC researchers were also able to distinguish between two groups within of the almond leaf scorch subspecies. They also used the multi-primer PCR assay to detect and differentiate strains of *X. fastidiosa* present in individual glassy-winged sharpshooter adults. The dominant vector in southern California is the glassy-winged sharpshooter, *Homalodisca coagulata*. The high mobility of this insect, and its utilization of large numbers of host plant species, provides this vector with ample exposure to multiple strains of *X. fastidiosa* during its lifetime. Insects were sequentially exposed to plants infected with a Pierce's disease strain in grapevine and an oleander leaf scorch strain in oleander. After sequential exposure, a few insects tested positive for both strains. However, in most cases individuals tested positive for only one strain. In transmission studies, individual adults transmitted either strain of the pathogen at a rate similar to that previously reported after exposure to a single strain, but no single individual transmitted both strains of the pathogen. UC researchers also conducted a study to evaluate the effectiveness of antibiotics and antimicrobial peptides against 10 strains of *Xylella fastidiosa*. The minimal inhibitory concentration (MIC) of 12 antibiotics and 18 antimicrobial peptides were

determined by agar dilution tests and growth inhibition assays. This study shows that antibiotics and antimicrobial peptides have some activity against the pathogen, *X. fastidiosa*. Antibiotics with the lowest MIC for *X. fastidiosa* strains were gentamicin, tetracycline, ampicillin, kanamycin, and novobiocin, chloramphenicol, and rifampin. Plate growth inhibition assays showed that four of the antimicrobial peptides (Magainin 2, Indolicidin, PGQ, and Dermaseptin) were toxic to all *X. fastidiosa* strains. Minor differences in toxicity of these proteins were detected for different strains of these bacteria.

Impact: The development of improved diagnostic methodology for the Pierce's disease bacterium, *Xylella fastidiosa*, allows the researchers to more rapidly characterize strains from new hosts of *Xylella fastidiosa* that they are encountering and to predict whether the strains from these new hosts pose a threat to important agronomic crop species. This lead to vegetation management strategies to reduce the impact of this disease on grapevine or other economic crops.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Project: CA-R*-PPA-6393-H

Title: ETIOLOGY, BIOLOGY, EPIDEMIOLOGY, AND MANAGEMENT OF PRE- AND POSTHARVEST DISEASES OF FRUIT AND NUT CROPS IN CALIFORNIA

Description: In 2005 UC researchers continued research on the biology, epidemiology, and management of pre- and postharvest diseases of fruit and nut crops in California. In etiological studies, they described for the first time the *Penicillium* complex on summer and winter pears using traditional cultural and microscopic morphological characteristics, as well as newly developed molecular techniques for rapidly separating *Penicillium* species based on DNA sequence variability in the beta-tubulin gene. Multiple species were shown to cause blue mold decay of pear in cold storage including *P. expansum*, *P. solitum*, *P. commune*, and *P. roquefortii*. In their epidemiological studies they continued to study the lifestyles of *Colletotrichum acutatum*. On almond, a bimodal host-pathogen interaction was described that included a subcuticular-intracellular hemibiotrophic and an intercellular necrotrophic development. This information was further elaborated in a comprehensive comparison of life styles of the pathogen on almond, citrus, pome fruit, and blueberry based on disease cycles and pathology at the cytological level. This research demonstrated the plasticity and adaptability of the pathogen. In stone fruit they continued to study the

cytological host-pathogen interaction of rust on cling peach. They documented a non-thigmotropic penetration process, only vascular delimitation of infections in leaf tissue, and a wound-periderm delimitation of stem infections in juvenile stem tissues that results in the complete recovery of the host following initiation of secondary growth. In citrus, they initiated epidemiological research on Septoria spot of oranges in an effort to minimize the risk of exporting the disease to international markets free of the disease. Field investigations demonstrated the low natural incidence of the disease even in years with highly conducive environments for disease development. Geographical distribution maps of the disease in Fresno, Tulare, and Kern Co. were generated from over 3200 sample plots representing 89,000 A of orange groves. In controlled environment-postharvest studies using inoculated fruit, they demonstrated that cold- followed by warm-temperature treatment predisposed wound-inoculated Valencia orange fruit to Septoria spot. Additionally, pre- and postharvest fungicide treatments were evaluated for effectively managing this disease that emphasized the importance of protective, preharvest treatments. As a component of IPM in citrus, pome, and stone fruits, they continued to evaluate the efficacy of new reduced risk fungicides and provided data that supported registration and use patterns of these materials for management of pre- and postharvest diseases of these crops. In resistance management studies, they characterized the resistance potential of new postharvest fungicides to the citrus postharvest pathogens. This information is being used in the design of resistance management strategies to ensure the future efficacy of the new fungicides. For management of stone fruit decays they continued to identify new outbreaks and to develop pre- and postharvest sanitation and fungicide programs for managing sour rot.

Impact: This project is continuing to serve the fruit industries of California and the United States by studying the etiology of fruit decays and the biology of pre- and postharvest pathogens, as well as by providing new postharvest treatments to reduce crop losses. An important outcome of the research on the epidemiology and management of Septoria spot of oranges was that major international markets were kept open for trade. Another important focus has been the simultaneous development and introduction of new fungicides that belong to different classes with different modes of action that were essential for development of fungicide resistance management practices that are currently being implemented. Thus, mixing and rotation practices between the different classes are being utilized by fruit industries. In addition, the researchers are providing critical information on baseline fungicide sensitivities in fungal pathogen populations that was obtained using a new method that was developed in their laboratory. Based on the research, in 2005 at the state regulatory level, fludioxonil was registered on citrus, pome fruit, and kiwifruit in California; pyrimethanil was registered on citrus and pome fruit; whereas fenhexamid was registered on stone fruit and kiwifruit.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: ECOLOGY, EPIDEMIOLOGY, AND CONTROL OF ROOT-INFECTING FUNGI ON CROPS IN IRRIGATED DESERT AGRICULTURE

Description: Objective 1: To evaluate the efficacy of fludioxonil (Cannonball) and thiophanate-methyl (Topsin M) applied (i) through the drip irrigation system and (ii) by shank injection into preformed beds prior to planting for the control of charcoal rot of melons caused by *Macrophomina phaseolina* and vine decline caused by *M. cannonballus*. Shank-infected treatments will be furrow irrigated. Shank infection is being investigated because many growers do not use drip irrigation. Results: By four weeks after planting, ca. 50% of the plants (one or more roots per plant) in all treatments were colonized by both *M. phaseolina* and *M. cannonballus*. By seven weeks after planting, almost all plants (75-100%) in all treatments were infected with both pathogens. At harvest on June 30, the root disease severity ratings, the percentage of roots with perithecia, and the percentage of roots with lesions were significantly less in the Cannonball treatment compared to the nontreated plots or Topsin M treatments. Relative to the nontreated control and Topsin M, Cannonball provided significantly greater disease control. However, they had problems with the irrigation systems (both drip and furrow) which impacted negatively on the efficacy of the chemical treatments. Thus, the experiment will be repeated in 2006. Objective 2. Assess the colonization of melon roots by *Monosporascus cannonballus*. Results: Penetration of *Monosporascus cannonballus* into and growth within cantaloupe roots was studied using light and electron microscopy. Germ tubes penetrated the epidermis, and hyphae grew, without branching, almost directly to the xylem. The hyphae traversed the endodermis into protoxylem cells, and then grew extensively within the lumen of metaxylem vessels. Eventually, the hyphae grew back out into the cortical cells. A relatively low percentage of cells within both the cortex and xylem of lesions contained hyphae. The hyphae were generally localized within the lesion and could rarely be isolated more than 2 mm away from the margin of the lesion. Regardless of tissue type, hyphae were predominately intracellular. *M. cannonballus* appeared to be most similar to vascular wilt pathogens in its mode of parasitism, but does not spread via the vascular system to above-ground plant tissues.

Impact: Data indicates that chemical control of these late season root diseases of cantaloupe may be possible but further research on timing and frequency of chemical application is needed.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: MANAGING PLANT-MICROBE INTERACTIONS IN SOIL TO PROMOTE SUSTAINABLE AGRICULTURE

Description: 1. Insect control studies: Expanded studies on the efficacy of the Bb-bait for control of shore flies, other greenhouse insect pests, and nuisance flies associated with animal facilities. Results: Bait formulations of *Beauveria bassiana* remained viable after two years of storage at refrigeration temperatures. Efficacy studies involving control of nuisance flies with the Bb-bait were not successful. 2. N-Serve studies: Initiate qualitative and quantitative assessment of changes in the resident bacterial, including the fluorescent pseudomonad, populations in recycled nutrient solutions amended with the chemical and determination of the biological effect of such changes on plant growth and disease control. Additionally, investigations will be initiated on the mechanism(s) associated with selective enhancement of specific bacterial populations in the chemical-amended and recycled nutrient solutions. These studies will involve the use of specific rifampicin-resistant strains of *Pseudomonas* spp. which have been previously associated with control of root-infecting pathogens or enhancing plant growth. Results: Populations densities of fluorescent *Pseudomonas* spp. increased from 103 CFU/ml to 106 CFU/ml within 48-72 hr after amending the recycled nutrient solution in a hydroponic cultural system with N-Serve. Similar results were obtained using xylene as the amendment. *Pseudomonas putida*, biotype A, was the dominant indigenous fluorescent *Pseudomonas* spp. identified following chemical amendment of the nutrient solution. In *in vitro* studies, significant population increases of known fluorescent *Pseudomonas* species (i.e., Pf-5 and *P. aureofaciens* 30-84) occurred following their addition to the nutrient solution in the presence of N-Serve but those populations were lower (2X) than the population increases of the indigenous fluorescent *Pseudomonas* spp. However, Pf-5 and *P. aureofaciens* 30-84 were not competitive with indigenous fluorescent *Pseudomonas* spp. in *in vivo* studies and their populations decreased significantly following their addition to the nutrient solution in the presence or absence of N-Serve. Significant disease control (using pepper plants as the host and *Phytophthora capsici* as the root pathogen in a model system) was achieved following amendment of the nutrient solution with various concentrations of N-Serve or xylene. 3. Biosurfactants. Conclude studies on the efficacy of biosurfactants (Zonix and ThermX70) on the control of zoosporic pathogens in recycled nutrient solutions. Results: Amending the nutrient solution with either a rhamnolipid or a saponin completely suppressed disease development (root rot of pepper caused by *Phytophthora capsici*) in both ebb-and-flow and top-irrigated cultural systems, with either an organic potting medium or rockwool. These results provide evidence that biosurfactants may be a suitable alternative to registered fungicides or synthetic surfactants in the management of diseases

caused by zoosporic pathogens in cultural systems employing recycled irrigation water.

Impact: The biopesticidal bait has a long shelf life which increases its potential use in commercial greenhouse applications.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-D, CA-R, ID, IL, MT, NM, NYG, OH, OR, WA

Theme: 4.12 Integrated Pest Management

Title: Management of Diseases of Turf and Landscape

Description: (1) Developing management strategies for Turfgrass Anthracnose (*C. cereale*) UC researchers have been focusing the work on three aspects of *C. cereale* (ex. *C. graminicola*) (i) differential responses to sterol biosynthesis inhibitor (SI-) fungicides, (ii) sensitivity to fludioxonil and (iii) field testing of fungicides. They have found that in testing baseline and reduced-sensitivity populations that isolates of *C. cereale* were most sensitive to tebuconazole, followed by propiconazole, myclobutanil and triadimefon. This shows that for practical control of this disease that fungicides with the highest activity should be used for its control in the field. Fludioxonil is a phenylpyrrole fungicide recently labeled for the control of *C. cereale*; and is at risk for resistance development. To develop methods to resistance development, a baseline sensitivity distribution was determined; ED50 values for 60 baseline isolates ranged from 0.0010 to 2.5 mg/L with mean of 0.60 mg/L. The impact of the isolates with increased ED50 value is being investigated at this time. Since there is a high prevalence of QoI, benzimidazole and SI- resistance in *C. cereale* populations, the efficacy of alternative fungicide treatments was investigated in the field. It was found that preventive applications of chlorothalonil, fludioxonil, polyoxin-D and tank mixes with fosetyl-Al were good alternative treatments. (2) Developing management strategies for Grey Leaf Spot (*P. grisea*) on Perennial Ryegrass and Kikuyugrass in California A survey to detect QoI resistance in populations of *P. grisea* indicated both F129L tolerant isolates and G143A immune isolates were found in California populations. The population structure of *P. grisea* was analyzed using amplified fragment length polymorphisms (AFLP) and specific amplification of mating type genes. Initial results indicate that this pathogen is not a recent introduction to California and that Kikuyugrass isolates may be closely related to crabgrass isolates and may be sexually reproducing. (3) Evaluation and characterization of fungicides for turfgrass disease management In 2005, fungicide performance was evaluated against *C. cereale*, *Rhizoctonia cerealis*, *Sclerotinia homoeocarpa*, *Microdochium nivale*, *Sclerotium rolfsii* and basidiomycetes causing fairy ring on turf. (4) Establishment of a state-wide diagnostic center for turfgrass disease diagnosis Over 350 samples were

diagnosed from California, Washington, Nevada, Colorado and Oregon. From the samples, it was determined that a species of *Waitea circinata* was causing disease in golf course putting greens that had not been previously described in the US. (5) Detection and characterization of *X. fastidiosa* strains from landscape hosts In 2005, it was shown that *X. fastidiosa* was the causal agent of disease in Mulberry, Sweetgum and ornamental plum. Characterization of these isolates showed that those affecting sweetgum and plum were subspecies *multiplex*. Strains affecting mulberry were almost 100% identical to strains previously described in the eastern US (6) Development of management strategies for the control of Fusarium Wilt of Palm No research was performed in this area this past year.

Impact: The impact of this project is providing new information to help reduce the impact of diseases of turf and landscape on the California green industry with regard to the economic cost of pest management and the aesthetic impact of these diseases. The research conducted this year has provided key insights on the biology and control of two diseases directly impacting the multi-billion dollar California golf course industry. Fungicide testing results have given the industry unbiased information regarding best control options and recommendations. Also the state wide turf disease diagnostic laboratory has provided turf managers timely and important information with regard to the correct identification of their problems, and identified a new disease affecting turf in the western US. Finally, the research has proved the role of *X. fastidiosa* in causing new diseases of landscape plants, indicating that the presence of this bacteria in California is not only a threat to agricultural crops but also to urban landscapes

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: High Value Specialty Crop Pest Management

Description: The WR (Western Region) has a magnitude of 234 residue food use field trials during the 2005 field season. Seven western states (CA, CO, HI, ID, NM, OR, WA) participate in the field program and the work is conducted at 17 field research sites. The WR received approximately \$178,000 in additional grants and gifts to support trials important to western growers and registrants. In 2005, the WR ornamental program conducted fungicide (*Phytophthora* at 4 sites), herbicide (4 research groups) and insecticide (mealy bug by 3 research teams) projects and carried out 42 efficacy trials in support of establishment of tolerances(11 trials) and on significant pest issues (onion thrips), herbicide safety and seed treatment. Sixteen biopesticide projects received IR-4 funding to research insect pest management (4 projects), nematode management (1

project), and plant pathogen management (11 projects). The web based Priority Setting Tool previously developed to track pest management needs was used at the National Research Planning meeting. On campus, a 2-day field and lab training meeting was held in March and in October the WR State Liaison Representatives met with members of the Commodity Liaison Committee at their annual meeting. The WR Analytical laboratory received 142 field trials, logged and processed 794 samples, and produced 168 stability samples. The Laboratory completed a total of 74 field trials during this period. Satellite laboratories in Hawaii and Washington State completed and submitted 3 and 7 field trials respectively. A total of 84 trials were carried out during this time period by the WR laboratory system. An EPA inspection of the laboratory resulted in no significant findings. An additional 2 EPA inspections were carried out at field sites during 2005. Audits and reports completed were 93 Critical Phase Inspections, 7 Facility Inspections and 113 Raw Data audits.

Impact: The Western Region IR-4 program is comprised of an analytical laboratory, a field research office and a quality assurance unit to support field trials, residue analysis and GLP compliance required for pesticide registration. IR-4 supports registrations for reduced risk pest management tools on high value specialty crops that represent a \$16 billion value and 40% of California agriculture.

Funding Source: Multistate Research and State

Scope of Impact: AL, AR, CA-D, CO, IA, ID, IL, ME, MI, MN, ND, NE, OH, PR, SC, SD, TX, UT, VA, WA, WI, Kentucky Cooperative Extension

Theme: 4.12 Integrated Pest Management

Title: Identifying potential targets for the control of nematode reproduction

Description: Nematodes are a significant agricultural problem causing crop-damage resulting in billions of dollars of lost revenue each year. Parasitic worms also infect and cause physical harm to animals and humans. Unfortunately, very few agents are effective in controlling these harmful pests, due in large part to the development of resistance. Nematodes have evolved a number of reproductive strategies, which results in prolific growth. Targeting reproduction represents an attractive approach to their control. To that end, UC researchers have successfully established the nematode, *Caenorhabditis elegans*, as a model for their studies. An important step in germline development and hence sexual reproduction is the initiation of meiosis. In *C. elegans* the germline is housed by the gonad and contains both proliferating cells and cells undergoing meiosis. Proliferation maintains the germline and the proliferative versus meiotic decision is regulated by the GLP-1/Notch signaling pathway. Meiosis is the process in which diploid cells undergo one round of DNA replication followed by

two rounds of nuclear division and specialized cell divisions that result in the production of haploid gametes. Meiosis can be easily visualized in *C. elegans*. Within the syncytial gonad, germ cell nuclei representing all stages of meiotic prophase are arranged in a temporal/spatial gradient and chromosome behavior can be easily monitored. They are using the unique features of *C. elegans* gametogenesis to determine the relationship between replication, nuclear reorganization, and chromosomal interactions. Over the last year, they have made significant progress towards examining the role of DNA replication in the sexual cycle of *C. elegans*. They have established an assay that utilizes microinjection of fluorescently labeled nucleotides into the gonad of *C. elegans*. They have found that the nucleotides are rapidly incorporated specifically into actively replicating nuclei. Treatment of the worms with the inhibitor, hydroxyurea, blocks incorporation. Furthermore, immunohistochemistry revealed that the labeled nuclei reside in a distinct domain of the gonad. Double labeling experiments have allowed us to determine the relative length of DNA replication in the gonad. To determine the contribution of DNA replication in proliferating versus meiotic cells, they have used a number of well-characterized mutants of the *glp-1* signaling pathway that perturb the proliferative vs. entry into meiosis decision. Analyses of these mutants using microinjection of fluorescent nucleotides has revealed that DNA replication takes twice as long in cells undergoing meiosis compared to proliferating cells. From these studies they also discovered that different regions of the genome replicate with different timing. In addition, progression through meiosis is substantially slower in self-fertilizing hermaphrodites compared to males.

Impact: Nematodes are a significant agricultural and animal health problem causing billions of dollars in damage each year. Unfortunately, very few agents are effective in controlling these harmful pests, due in large part to the development of resistance. Nematodes have evolved a number of reproductive strategies, which results in prolific growth. In fact, nematodes are the most numerous multi-cellular animals on earth. Targeting reproduction represents an attractive approach to their control. The UC researchers have successfully established the nematode, *C. elegans*, as a model for their studies. They have been examining the role of DNA replication in the sexual cycle of *C. elegans*. Using fluorescently labeled nucleotides they can label and monitor replicating DNA. Thus far, they have determined that DNA replication takes twice as long in cells undergoing meiosis, the specialized cell cycle that reduces the ploidy for sexual reproduction, compared to proliferating cells. Furthermore, different regions of the genome replicate with different timing. In addition, progression through meiosis is substantially slower in self-fertilizing hermaphrodites compared to males. By taking advantage of the large array of genetic, genomic, and proteomic tools available in *C. elegans*, they hope to identify genes involved in DNA replication during sexual reproduction, which may ultimately be targets for intervention.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Mosquito and Agricultural Pest Management in Riceland Ecosystems

Description: In 2005 a UC researcher made significant progress on several projects designed to generate and disseminate knowledge about mosquito production and control in riceland agroecosystems. He completed data analysis and write-up for a three-year project on how rice straw and winter flooding affect mosquito populations in the rice agroecosystem. This study showed that mosquito populations increased in response to on-site decomposition of rice straw, even though beneficial predators also became more abundant. The first paper from this work was the December cover article for *Ecological Applications* (Lawler and Dritz 2005). A second manuscript has been submitted to the *Journal of Medical Entomology*; this ms shows that winter flooding interacts with residual straw to increase mosquito numbers, and that draining fields for herbicide applications may lead to unusually dense mosquito populations upon re-flooding. The researcher and a colleague completed the U.C. ANR. extension publication 'Managing mosquitoes on the farm'. The work is now available online (U.C. ANR, IPM and Mosquito Research Program websites). This publication addresses how to manage mosquitoes in a wide range of agricultural settings, including dairy farms, orchards, rice fields and other row crops, and natural lands adjacent to fields. He revised a second manuscript on how the agricultural pesticide lambda-cyhalothrin affects mosquitoes and beneficial predators, and submitted it to *Pest Management Science*. Their previous results showing that this pesticide can kill mosquitofish have been incorporated into a California Rice Research Board brochure for growers (see <http://www.carrb.com/Facts/Mosquito.HTM>). They completed the second year of field work for a three-year study on how ultra-low volume pesticide fogs for mosquito control affect the invertebrates of seasonal wetlands. Seasonal wetlands in rice-growing areas both produce mosquitoes and harbor mosquitoes from adjacent rice fields. The Colusa Mosquito Abatement District applied a pyrethrin insecticide over wetlands on Colusa Wildlife Refuge twice per week in September and October of 2005, and left Sacramento Wildlife Refuge untreated. They established study areas in three large wetland basins per refuge. They completed two series of light-trapping samples on nights before, during, and after a spray to estimate mortality of flying insects. They collected zooplankton samples and sweep-net samples of aquatic insects from all sites. In addition, they used *Daphnia magna* as 'sentinel' zooplankton to test whether adulticides affect zooplankton. A parallel study by a colleague is assessing whether the pesticide precipitated into the wetlands. This work will not be published until after all years of the study are complete.

Impact: The online paper 'Management of Mosquitoes on the Farm' is a useful reference document for mosquito prevention and control in row crops, dairies and orchards. California's Mosquito and Vector Control Districts and U.C. extension personnel can refer growers to this publication for information. Their work on rice straw management informs growers and mosquito abatement districts about potential mosquito issues associated with on-site decomposition of rice straw and winter flooding.

Funding Source: Multistate Research and State

Scope of Impact: AR, CA-D, CA-R, FL, IL, KY, LA, TX

Theme: 4.12 Integrated Pest Management

Title: INTEGRATED PEST MANAGEMENT OF INSECTS IN AND AROUND STRUCTURES

Description: Invasive ant species are frequently transported in potted plants and the nursery industry faces a major challenge in producing potted plants free of ants. Tests were conducted to determine if pieces of plastic impregnated with permethrin would serve as barriers to red imported fire ants, *Solenopsis invicta*, and Argentine ants, *Linepithema humile*. Brief exposure of 1 minute provided complete knockdown within 15 minutes, but 70% and 5% of the Argentine and red imported fire ants recovered in 24 hours, respectively. A 1-cm-wide coil of impregnated plastic was sufficient to prevent ants from establishing colonies in flower pots with soil. Field and laboratory evaluations of ant baits to control Argentine ants, red imported fire ants, and yellowjackets are ongoing. Promising active ingredients included thiamethoxam, indoxacarb, and metaflumizone. Minced chicken baits treated with 0.1% fipronil or 0.1% imidacloprid failed to provide control the western yellowjacket, *Vespula pensylvanica*. Intensive trapping with Reiersen traps or Victor traps reduced the numbers of foraging yellowjackets and the number of stinging incidents. However, yellowjacket numbers were still unacceptably high at the end of the season. The susceptibility of cat fleas, *Ctenocephalides felis*, to imidacloprid was determined for five laboratory and 12 field-collected strains. The probit lines generated by different laboratories provided similar LD50 values ranging from 0.32 to 0.81 ppm. With this data a diagnostic dose of 3-ppm imidacloprid incorporated in to larval rearing media was established. From 2002-2005, this diagnostic dose has been evaluated against over 700 flea isolates collected from the United States and Europe. The diagnostic dose of 3 ppm is robust enough to eliminate most of the susceptible strains and yet low enough to identify possible isolates for further testing. Probit analyses were conducted on about 6 of these isolates, but none of them were resistant to imidacloprid.

Impact: In the last 5 years, nurseries in southern California have spent millions of dollars in treating potted plants to kill red imported fire ants. Huge amounts of insecticide have been applied and some of it has entered the water shed. The development of plant pots that prevent ants from establishing colonies in them would eliminate the need for these massive chemical treatments. The plastic impregnated with permethrin would reduce the potential for pollution of the environment. The development of insecticide resistance by cat fleas to insecticides that are used to topically treat cats and dogs would be disastrous. Topical application of fipronil and imidacloprid has revolutionized cat flea control. The intensive monitoring program that has been developed is the first step in preventing the development of resistance. It is the first such program to be developed in the animal care industry. The development of baits for ant and yellowjacket control is an important step in reducing the amount of chemical applied urban environments. There are a number of novel and new insecticides that look promising. The laboratory and field studies are the first step in developing these new active ingredients.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: BIOLOGY AND CONTROL OF STRUCTURAL INSECT PESTS

Description: Western subterranean termites, *Reticulitermes hesperus*, preferred various mono-, di-, and trisaccharides in feeding studies. Termites consumed significantly more paper treated with 5% ribose, 3% xylose, and 2% maltose, fructose, arabinose, or ribose than they did on control papers and these treated papers were most preferred in choice studies. Termites readily consumed ¹⁴C labeled sucrose converting 89.2% of it to respiration. The amount transferred to other termites via contact, grooming or trophallaxis was very small. Sugars, at concentrations much higher than those naturally encountered by termites, served as phagostimulants. Their use in bait matrices may increase consumption and help retain termites at bait stations. Uptake of ¹⁴C-labeled hexaflumuron peaked rapidly at 280 ng per termite at 12 days. Dead termites consistently contained about 113 ng of hexaflumuron. Excretion of hexaflumuron was rapid after single bouts, the half-life ranging from 2.1 to 4.7 days. Movement of hexaflumuron by cannibalism and coprophagy was only significant when termites were starved. Hexaflumuron appeared to adversely affect egg hatch. Variable efficacy of the hexaflumuron bait in the field in southern California may be the result of sporadic feeding by the western subterranean termite, rapid clearance of the bait, and low densities of termites in arid environments. Extensive studies with ¹⁴C labeled insecticides such as chlorfenapyr, imidacloprid and fipronil have been conducted to determine if horizontal transfer is an important factor in termite control. Limited

transfer of insecticide occurred at biologically relevant conditions for chlorfenapyr and fipronil. Factors that influenced the distance that insecticides were transferred included the type of substrate, concentration of insecticide, and the exposure period. Transfer was primarily facilitated by contact and possibly grooming between termites. Trophallaxis did not play a significant role.

Impact: The use of baits to control western subterranean termites has only been partially successful. Low population densities, sporadic feeding and arid conditions have contributed to this lack of efficacy. This research verifies that a number of sugars result in increased feeding and the use of sugars to increase feeding consumption and retention at these bait stations should improve their efficacy. The radioabel studies with hexaflumuron showed that the short half-life of hexaflumuron in the termite allowed termites to elimination lethal doses prior to molting. Insect growth regulators with greater retention in the termites are necessary in these situations. Perimeter treatments of insecticides around structures have been advocated because of claims of area wide control by non-repellent insecticides. Their effectiveness has been attributed to horizontal transfer. This research clearly demonstrates that the primary effects of these insecticides was due to termites contacting lethal barriers and not due to horizontal transfer.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: GENE TRANSFER IN INSECT SPECIES OF ECONOMIC IMPORTANCE

Description: In 2005 UC researchers achieved several breakthroughs. They published their discovery of the Herves transposon from the malaria mosquito *Anopheles gambiae* and commenced a mutagenesis assay of this element. They demonstrated that this transposon is active in yeast thereby allowing them to develop high throughput genetic screens in this organism for hyperactive and hypoactive forms of the transposase. These complement their studies on the related Hermes transposon from the housefly in which they are already testing some candidate hyperactive mutants in insects. These studies have been augmented by the availability of the crystal structure of the Hermes transposase. This provides important insights into how this enzyme may function and so enabled them to target specific amino acid residues and then determine the impact that changing these has on enzyme function. They discovered three subfamilies of hAT transposons in the genome of the mosquito *Aedes aegypti* which is the principle vector of dengue and yellow fever. These are related to the Hermes and Herves elements described above. These elements were discovered using bioinformatics and all are predicted to be functional. One of

these subfamilies is particularly interesting and they have cloned one member of it and indeed shown it to be functional. This transposon, called AeBuster1, is closely related to a gene in humans, called Buster, the function of which is unknown. Buster itself is highly conserved in many mammals pointing to it being under strong positive selection. The significance of the Buster discovery is twofold. First it is the first active transposon discovered in *Ae.aegypti*. This mosquito is a prime target for genetic control strategies and an active endogenous element may well provide a means by which high frequency genetic transformation of this species can be routinely obtained. Furthermore this transposon may be able to drive beneficial genes through *Aedes* populations. To this end they are constructing AeBuster1 transposons for *Aedes* transformation. Second, the relationship between this Buster transposase and the human homolog demands investigation of the function of the human gene and whether it has a function in recombination and chromosome stability. It also provides them with an important model for examining how possible horizontal transfer between mosquitoes and humans may or may not occur and what impact this may have on genetic control programs. Finally in 2005 they are able to identify a number of insect genes that may be host factor genes controlling Hermes and Herves mobility insects. The identity of these genes is important since they may influence the behavior of transposons in new hosts and so directly affect the outcome of any genetic control program. They have identified a choline kinase-like gene in *Drosophila* that they believe acts by phosphorylating the transposase leading to a conformation change that may act as a regulatory switch. Interestingly these kinases are potent oncogenes in mammals perhaps suggesting a link between transposon regulation and oncogenesis.

Impact: The long-term goal of the research is to develop viable and robust gene transfer technologies for insects of economic and medical importance and in doing so bring the full repertoire of contemporary genetics to bear on relevant problems in entomology for the benefit of the citizens of California. The central bulwark of the research is that effective genetic control programs based on the use of transposable elements to transform insects can only be developed if they understand how these elements function both *in vitro* and *in vivo*. Their program is unique amongst those who use transposons in entomology since they use the tools of biochemistry and molecular genetics to understand how these transposons function. Their program is unique amongst transposable element biologists in that they seek to understand how these transposons function in different hosts. The impact of their work will be a sufficient level of understanding of these transposons which will enable their efficient use in genetic control strategies aimed particularly at insects that vector human disease, such as mosquitoes. This work will enable sensible and realistic estimates to be made of any risk associated with this type of genetic control since the calculus they will employ will be based on empirical measurements of transposon behavior with knowledge of the chemical basis of transposition. These outcomes will greatly facilitate the deployment of this technology in the field and increase the

probability that a favorable outcome will be achieved.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Development, Biology, and Application of Novel Proteins and Peptides for Insect Control

Description: The long-term goal of this project is to develop peptides that can be used in transgenic plants to control sucking insect pests such as glassy-winged sharpshooter (GWSS), HOMALODISCA COAGULATA, lygus bug, LYGUS HESPERUS, greenhouse whitefly, TRIALEURODES VAPROARIORUM, and cotton aphid, APHIS GOSSYPHII. The approach is to identify key transporter proteins on the midgut microvilli of these pests, clone the genes for these proteins, develop antibodies to the protein exposed functional regions, and derive peptides from the variable regions of the antibodies that can be used in plants to control these pests. The researchers are also examining the possibility of blocking the function of certain salivary proteins using the same approach. Our first objective is to identify and clone genes for key midgut proteins. Using RT-PCR and degenerate primers for the V-ATPases A and c subunit genes from the yellow fever mosquito, Aedes Aegypti, they were able to clone portions of each of these genes from each insect. Using a magnetic bead based clone capture procedure they have isolated the complete transcript clones for the V-ATPase c subunit genes from cDNA libraries constructed for each insect. The V-ATPase c subunit protein is known to be the lumen exposed subunit of this transporter which is involved in critical transport processes in the gut. These clones will be their first candidates for mimetic peptide synthesis aimed at blocking the function of this critical protein in sucking insect pests. They had affinity purified antibodies prepared to the GWSS V-ATPase c protein and are conducting feeding studies over the next few months to assess the efficacy of their approach. RNA extracted from the rabbits used to prepare these antibodies will be used to construct phage display libraries, which will be screened to isolate the most effective antibody peptide. Using RT-PCR with consensus degenerate hybrid oligonucleotide primers (CODEHOP primers) they also have amplified fragments of two key salivary gland specifically expressed genes. These are the trypsin-like protein gene originally isolated from lygus bug, and the maltase-like, MAL-1, protein gene isolated from the yellow fever mosquito. These genes are excellent candidates for use in development of mimetic peptides targeting the plant cell wall degrading enzymes of these vascular-feeding insects. The clone capture procedure is being used to isolate the full-length transcript clones for each of these genes. RNA and DNA blot hybridization studies are currently being

conducted to determine gene expression level and copy number. They have initiated in situ hybridization studies to determine the expression pattern of the GWSS V-ATPase A and c genes and have determined that they are expressed as expected in the target tissues. Manuscripts combining the sequence, structure, expression, and relatedness studies of these groups of genes are now in preparation. The researchers are also conducting cDNA microarray studies with targets prepared from two differentially pyrethroid resistant populations of GWSS to identify genes related to resistance development. These studies will enable them to identify gene products that may be targeted with new insecticides.

Impact: If the protein targeting project is successful, it will provide a novel and environmentally safe tactic for controlling many important insect pests. With the information gained from the pesticide resistance studies the researchers will be able to identify genes whose expression levels are affected by pesticide treatment. Subsequent analyses can identify the gene function, allowing them to determine the relevance of that gene in resistance/tolerance to the selecting insecticide and the likelihood of that gene conferring cross resistance to chemically unrelated insecticides. This will allow them to make better pesticide use recommendations to growers.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: BIOLOGICAL CONTROL IN PEST MANAGEMENT SYSTEMS OF PLANTS

Description: The goal of this project is to improve biological control programs in agroecosystems through an improved understanding of the ecology of predator-prey and parasitoid-host interactions. During 2005, work was focused in three areas. (1) First, the researchers worked on developing a better understanding of biological control of the western tarnished plant bug, *LYGUS HESPERUS*, in California cotton. Cotton hosts a diverse community of predators, and they analyzed two years of survey data (approximately 20 time-series in all) to identify predators that might be responsible for stable variation in the densities and age structure of *LYGUS* populations. They discovered that big-eyed bugs, *GEOCORIS* spp., are negatively correlated with the proportion of *LYGUS* populations made up of nymphs. *GEOCORIS* spp. appear to prey selectively on nymphs (adults are too big to be captured). Because nymphs are damaging, and because nymphs are often poorly sampled by routine scouting of fields, *GEOCORIS* may play a particularly important role in suppressing cryptic but damaging populations of nymphs. Ongoing work is assessing the importance of

different factors that may constrain the population growth rate of GEOCORIS in cotton fields. (2) Second, they conducted a series of observational studies, field bioassays, and manipulative field experiments to understand the impact of sulfur, which is applied to vineyards to suppress powdery mildew, on biological control of grape leafhoppers, *ERYTHRONEURA ELEGANTULA*, by parasitoids in the genus *ANAGRUS*. They discovered that although short-term bioassays suggest that sulfur is highly toxic to *ANAGRUS*, sulfur has little effect on reproductive success of parasitoids in the field, and no detectable effect on the ability of *ANAGRUS* to impose mortality on leafhopper populations. It may be that even in the absence of sulfur, other factors place major constraints on the ability of *ANAGRUS* to function as a good biocontrol agent. Improvements in biological control may therefore require the simultaneous removal of multiple constraining factors from vineyards. (3) Finally they conducted a meta-analysis of the effects of intraguild predation on the success or failure of biological control. Contrary to the conventional wisdom, it appears that adding an intraguild predator to a 2-species predator-prey module can have diverse effects: biological control may be improved or disrupted, or there may be little overall effect. Ongoing work is attempting to understand what factors shape the type of result that is observed.

Impact: The work on GEOCORIS is motivating growers to incorporate predator densities into their decision rules regarding when they should apply pesticides to control *LYGUS* in cotton, thereby decreasing pesticide use. On the longer term, the researchers' work is helping to produce a solid basic understanding of natural enemy ecology upon which ecologically sound biological control programs can be developed within an IPM framework.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-B, CA-D, CA-R, CO, DE, GU, HI, ID, KS, MT, ND, NJ, NM, NYC, OR, SAM, UT, WA, WY

Theme: 4.12 Integrated Pest Management

Title: DEVELOPMENT OF BIOLOGICAL CONTROL/IPM STRATEGIES IN ENVIRONMENTAL HORTICULTURE

Description: Research has focused on developing and implementing an IPM program for gerbera and roses in California. Such an effort encompasses the evaluation of biorational pesticides, the development and validation of sampling plans for spider mites, whiteflies and leafminers in addition to the evaluation of 'new' biological control agents. A stratified sampling plan based on where pest occur together with a full spatial analysis has yielded an efficient sampling plan for the most important pests of these two major flower crops. Research has continued with a lady beetle in the genus *Psyllabora*, an obligate feeder on different species of mildew and the UC researchers are studying its functional

and numerical response to mildew populations in the greenhouse, landscape and laboratory. Work with a number of biorational pesticides may yield alternatives to organophosphate materials and provide compatibility with natural enemies. A Gerbera Alliance (consisting of growers, researchers, extensionists and allied industries) has been formed to move the statewide development and implementation of IPM forward in this crop. In connection with this alliance, they are evaluating different fertilizers with respect to crop yield and quality and severity of attack by insect pests. For example, the addition of potassium silicate to the fertilizer mix appears to reduce leafminer populations in controlled greenhouse studies.

Impact: The use of yellow sticky cards for monitoring pest populations with the use of economic thresholds by the floriculture industry have been major advancements fostered by this project. This project has also been responsible for more biological control being used in the industry and a parallel decline in the use of broad spectrum pesticides.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: INTEGRATED PEST MANAGEMENT STRATEGIES FOR CALIFORNIA HORTICULTURAL CROPS

Description: IPM research was conducted on strawberry, tomato, almond, prune, peach, grape and olive insects. Strawberry research focused on control of two spotted spider mite TETRANYCHUS URTICAE, greenhouse whitefly TRIALEURODES VAPORARIORUM and Lygus bug (primarily LYGUS HESPERUS). UC research led to the California registration of several new acaricides for control of TETRANYCHUS URTICAE including bifenazate, etoxazole, acequinocyl, and spiromesifen (which is also effective for control of TRIALEURODES VAPORARIORUM). Tomato research focused on the consperse stink bug EUSCHISTUS CONSPERSUS and the potato aphid MACROSIPHUM EUPHORBIAE. Continuing evaluation of alternatives to organophosphate insecticides confirmed that combinations of pyrethroid and neonicotinoid insecticides afforded better control of EUSCHISTUS CONSPERSUS than did candidate chemicals of either category alone. Research on MACROSIPHUM EUPHORBIAE focused entirely on organically acceptable products and adjuvants used to improve their effectiveness. Almond and stone fruit research focused on dormant season control of peach twig borer ANARSIA LINEATELLA treatment thresholds and control for San Jose scale QUADRASPIDIOTUS PERNICIOSUS, mitigation of stormwater runoff containing dormant season pesticides applied for their control, and development of seasonal

phenology of the ten lined June beetle *POLYPHYLLA SOBRINA*. A number of pyrethroids, insect growth regulators and the biologically-based insecticide spinosad were shown to provide equivalent control of *ANARSIA LINEATELLA* to organophosphates in a field trial. An IGR dormant spray was shown to manage moderate densities of *QUADRASPIDIOTUS PERNICIOSUS* over 2 seasons in another field trial, and spur samples were shown to be predictive of scale damage. Studies of the reproductive biology of the glassy-winged sharpshooter *HOMALODISCA COAGULATA* indicated the presence of 2 or 3 generations in southern California depending on year, and the capacity of this important insect vector of Pierce's disease of grapes to continue to be reproductively active throughout the winter in that area. Research on the exotic olive pest *BACTROCERA OLEAE* continued in 2005 and included monitoring of 20 sites to validate a phenology model developed from data collected the 2 previous years. Control studies to evaluate new chemical and cultural control approaches and food lures was initiated as was a study to evaluate the preference and reproductive success of the flies on different olive varieties.

Impact: This project provides California's fruit, nut and vegetable producers with mitigation measures for organophosphate insecticides and/or IPM alternatives for key arthropod pests affecting fruit quality and yield. Decision support tools developed for monitoring pest abundance, pest resistance and phenology affords economical pest control and reduced environmental impact.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: EXPLOITING PHEROMONES AND RELATED CHEMICALS FOR DETECTION, MONITORING, AND CONTROL OF INSECT PESTS

Description: In 2005, UC researchers identified, synthesized, and tested the pheromones of several economically important lepidopteran species. First, after 15 years of sporadic effort with several collaborators, they have finally identified missing components of the sex pheromone of the navel orangeworm, a major pest of nut crops in California. The major component of the pheromone, (11Z,13Z)-hxadecadienal, had been known for about 25 years, but it was minimally active as an attractant. The missing components include (3Z,6Z,9Z,12Z,15Z)-tricosapentaene and (11Z,13Z)-hexadecadienol, and lures containing these two components in combination with the known aldehyde are much more attractive than the aldehyde alone. Second, they identified, synthesized, and tested the pheromone of the citrus leafminer, *Phyllocnistis citrella*. This insect is of major concern as a vector of the deadly bacterial disease citrus canker. In field tests in California, Florida, and Brazil, the pheromone

proved highly attractive to the insect, and lures lasted for at least 4 weeks under field conditions. Third, they identified and synthesized the pheromone of the fir coneworm *Dioryctria abietivorella*. This insect is a devastating pest of conifer seed orchards throughout temperate western North America. Field testing was done in conjunction with collaborators in British Columbia, Ontario, Quebec, and northern California. One component of this pheromone was also a pentaene hydrocarbon, namely (3Z,6Z,9Z,12Z,15Z)-pentacosapentaene. In 2005, they completed work on the identification, synthesis, and field testing of the sex pheromone of the obscure mealybug *Pseudococcus viburni*. This insect is a serious vineyard pest in the coastal vineyards of California, as well as being a pest of ornamentals and nursery/glass house crops worldwide. They also have identified the pheromone of longtailed mealybug *Pseudococcus longispinus*, another worldwide pest in vineyards and nursery crops, and are currently working on the synthesis of its pheromone, to provide sufficient material for field trials. Taken together with the pheromone of vine mealybug that they had previously identified, the pheromones of these two pests will provide California grape growers and nurserymen with sensitive sampling tools. They also worked with a Brazilian group to identify male-produced sex pheromones from the stink bug *Thyanta perditor*. This species is a major pest of soybeans and other legumes in Brazil.

Impact: Several projects have come to fruition, with pheromones identified for a number of serious insect pests. The results of this research are already being implemented in several of the largest cropping systems in California. The UC research group were co-inventors on a patent application on the navel orangeworm pheromone. Second, the pheromones of citrus leafminer and fir coneworm are being commercially developed in the US and overseas. Third, pheromones of obscure and longtailed mealybugs have been tested in California, and tests by collaborators in New Zealand, Australia, and South America are in progress. Furthermore, with the pheromones of vine, obscure, and longtailed mealybugs now being available, testing can be expanded into other crops, such as ornamentals production.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: BIOLOGICAL CONTROL IN PEST MANAGEMENT SYSTEMS OF PLANTS

Description: UC researchers are evaluating the parasitoid complex on soft scales (COCCIDAE), the host stages/sizes they use, and the relationship between host phenology/size and host choice in southern California citrus groves. They used a biweekly, year round survey with live brown soft scale

COCCUS HESPERIDUM (Linn) as hosts. The scale infested yucca leaves are placed in the field for two weeks at 10 sites before they are returned to the laboratory and a representative number of parasitized scales are isolated for parasitoid emergence. METAPHYCUS spp (ENCYRTIDAE) parasitizing brown soft scales are their principle interest because the same parasitoid complex also exploits citricola scale, COCCUS PSEUDOMAGNOLOIARUM (Kuwana) as a host. They have identified 12 parasitoid species (HYMENOPTERA) parasitizing brown soft scales in southern California citrus. It consists of two COCCOPHAGUS SPP. (APHELINIDAE), four METAPHYCUS SPP., one MICROTERYIS SP. (ENCYRTIDAE), and five, rare, hyperparasitoid species. This contrasts with 10 parasitoid species collected from citricola scale, COCCUS PSEUDOMAGNOLOIARUM (Kuwana), in the San Joaquin Valley. These two coccids are attacked by three of the same METAPHYCUS SPP. M. ANGUSTIFRONS Compere, which is absent from the San Joaquin Valley, is the dominate METAPHYCUS sp. on brown soft scale in southern California. It has not been recorded previously in California since its initial release during a 1954-55 biological control effort against black scale, SAISSETIA OLEAE (Olivier) (COCCIDAE). M. ANGUSTIFRONS and three other METAPHYCUS SPP., readily parasitize citricola scale in laboratory trials and all three are being evaluated as potential augmentative biological control agents for release against citricola scale, a key citrus pest in San Joaquin Valley citrus. They are also developing a mass-rearing method for producing these METAPHYCUS SPP.

Impact: The UC researchers are developing an ecological understanding of the relationships between the soft scale hosts and their parasitoid complexes in California citrus. This understanding, coupled with their previous work on augmentative biological control of California red scale, AONIDIELLA AURNATI (Maskell) (DIASPIDIAE), using APHYTIS MELINUS DeBach (APHYLINIDAE), provides a foundation for an economically sustainable IPM program in California citrus. Their research with citrus pests in southern California and San Joaquin Valley has allowed them to reduce pest control costs and pesticide use substantially while maintaining grower returns.

Funding Source: Multistate Research and State

Scope of Impact: AZ, CA-B, CA-D, CA-R, CO, DE, GU, HI, ID, KS, MT, ND, NJ, NM, NYC, OR, SAM, UT, WA, WY

Theme: 4.12 Integrated Pest Management

Title: POPULAR ROMAINE LETTUCE NEEDS RESEARCH SUPPORT

Description: For many years the classic iceberg or crisphead lettuce dominated the lettuce industry and led in yield, acreage and value. However, with changing

consumer tastes and new market trends, the king of lettuce was recently dethroned and romaine lettuce displaced iceberg as the number one lettuce in Monterey County. The prominence of romaine also has been seen in other parts of California. Unfortunately, just as romaine acreage was increasing, two new diseases appeared in the crop, reducing romaine yield and quality. The first new disease, lettuce dieback, affects romaine both in California's coastal region and in Arizona. Romaine consistently shows the most pronounced and serious symptoms, though some other lettuce cultivars are also susceptible. Caused by the lettuce necrotic stunt virus, lettuce dieback disease results in short, stunted and yellowed romaine plants. The second new romaine disease is Phoma basal rot, which causes a distinct black rot to form at the base of romaine plants. Affected plants can be stunted and uneven in shape. They eventually die. Phoma basal rot is caused by a fungus (*Phoma exigua*) found in the soil. A CE farm advisor stationed in Monterey County, conducted extensive research on diseases of lettuce. When these new romaine problems began to occur, he worked closely with the lettuce industry to inform them of these new developments. He created partnerships with researchers at UC Davis, USDA research stations, California Department of Food and Agriculture, and a mycology institute in the Netherlands to identify the responsible pathogens and create management options for California growers. He set up and completed all field aspects for two research projects, conducted an extensive education program to inform the farmers of the two new threats, and investigated ways to control the romaine problems by using integrated disease management methods.

Impact: The advisor presented research results to lettuce growers throughout California. He was a part of the research team that characterized lettuce dieback virus problem, which is now being managed by rotating romaine crops to non-infested fields. Virus resistant romaine varieties are now being released and used. He was the first to identify and characterize Phoma basal rot. He also he developed fungicide treatments that protect the romaine crop from the disease. Of the almost 28,000 acres of romaine grown in Monterey County, this fungicide treatment was applied to virtually all romaine in affected areas. Due to these protectant treatments, Phoma basal rot was rarely found in 2005 and was not an economic issue for growers. This new treatment is now the foundation of the romaine disease control program in this region.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: UC ANR HELPS LANDSCAPE INDUSTRY AND MUNICIPALITIES
MANAGE TWO SERIOUS DISEASES RAVAGING PALMS IN LOS ANGELES

Description: Palms are high-value and increasingly common components of landscapes wherever they can be grown. They are widely planted in Southern California, especially in Los Angeles, where they are emblematic of the lifestyle in that part of California. Large specimens costing up to \$20,000 each are frequently planted to create instant, mature landscapes. Unfortunately, two serious diseases, Fusarium wilt and sudden crown drop, are ravaging some of the most valuable palms in Los Angeles county, and are especially conspicuous in high-profile areas such as Beverly Hills, West Los Angeles and Malibu. Diseased trees die and then pose a hazard to life and property when they fall, sometimes without warning. They are costly to remove and replace. Working with the City of Beverly Hills and a commercial tree maintenance firm, a UC CE advisor developed an inspection program and leaf-pruning protocol that enables tree trimmers to detect infected trees and prevent new infections. Using this information, along with other information about these diseases developed by UC ANR researchers, they were able to conduct numerous educational events on preventing and managing these two diseases of palms

Impact: Nearly all landscape and tree maintenance firms as well as municipalities now follow the UC ANR recommendations that prevent the spread of Fusarium wilt and sudden crown drop. As a result, although many trees are infected and will die, the rate of new infections is declining and the spread of these two diseases is being controlled.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: ALTERNATIVE METHODS FOR TERMITE MANAGEMENT TESTED AT UC

Description: Hundreds of million of dollars are spent in California on termite detection, management, and damage repairs. An ANR scientist in Insect Biology, CNR-UCB has aggressively undertaken research and outreach projects to improve how termites are detected and managed. In California, the costs attributed to the management of termites and repair of the damage caused annually exceed \$500 million. The most damaging termites live and forage in the soil, and belong to an ecological group called subterranean. Another ecological group common in California, drywood termites, does not require soil contact and can occur in boards far removed from soil. Chemicals, fumigants, and liquids have traditionally been the method of choice for termite control. Today, however, the public is demanding alternative methods of control, including nonchemical and least-toxic alternatives that minimize exposure of toxicants to people, their

pets, and the environment. technologies and pest management regulatory changes regarding termites. Some detection devices are commercially available and being used by the State's pest control industry. Workshops and seminars are actively conducted each year to assist the pest control industry and public in adapting to the new technologies and pest management regulatory changes regarding termites. Many of the termite alternative detection and management methods were first tested by ANR scientists before commercialization.

Impact: At least 10% of termite management methods now used in the State are least- toxic or nonchemical. A large testing structure, the Villa Termiti, at the Richmond Field Station, UC Berkeley was built from industry and public funds to test new and developing termite detection and management technologies. A website (CAL Termite webpage, www.cnr.berkeley.edu/lewis) has also been created to assist the public in their quest for information on termite biology, detection, and management.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management

Title: Benefits and Costs of Natural Resources Policies Affecting Public and Private Lands

Description: This year, work related to the project had two areas of emphasis: (i) developing theoretical foundations for models of environmental valuation that use information on how people spend their time, and other scarce resources besides money, on the environment; and (ii) seeking out new areas of application to important problems that society faces. The work on theoretical foundations is important because many gaps remain in the ability to fully ascribe economic values to actions people take, i.e., their behavior related to use and appreciation of environmental amenities. For many environmental amenities, there are few or no conventional price signals to indicate the magnitude of this value. An important indicator that can be measured for many activities people engage in that use the environment is how much time is spent. Time is an important resource that has an economic value, though outside of a few key areas such as labor supply and transportation, both methods for analysis and empirical evidence are lacking and need additional work. A UC researcher developed a series of papers with a colleague to tackle some of these issues, using information on beach use in San Diego County. They have developed a random parameters specification of people's labor supply and beach participation and location decisions, which is innovative in the way it identifies the 'shadow' value of time used in beach going. Results indicate that beach-going time is valued at only slightly less than what is earned in working, and that the value of a beach

day is approximately \$28. The value of individual beaches within the group of approximately 30 within San Diego County are quite low because of the abundant substitutes available. This work also addresses the second area of emphasis for the project, as it fills an important gap in information on beach values in Southern California, for which there is very little direct information available. Three other papers, with colleagues address methods of valuing environmental amenities. The paper with shows how information on people's willingness to engage in additional household preventive activities to reduce their effluent of waste water, along with their willingness to pay money for water quality improvements, identifies their valuation of household maintenance time. The paper with another colleague shows how two main approaches to valuation, stated preference and revealed preference, can be fully reconciled through use of the weak complementarity restriction on preferences as a wholly-plausible identification restriction. The third work shows how information on how people are willing to pay for environmental restoration programs of different lengths produces an estimate of their personal discount rate, a point that has been overlooked in the literature on valuing environmental programs with over time. Finally, a series of papers written with another group of colleagues investigate topics of particular relevance to California: preserving open space, value to consumers of recycling programs, and the price premia that consumers are willing to pay for specific attributes of organic produce.

Impact: Results from this research continue to be adopted and implemented by other researchers and government agencies. For example, environmental economics researchers in Korea are now using the wtp time-wtp money-value of time model in their research on willingness to pay for water quality improvements. The City of Seattle has adopted the time valuation approach in their evaluation of recycling programs. The National Marine Fisheries Service is using the 'labor supply-recreation demand' time valuation approach in their upcoming analysis of sportfishing for Pacific halibut.

Funding Source: Multistate Research and State

Scope of Impact: AL, CA-A, CA-B, CA-D, CO, CTS, DE, GA, IA, IL, KY, LA, MA, MD, ME, MI, NC, ND, NH, NYC, OH, OR, PA, RI, TX, UT, WA, WVA, WY

Theme: 4.14 Natural Resources Management

Title: OAK SEEDLINGS CAN BE ESTABLISHED ON GRAZED RANGELANDS

Description: For nearly 100 years, there has been concern that several native California oak species are not regenerating adequately to sustain populations. Inadequate regeneration could adversely affect woodlands, resulting in conversions to shrub fields or bare pastures. A principal factor believed to significantly contribute to poor oak regeneration in California is livestock grazing.

Since approximately 80% of California's oak woodlands are privately owned and the principal activity on many of these lands is livestock grazing, it is vital to understand how oaks can be regenerated in the presence of livestock. Such information will help ensure that their oak woodlands remain healthy and productive. The UC Integrated Hardwood Range Management Program (IHRMP) has conducted several research studies at the Sierra Research and Extension Center to identify grazing management practices and seedling protection techniques that will allow outplanted oak seedlings to survive from the seedling to the sapling stage, even in areas grazed by cattle. Studies have examined whether or not individual seedlings can be successfully protected in grazed pastures; how the timing of grazing affects damage; how tall seedlings must be before livestock can be reintroduced into planted areas; and how livestock movement and congregation patterns can be impacted by water placement, supplements and salt blocks.

Impact: Research suggests that cattle will damage both planted and “volunteer” oaks, but that damage varies by season, with less damage during the winter when deciduous oaks don't have leaves. Damage is also influenced by stocking density (the number of cattle per unit area) and cattle distribution patterns. Unprotected oak saplings appear relatively resistant to cattle damage in low- to moderately-grazed pastures if they are at least 6.5-ft tall and smaller seedlings can be protected with fencing or individual protectors. These and other steps can greatly enhance the chances for regeneration success. Together, these findings suggest that in some situations cattle and oaks can be raised simultaneously if grazing management practices are tailored to minimize damage, or seedlings are physically protected from animals.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.15 Nutrient Management

Title: Increasing the Efficiency of Zinc Applications in Orchards

Description: A double-labeled solution containing N15-enriched urea and Zn68 sulfate was applied manually late in the season, to the foliage of fifteen, one-year-old OHenry peach trees. The UC researchers' objectives were two-fold: a.) to quantify N and Zn movement out of leaves following foliar application and b.) to quantify redistribution of foliar-applied N and Zn from the tree structure to the new growth following spring growth resumption in the subsequent year. Between 45 percent and 49 percent of the labeled N applied to the foliage was recovered in the permanent structure of the trees after leaf fall implying both uptake through leaf surfaces and transport out of the leaves. In contrast, only seven to nine

percent of the labeled zinc painted on the leaf surfaces was translocated from the leaves to the permanent tree structure before leaf fall. The percentage redistribution of labeled Zn from the perennial tree parts to the new growth in the subsequent season exceeded the percentage redistribution of labeled N. By the end of the experiment-five weeks after bloom, 38 percent and 56 percent of the labeled N and Zn, in the perennial tree parts respectively, had been redistributed from storage in roots, trunk, and one-year old shoots to the new growth. Their data also permitted estimation of total N and Zn remobilization to new growth. Within two weeks following bud break, i.e., prior to significant tree biomass accumulation, 77 percent and 85 percent of total N and Zn, respectively, the new growth could be attributed to nutrient redistribution from storage in perennial tree parts. The percentage redistribution from storage was estimated to be 28.4 percent and 33.6 percent for total N and Zn, respectively.

Impact: Foliar applications of Zn may, in actuality, be considered soil applications because less than 10 percent of Zn applied to the leaves was translocated out of leaves before leaf fall. Greater than 90 percent of the foliar-applied Zn was carried to the orchard floor at the time of leaf fall. These data warrant continuing discussions with respect to a.) The efficacy of foliar applications for Zn nutrition of fruit trees and b,) the possible contributions of foliar zinc applications to heavy metal accumulation in soils

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.15 Nutrient Management

Title: ECOLOGICAL AND PHYSIOLOGICAL ASPECTS OF NUTRIENT USE EFFICIENCY OF CROP PLANTS

Description: The absorption of Si by wheat, *Triticum aestivum* L. Yecora rojo, followed Michaelis-Menten kinetics over a concentration range from 0.004 to 1.0 mM. The absorption resulted in accumulation ratios of 200/1 or more. In keeping with that finding, this study also demonstrated that Si uptake by wheat is under metabolic control, being severely restricted by dinitrophenol (DNP) and potassium cyanide (KCN). Silicon uptake by wheat was not significantly affected by phosphate ions, but the chemical analog Ge exerted a direct competitive effect on Si uptake, and vice versa. The microbial community composition of two soils was evaluated using phospholipids fatty acid (PLFA) analysis. The soils, a Wasco sandy loam and a Panoche (clay loam) were from a three-year N rate study in a cotton based system of the San Joaquin Valley, CA. The study provided a comparison of soil types, N levels, and continuous cotton residue incorporation, followed by a cereal rotational crop. The PLFA analysis was used to provide comparative information on soil microbial communities and microbial

biomass of the two soils affecting N mineralization and soil organic matter formation. The objective of the study was to investigate the role soil microbial communities play in soil nutrient cycling in a cotton based cropping system. After three continuous cotton crops, distinctly different microbial communities, as identified from specific biomarkers, were found inhabiting these two soils. Based on PLFA analysis, the microbial community in the Wasco soil showed a dominant bacteria composition and the Panoche soil was characterized by indicators of fungi populations. Microbial community composition within each of the soils showed minor differences. There was greater microbial diversity in the Wasco soil than for the Panoche soil. The Wasco soil experienced a greater change in microbial diversity from the maize rotation than the Panoche soil experienced from a wheat rotation following three annual cotton crops. The analysis used to compare N rates showed a slight increase in total microbial biomass with high N, but overall N rate effects were not significantly different. Soil texture and chemical properties create specific environmental habitats for soil microbes. The results of this study show that specific microbial communities inhabit different soil textures and that rotations can influence microbial biomass quantities but not alter the community structures.

Impact: Research on the distribution and availability of nitrogen applied as fertilizer is important for making decision on the efficient use of this fertilizer. A number of field studies have shown that N-fertilizer applied to cotton crops is overused with indications that the excess N moves down in the soil profile ultimately with the potential of contaminating the underground water supply. The research reported provides information on the microbial turnover of organic matter and potential release of N into the soil. These data will be used for the development of new guidelines for N fertilizer application in cotton cropping systems. A bulletin providing these guidelines will be published for use of cotton growers in the San Joaquin Valley. Silicon is known to play a role in pest resistance in plants. Understanding the uptake and distribution of silicon will provide information on the amount and regulation of this element in plants. Correlation of this information with pest resistance will be necessary for future studies on the role silicon plays in this resistance.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.17 Pesticide Application

Title: MOLECULAR GENETICS OF HUMAN CELL RESPONSE TO ENVIRONMENTAL CARCINOGENS

Description: The objective of this project is to characterize the mechanisms of environmentally induced genetic toxicological response. Much of the work has

focused on recombinational mechanisms for mutation. The findings have led to the development of a detailed new mechanistic model, which describes recombination-mediated pathways for mutation at chromosomal genes. Recombination-mediated pathways of mutation are frequently observed in human cancer, particularly at tumor suppressor loci. Other work has been ongoing on the characterization of genomic instability induced by very low doses of ionizing radiation, which are consistent with environmental exposure levels. Genomic instability, which refers to an elevated risk of genetic change for many generations after exposure, represents another important but incompletely understood mechanism for environmental carcinogenesis. The UC researchers have made progress on understanding an important mechanism for genomic instability in human cells, which involves the formation of breakage-prone chromosomal rearrangement junctions. These act as de novo chromosomal breakage hot spots and lead to multiple rearrangements of the chromosome containing the breakage-prone junction. Therefore, this mechanism of instability primarily affects a single destabilized chromosome, although other chromosomes can be affected by interaction with breaks and fragments that are produced at the breakage-prone junction. These junctions are commonly, though not always, characterized by the presence of heterochromatin sequences. They have several lines of new evidence to support this model. For example, they have shown a highly significant non-random distribution of chromosomal rearrangements in unstable clones induced by a variety of treatments. They have also demonstrated that instability can be induced by the introduction of non-coding heterochromatic repeat sequences into test cells, following incorporation into the host genome. The level of instability is comparable to that observed with high doses of mutagens such as ionizing radiation, though control sequences have no impact on genomic stability. They found that this mechanism of instability plays an important role following exposure to very low dose exposure of ionizing radiation, comparable to permitted occupational exposure levels. Recently, they have also initiated an extensive series of experiments designed to test the hypothesis that a mutational signature can be identified at the important tumor suppressor locus p53 by analysis of megabase scale deletions. They are in the process of characterizing the radiation-induced spectrum at p53 by inserting a selectable marker into one of the p53 alleles. Targeting is underway in human lymphoblasts, for direct comparison with existing spectra at model loci, and will also be performed in mouse embryonic stem cells. The targeted embryonic stem cells will enable development of a transgenic mouse system to directly compare mutational spectra induced by chromosome breakage agents with tumors induced by the same agents in the mouse model.

Impact: A variety of environmental hazards create genotoxic risk to Californians that result in cancer and inherited deformities. The work within this project contributes to the identification of risk levels as well as a better understanding of the mechanisms by which genetic damage is induced. This information can ultimately be used in establishing and monitoring safe exposure levels.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.18 Recycling

Title: MUSHROOM PRODUCTION AND WASTE MANAGEMENT

Description: California produces more than 10 million tons of grass clippings, tree leaves, limbs and twigs, vegetable cuttings and other organic wastes every year. The Integrated Waste Management Act of 1989 (AB 939) required a 25% diversion of this waste stream from landfills by 1995, and a 50% diversion by 2000. Mushrooms grow and produce effectively on highly lignified and composted material. From 1985 to 1999, mushrooms--mostly white button mushrooms (*Agaricus* spp.)--were the number one cash crop in Santa Clara County. California produces about 40% of all mushrooms in the United States. Mushroom production worldwide has increased in the last 15 years from about 350,000 tons to about 9.9 million tons. The City of San Jose's Environmental Services Department contracted with UCCE to conduct a series of research projects to find new applications for composted waste in Santa Clara County's agricultural industry (For details, see www.urbancompost.com). In 1997, as an ongoing project, UCCE started an environmentally controlled evaluation of three substrate formulas based on municipal yard trimmings, to be used for commercial production of a specialty crop, oyster mushrooms. They studied the response of two species of oyster mushroom (*Pleurotus ostreatus* and *P. pulmonarius*) to different production methods as a way to give the growers an opportunity to diversify, capturing existing markets, gourmet stores and other consumers. At the same time, they built several vermicomposting (composting with worms) windrows under a protective shed, to handle and process vegetable and fruit waste from supermarkets. The units, originally located at the UC Bay Area Research and Extension Center, were rebuilt at a mushroom-growing operation in Morgan Hill. The goals are to (1) demonstrate "low-tech" mid- to large-scale vermicomposting as a valid food-waste reduction mechanism, (2) help growers recycle their own agricultural waste (mushroom sumps), (3) provide training in the vermicomposting process and (4) maintain a demonstration site. They also are studying the potential use of vermicompost as a substitute for the peat moss used in the casing layer, a very important step in white button mushroom production

Impact: The City of San Jose diverted 53% of its waste from landfills by the year 2000 and was one of the first large cities to be in compliance with AB 939. As a result of their small to medium-scale demonstration vermicompost units, children of K-6 age, high school and college (San Jose State University) students, Master Gardeners and Master Composters, public agency representatives and the general public are getting information and training on an

exceptionally simple technology for food waste reduction. Two local chefs have adopted, with slight modifications, the proposed technology to dispose of their restaurant food waste. The mushroom industry in Santa Clara county has increased from \$35 million gross value (1996) to \$48 million (2004). A considerable shift has occurred in the varieties used for the mushroom supply. White button mushrooms still account for 70% of the market, but oyster mushrooms and shiitake, the main specialty genera, are increasing their shares.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.21 Soil Quality

Title: Analysis of Disease Resistance in Rice

Description: Systemic acquired resistance (SAR) is an important defense response in plants. SAR induces expression of pathogenesis-related (PR) genes (Ryals et al., 1996) and confers lasting broad-spectrum resistance to viral, bacterial, and fungal pathogens. In dicots, such as *Arabidopsis* and tobacco, the phytohormone salicylic acid (SA) as well as the synthetic chemicals 2,6-dichloroisonicotinic acid (INA) and benzothiadiazole (BTH) is potent inducers of SAR (Friedrich et al., 1996). In monocots, SAR was shown to be induced by BTH in wheat (Gorlach et al., 1996) and by *Pseudomonas syringae* in rice (Smith and Metraux, 1991). BTH can also induce disease resistance in rice (Schweizer et al., 1999; Rohilla et al., 2002) and maize (Morris et al., 1998), although it is not clear whether the resistance was SAR. The NPR1 (also known as NIM1 and SA11) gene is a key regulator of the SA-mediated SAR pathway in *Arabidopsis* (Cao et al., 1994; Delaney et al., 1995; Glazebrook et al., 1996; Shah et al., 1997). Upon induction by SA, INA, or BTH, NPR1 expression levels are elevated (Cao et al., 1997; Ryals et al., 1997). NPR1 affects the SAR pathway downstream of the SA signal. *Arabidopsis npr1/nim1* mutants are impaired in their ability to induce PR gene expression and mount a SAR response, even after treatment with SA or INA. Over-expression of *Arabidopsis* NPR1 or the rice NPR1 homologue 1 (NH1) in rice results in enhanced resistance to the pathogen *Xanthomonas oryzae* pv. *oryzae* (Xoo), suggesting the presence of a related defense pathway in rice. They investigated this pathway in rice by identifying proteins that interact with NH1. Here they report the isolation and characterization of a rice cDNA encoding a novel protein, named NRR (for Negative Regulator of Resistance), which negatively regulates resistance to Xoo when over-expressed in rice. NRR interacts with NPR1 in the NPR1-interacting domain (NI25) consisting of 25 amino acids. NRR also interacts with NH1; however, NI25 was not sufficient for a strong interaction, indicating a difference between the rice and *Arabidopsis* proteins. When constitutively over-expressed in rice, NRR affected basal

resistance, age-related resistance and Xa21-mediated resistance, causing enhanced susceptibility to Xoo. This phenotype was correlated with elevated NRR mRNA and protein levels and increased Xoo growth. Over-expression of NRR suppressed the induction of defense-related genes. NRR:GFP protein was localized to the nucleus, indicating that NRR may act directly to suppress activation of defense genes. NRR is the first gene demonstrated to compromise Xa21-mediated resistance, indicating cross-talk or overlap between NH1- and Xa21-mediated pathways.

Impact: Why would plants want to suppress defense responses? Programmed cell death or hypersensitive response normally accompanies defense responses. Mutants and transgenics with mis-regulated, untimely, or over-active defense responses tend to lead to a lesion mimic phenotype (reviewed by Lorrain et al., 2003; Yin et al., 2000; Chern et al., submitted). Rice contains unusually high basal levels of SA (Silverman et al., 1995). Keeping defense responses in check in rice may be especially challenging. The presence of NRR and related proteins may serve the purpose to keep defense responses in check, which is essential for normal plant development. Cereals such as rice, maize and wheat provide most of the calories consumed by humans and animals. These crops are therefore the world's most important, from both a humanitarian and an economic standpoint. Of these cereals, rice provides the most amenable system for molecular genetic studies because of its small genome size, extensive genetic map, large sequence databases, and relative ease of transformation. Therefore, knowledge gained about plant defense signaling pathways in rice will be applicable to many other cereal crops.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.21 Soil Quality

Title: ABIOTIC DEGRADATION OF CHEMICALS THROUGH INTERACTION WITH DISSOLVING MINERALS

Description: This research concerns the molecular mechanisms by which metal toxicants are released, and taken up, from soil and rock materials and the pathways for bond cleavage. Because the goal is a predictive model that can address many potential contaminants, the UC researchers couple the experiments that isolate key variables to computer simulation. This year they focused on the rupture of metal-oxygen bonds in key solids and molecules that are linked together with bonds between oxygens and trivalent metals. They coupled the experiments to simulations at the highest level of theory.

Impact: This research provides a scientific basis for decisions about the use of chemicals and their effect on soil and soil solutions. Some of the results have already been incorporated into text books used to train agricultural students and agricultural professionals.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.21 Soil Quality

Title: Long-Term Sustainability of Groundwater Quality in California Agricultural Basins

Description: A UC research group has shown that, as a general rule, groundwater ages in typical, heterogeneous geologic systems tend to be widely variable, even within single water samples collected from small volumes of the subsurface. This in turn indicates that groundwater quality in basins undergoing persistent, non-point source pollution may undergo a decades- to centuries-long decline and that the worst effects have not yet occurred. Their detailed modeling experiments have further indicated that field tests involving transient monitoring of the age of groundwater discharged from a pumping well can be used to investigate and possibly quantify not only the dispersion of groundwater ages in a system, but the specific hydrogeologic characteristics (e.g., degree of heterogeneity) giving rise to the age dispersion phenomenon. With NSF funding in 2003-04 they conducted such a field test by pumping and intensively sampling a well constantly for 50 days. Interpretation of those data continued in 2005 with the help of additional field sampling of other potential sources of environmental tracers (CFCs) and through high-resolution modeling. Results show that erratic CFC levels in the shallow zone emanate from an unknown source of shallow groundwater contamination upgradient of the field site. Most importantly, the modeling results show that even the subtle trends in apparent (monitored) groundwater age during the test are due to effects of heterogeneity and dispersion. This confirms the original hypothesis that heterogeneity can cause significant age dispersion and that larger scale, similar field tests could be used to more accurately measure or infer the magnitude of this mixing and its effects on reliability of groundwater age dates as well as the implications for groundwater quality sustainability. In other, related work with a colleague, they have shown that fractionation of isotopes due to molecular diffusion, which is ubiquitous in the subsurface, can lead to spurious groundwater age estimates with the popular tritium-helium method. Motivated by these and previous results, the PI organized and led a special scientific forum (National Ground Water Association Theis Conference) on the issue of groundwater age, particularly methods of estimating it with environmental tracers and advanced modeling investigations for interpreting the tracer data. The meeting brought

together a select group of the top scientists in the world on groundwater age estimation and modeling and is already providing new direction for this important genre of research. Work continues on their random walk computer code (RWHET) for accurately modeling transport of non-point source and point source pollution. They are adapting the code for inclusion into the family of groundwater flow and transport codes used by the US Geological Survey.

Impact: This work is providing more efficient, scientifically-based means of characterizing and modeling contaminant problems in groundwater, especially for nonpoint sources. The results lead to more effective, cost-effective protection and cleanup of groundwater resources as well as reduction in the probability of human exposure to harmful substances. This work points toward land-management strategies that will preserve rather than damage groundwater quality.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.21 Soil Quality

Title: VINEYARD COVER CROP TRIAL

Description: Cover crops are grown in vineyards for various reasons, such as erosion control, nitrogen or organic matter addition, improved soil structure and water penetration, reducing excessive soil moisture and vine vigor, and enhanced pest management. Species selection is important for obtaining the desired benefit without negatively impacting yield or quality, or using excessive water. Several growers report improved red wine quality with cover crops, but some experience challenges in maintaining vine vigor and adequate yields due to excessive devigoration. Beneficial microbial organisms are essential for production agriculture, and they strongly mediate interactions of agriculture with the natural environment. Microorganisms govern the capacity of soils to deliver nutrients to crops and retain nutrients in the profile, contribute to formation of soil structure, suppress plant pathogens, and form soil humus. UC CE Advisors planted several cover crop mixes in a wine grape vineyard in Sacramento County to test their effects on vine growth, production, juice quality, soil microbial ecology, and gopher activity over a 3-yr period (1998-2000). The mixes used were: 1) California native perennial grass (no-till), 2) annual clover (no-till), 3) green manure (disked), 4) cereals (disked), and 5) disked control. Weeds increased in the clover mix but decreased in the native grass mix. Grapevine petiole nitrogen content was highest in the bell bean mix and lowest in the native grass mix. There were very few differences in plant water stress or pruning weights of the vines, nor in yields or juice quality. Cover-cropped soils had greater microbial biomass than disked soils, and the no-till mixes had greater

microbial biomass than the disked mixes. Gophers were very numerous in the clover mix only

Impact: Using information from this and other Cooperative Extension cover crop trials, grape growers statewide are selecting cover crops that provide economic and environmental benefits, including soil conservation, natural fertilization, and in some cases improved wine quality. Cover crops can be seen in vineyards throughout the state

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.22 Sustainable Agriculture

Title: Conservation tillage production systems for economic and environmental sustainability in California's Central Valley

Description: Projections for what California agriculture will look like twenty or more years from now identify water, labor, regulation and competition as major drivers. Competition for finite and often highly variable water supplies will increase from urban and environmental demands. Labor availability and cost will be influenced by global political and competitive conditions and the expanding regulation of agriculture will have profound impacts on productivity and competitive performance. Agriculture, particularly for agronomic crops in California, will be very different in the future than it is now. It will face powerful pressures for new, cheaper and more efficient cropping systems. One means for reducing costs is to reduce or eliminate preplant land preparation or tillage. Tillage systems in agronomic crop production in the San Joaquin Valley were generally developed more than six decades ago and changes have largely been incremental in nature, with only modest reductions in tillage practices on most farms. Although there has been some movement toward minimum (reduced pass) tillage in recent years, SJV production systems remain relatively tillage intensive. Recent changes in tomato production toward semi-permanent beds and drip irrigation and minimum till approaches, and in dairy forage production systems toward NT and strip-till planting have been undertaken by some producers, however, for various reasons, more classic forms of conservation tillage such as NT or strip-till, have not rapidly expanded in this region. A major component of a UC researcher's program is investigating opportunities for these conservation tillage production systems in California. The US Environmental Protection Agency has designated the San Joaquin Valley a serious non-attainment area for PM10, particulate matter with an aerodynamic diameter less than 10m. PM10 can bypass the body's respiratory defense mechanisms and has been linked to cardiac and lung diseases. Because air quality violations occur during periods of intense tillage activity, row crop agriculture has been pinpointed

as a major contributor of PM10. Conservation tillage (CT) production systems that reduce or eliminate tillage have been developed in other regions largely as a means to control soil erosion. Less than 2 percent of California's annual acreage, however, currently uses CT approaches. Do CT production practices reduce dust and can they be developed for California crops? Starting in 2002, the researchers have compared dust generation in standard (ST) and conservation tillage systems in a variety of studies in the San Joaquin Valley. In a comparison conducted at the UC West Side Research and Extension Center in Five Points, CA, dust emissions were reduced by about two-thirds in the CT system relative to standard tillage through a cotton-tomato rotation. CT yields were maintained in this study for tomatoes, but were lower for cotton due primarily to reduced crop stands. Work at two San Joaquin Valley dairy farms from 2003 to 2005 showed that CT corn and winter forage systems may also reduce emissions and that yields can be maintained for some CT approaches relative to standard tillage.

Impact: Costs can be reduced by 14-18 percent when using CT cotton planting and postharvest stalk management systems, while yields are maintained. Initial findings of the dust work indicate significant potential of CT production practices to reduce dust generation in common San Joaquin Valley cropping systems. The researchers are now working with Valley farmers to refine and improve various aspects of the productivity and overall profitability of these and other CT systems.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.22 Sustainable Agriculture

Title: CENTRAL VALLEY FARMLAND TRUST

Description: Prime farmland is disappearing at an alarming rate all across the nation and the problem is especially acute in the San Joaquin Valley. Both farmers and local governments need more effective tools for preserving prime farmland. There is considerable interest among farmers in starting farmland trusts, but the technical obstacles are numerous. Working with a group of interested farmers, Merced County CE gave technical assistance in organizing a farmland trust for the county, and later for the north San Joaquin Valley - providing a significant amount of personal and institutional expertise to the founding and development of the Merced County Farmland and Open Space Trust and later the Central Valley Farmland Trust. A Farm Advisor developed the criteria and chaired the technical committee that developed priorities for areas that needed protection. He developed the procedures by which applications from farmers wishing to protect farms are evaluated, and wrote the first fund-raising letter to solicit funds for operations. A Cooperative Extension public policy specialist, and experts from the American Farmland Trust, consulted with the

local team which developed the Merced trust's organizational structure and operational procedures. The Merced group later collaborated with groups from Stanislaus, San Joaquin and Sacramento counties and, with assistance from the Great Valley Center, established the Central Valley Farmland Trust

Impact: The Central Valley Farmland Trust is fully operational and working to expand its capacity to serve area farms. As of September 2005, 142 acres of orchard land, 630 acres of field crop land and 7,389 acres of range land have been protected in Merced County and projects are pending in the other counties. The number of applications by growers who would like to place their farms into the trust has increased. Town hall meetings have been held in local communities around the Valley to brief farmers about the program. Memberships in the Trust also have increased, indicating better awareness and support in the community. All of the farms that have entered the program are still in production agriculture today.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.22 Sustainable Agriculture

Title: CONSERVATION TILLAGE WORKGROUP INTRODUCES NEW TILLAGE ALTERNATIVES

Description: Conservation tillage (CT) production systems have been developed in a number of regions around the world for crops such as corn, wheat, cotton, and soybeans. Widespread adoption of CT practices for these crops is common in South Dakota, Iowa, Georgia, Australia, and Brazil; however, CT currently is used on less than 2 percent of California's annual cropland. CT production may be a means for improving production economics of farming systems while also sustaining air, water, and soil quality; but, little research-based information and experience about CT is available that addresses California's diverse production environments. The UC Conservation Tillage Workgroup, with over 540 UC, farmer, USDA Natural Resources Conservation Service, private sector, and other public agency and environmental group members, develops knowledge and exchanges information on CT production systems, coordinates related research and extension programs related to CT, responds to needs for information on reduced tillage production alternatives, and conducts conferences, workshops, and training demonstrations. The workgroup conducted more than 60 different evaluations of CT practices throughout the Central Valley.

Impact: The workgroup established local networks of farmers, researchers, NRCS conservationists, and private sector partners to work on CT systems. Research demonstrates the potential to reduce dust emissions by over 50

percent using certain CT systems relative to standard tillage (ST) approaches and shows the ability to reduce fuel use, lower production costs, and, in some cases, increase farm profitability. These studies identified key barriers to more widespread adoption of CT in California, including problems with crop stand establishment, irrigation efficiency, and weed management. The most promising CT systems are being refined further in various farm and UC research center studies. Research shows that CT dairy forage production systems reduce dust emissions typically by 60 to 90 percent, relative to conventional production approaches, and that fuel use is significantly lower in CT cotton, tomato, and dairy systems. The workgroup tracked CT adoption throughout the Central Valley, documenting a 300 percent increase in the use of CT practices from 2002 to 2004

Funding Source: Smith Lever, Hatch and State

Scope of Impact: State Specific

Theme: 4.23 Water Quality

Title: STRUCTURE FUNCTION STUDIES ON PHYTOCHROME

Description: UC researchers previously showed that the efficiency of this photochemical process is profoundly altered by mutation of a conserved tyrosine residue (Tyr176) within the bilin binding GAF domain of the cyanobacterial phytochrome Cph1. In the present study, they show that the equivalent mutation in plant phytochromes behaves similarly, indicating that the function of this tyrosine in the primary photochemical mechanism is conserved (FISCHER et al, 2005). Saturation mutagenesis of Tyr176 in Cph1 established that no other residue can support comparably efficient photoisomerization. The spectroscopic consequences of Tyr176 mutations also reveal that Tyr176 regulates the conversion of the porphyrin-like conformation of the bilin precursor to a more extended conformation. The porphyrin binding ability of the Tyr176Arg mutant protein indicates that Tyr176 also regulates the ligand binding specificity of apophytochrome. Based on the H-bonding ability of Tyr176 substitutions that support the non-photochemical C15-Z,syn to C15-Z,anti interconversion, they propose that Tyr176 orients the carboxyl side chain of a conserved acidic residue to stabilize protonation of the bilin chromophore. A homology model of the GAF domain of Cph1 predicts a C5-Z,syn, C10-Z,syn, C15-Z,anti configuration for the chromophore and implicates Glu189 as the proposed acidic residue stabilizing the extended conformation - an interpretation consistent with site-directed mutagenesis of this conserved acidic residue.

Impact: The identification of a conserved residue in phytochrome that directly participates in its primary photochemistry led to the production of an intensely red fluorescent biliprotein or phytofluor. The ability to genetically label other proteins

with phytofluors will impact the fields of functional genomics and cell biology. Since these mutations affect the primary mechanism of light activation, it is conceivable that the Tyr mutant alleles of plant phytochromes will be locked into 'active' and 'inactive' states which should have novel biological activity in plants. Expression of hyperactive phytochromes in agronomically important crop species should effectively counteract shade avoidance responses that result in yield losses from high-density plantings.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.23 Water Quality

Title: Factors Controlling the Distribution of Trace Elements in the Solid-Phase of Terrestrial Ecosystems

Description: Selenium in the form of selenate is commonly considered non-reactive with the solid phase of soils and sediments. UC studies of selenate retention in several different soils showed that at and below selenium concentrations of 30 ppb (micrograms selenium per liter solution) certain soils showed a significant retention capacity. Soils showing the most significant retention of selenate were from an area that frequently undergoes strong reducing conditions. Soils developed in a more oxidizing environment showed smaller amounts of retention. This is a significant finding since the most mobile form of aqueous phase selenium in the environment is selenate. Thus, at very low and environmental significant selenate concentrations selenate mobility may be much lower than previously thought in certain soils. Because of the low concentrations of retained selenate in the soils and sediments none of the spectroscopic methods are sensitive enough to allow us to determine molecular bonding mechanisms. It is possible that selenate is reduced to selenite which is sorbed on certain soil minerals with greater retention. The following is a summary of some of the UC researchers' more significant research from previous years. In a constructed wetland designed for remediation of contaminated agricultural drainwater they found significant increases in the concentrations of arsenic, molybdenum, and vanadium in the top 2 to 4 cm of sediment. The potential for molybdenum accumulation to very high concentrations was particularly significant when large amounts of sulfate are present in the drainwater. This is most likely due to the formation of thiomolybdate and its precipitation as an insoluble compound. With oxidation, large amounts of molybdenum would be solubilized. In another study they examined the distribution and oxidation states of arsenic and selenium in micron-sized mineral aggregates formed in the top horizon of an acid sulfate soil. Using synchrotron-based X-ray fluorescence microprobe to generate elemental distribution maps of soil thin sections they showed that the arsenic and selenium become preferentially associated with iron

oxides during the weathering process. Arsenic was present in the iron oxide aggregate as arsenate. Selenium was present in the soil as both selenite and selenate, with a higher percentage of selenate in the jarosite aggregate than the iron oxide aggregate. These results provided direct evidence of the distribution, oxidation states, and speciation of As and Se in the solid phase of an unaltered native soil. A separate study was made on boron interaction with several different model minerals. They were able to show that the extent of its retention was directly to the magnesium concentration in the mineral phase. Maximum sorption for all minerals was between pH 8.3 and 11.3. Increases or decreases as little as 0.3 pH units from the maximum sorption pH dramatically decreased sorption.

Impact: In wetlands where molybdenum and sulfate are present in the drain-waters molybdenum can potentially accumulate to very high concentrations as long as the system remains anoxic. Aeration of the sediments will most likely result in a flush of large concentrations of molybdenum in the water. Using high energy spectroscopic methods the researchers have shown the association of selenium and arsenic with soil solid-phases. Conversion or weathering of these solid-phases would result in releases of these toxic elements to potentially more bioavailable forms. These results have direct application to improving management practices in the Tulare Lake Basin of California and by agencies such as California Water Resources Board and San Francisco Bay area water quality organizations.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.23 Water Quality

Title: OAK MANAGEMENT IMPACTS ON WATER YIELD AND NUTRIENT CYCLING IN ANNUAL RANGELAND

Description: This project interfaces and supports CA-D-LAW6960-CG-Water quality on California rangeland watersheds by providing a long-term record of water flow and water quality against which management impacts on watersheds can be assessed. It also supports new water quality from irrigated rangeland projects by providing a nutrient loss framework for these studies. Annual rangelands occupy three million hectares in California, and represent the landscape where California urban-wild land-agricultural interface is most pronounced. The watershed-scale impacts of grazing and prescribed fire on watershed processes are not well known. The 2004-2005 water year represents the twenty-fifth year of continuous stream flow and periodic water quality data collection on this watershed at the University of California Sierra Foothill Research and Extension Center. For the twenty year period 1981-2000, the average daily nitrate-nitrogen flux from the 103-hectare watershed was 0.51

kg/day. The fluctuation around the mean ranged from close to 0 kg/day to nearly 70 kg/day. The mean annual export of nitrate-nitrogen was 186 kg/year. The lowest export for the twenty year period was 19 kg and the largest export was 681 kg. The average daily suspended sediment flux from the watershed was 0.9 kg/day. The fluctuation around the mean ranged from 0 kg/day to 15,924 kg/day. The mean annual export of suspended sediment was 21,149 kg/year. The lowest annual amount of suspended sediment over the twenty-year period was 2,470 kg and the highest was 49,375 kg. Nitrogen is flushed from the system after the soils have reached saturation or near saturation. Minimum flux occurred during base-flow periods that coincide with the dry late spring, summer and early fall months. Maximum daily events coincide with large rainfall events during the rainy winter season. The timing of rainfall events, in particular the number of days between major events in the winter control the daily hydrographs and the flux of nutrients and sediment from the watershed. The large variability in these two key environmental variables indicates that setting total maximum daily loads will be difficult and should not be based on either short-term records or annual values. Virtually no phosphorus is being exported from the watershed, in large part because the soils are rich in iron oxides that tightly retain P. The generally low concentrations of nitrate-nitrogen, suspended sediment, and phosphorus leaving this grazed watershed indicate that proper watershed management can produce animal products, oak products, wildlife and recreation without significant negative impacts on water quality.

Impact: This study is providing important information linking rangeland management effects to water quality, information that is being incorporated into improved rangeland management practices. The UC researchers' data will provide important information for the development of total maximum daily loads (TMDLs) to address non-point source pollutants from California rangeland watersheds. The data also provide a reference base for studies of water quality impacts from irrigated pasture management.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.23 Water Quality

Title: THE NATIONAL ATMOSPHERIC DEPOSITION PROGRAM (NADP)

Description: River water chemistry is controlled by numerous natural and anthropogenic factors. In the Sierra Nevada Mountains of California, atmospheric deposition of nitrogen ranges from about 2 to 5 kg/ha/yr. How different ecosystems process this nitrogen determines the amount of nitrate leaching from terrestrial ecosystems and nitrogen fluxes in stream water. Land use and land cover across 28 sub-basins within the Cosumnes River watershed (1989 square

kilometers) were correlated with nitrate and total suspended sediment loadings for water years 1999 to 2001. The impact of human activities on stream water quality was evident as both agricultural area and population density predicted suspended sediment loading in a linear mixed effects model. In contrast to the suspended sediments model, the nitrate-loading model was more complex with agriculture, grassland, and the presence or absence of waste water treatment plants all contributing. The lack of correlation between population density and nitrate loading indicates that human habitation of the landscape does not impact stream nitrate levels until a wastewater treatment plant is built within the sub-basin. Annual grasslands are an appreciable source of nitrate in the Mediterranean climate of California due to an asynchrony between periods of high nitrogen availability (fall-winter) and plant uptake demands (spring). During dry water years the models predict a linear reduction in suspended sediment loading but the correlations to agriculture and population density remain positive. In contrast, nitrate is positively correlated to grasslands during average water years and negatively correlated during dry water years. Analysis of constituent fluxes from the upper watershed versus the lower watershed indicates that silica is derived primarily from the uplands and that during dry water years the upper watershed is an important source of dissolved organic carbon and nitrate. The lower watershed contributes the majority of the sediment and nutrients during both dry and average water years, the one caveat being that during dry years the lower basin becomes a nitrate sink. This study demonstrates that differences in land use and land cover strongly affect nitrate and other water quality constituents at the large watershed scale.

Impact: These data provide important information to assess the potential impacts of atmospheric nitrogen deposition on nitrate leaching across a wide range of land use and land cover at the large watershed scale. The UC researchers document which geographic variables have the greatest control on water quality constituents, including nitrate. These data are useful for scientists and regulators alike for watershed study and planning.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, CO, CTS, FL, GA, IL, IN, KY, LA, MA, MD, MI, NC, NE, NYC, OH, OR, PA, TX, UT

Theme: 4.23 Water Quality

Title: RANCHERS USE NEW METHOD TO IMPROVE WATER QUALITY FOR SALMON

Description: To reduce impacts on salmon habitat, water-quality regulations concerning sediment are being established for Northern California watersheds. These regulations require agricultural landowners to inventory, monitor and

control sediment delivery to salmon-bearing streams, with the overall goal of reducing the impacts of fine sediment on salmon habitat. Exactly how to conduct such surveys across millions of acres of private and publicly managed rangeland was not entirely clear. Effectively identifying sites of water quality impact in an efficient manner is the critical first step for reducing the impacts. This is particularly true for rangeland managers, regularly facing overburdened schedules and limited budgets. UCCE advisors and specialists developed an improved method to inventory and monitor sites of sediment delivery, in collaboration with the Natural Resource Conservation Service, Regional Water Quality Control Board, California Farm Bureau Federation and private landowners. The new method has helped landowners and rangeland managers to reduce sediment delivery to streams and improve water quality. The monitoring method is available to the public online at <http://anrcatalog.ucdavis.edu/InOrder/Shop/ItemDetails.asp?ItemNo=8014> UCCE has trained more than 500 private and public rangeland managers in the new water-quality method through the Rangeland Watershed Program. These trained managers typically manage from 1,200 to 2,500 acres of rangeland within salmon-bearing watersheds. During the training, participants learn how to use a two-page worksheet and simple field evaluation methods to determine the quantity of potential sediment that will be delivered from a site. The rangeland manager then evaluates multiple sites to compare and prioritize the order and approach for controlling the sediment delivery at each site. In addition to training, UCCE surveyed sediment-delivery sites using the new method and site definition, as specified by the Total Maximum Daily Load process. As a result, 117 sediment delivery sites were characterized on 10 North Coast ranches. These results have been used widely: in presentations and conferences on water quality — such as the Ranch Water Quality Planning Program — and in ANR's California Agriculture magazine. These visible data highlight priorities for the control of sediment delivery sites that managers and regulators can both use in their decision making.

Impact: The UC sediment-delivery monitoring method complies with regulatory requirements -- including the federal Clean Water Act, state Porter-Cologne Act and sediment total maximum daily loads -- as a tool for identifying and prioritizing sites that impact water quality. This gives rangeland managers a cost-effective method to comply with these regulations and more importantly identify and prioritize the control of sediment delivery sites. The estimated cost to inventory sites for sedimentation with the new method is \$5 per acre compared to \$50 per acre using other common methods. Thus far, New Mexico State University Cooperative Extension and the Resource Conservation Districts of Yolo and Shasta Counties have adopted the new UC method, improving water quality at a lower cost.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.24 Weather and Climate

Title: UTILIZATION OF CIMIS CONSERVES WATER AND INCREASES WATER AVAILABILITY FOR URBAN USERS

Description: Growers in California are under continuous pressure to conserve water and transfer some of the agricultural water to urban regions in the state. The Colorado River is the lifeblood of the Imperial Valley and Southern California; it is the only source of irrigation and drinking water in the Imperial Valley. As much as 3.0 million acre-feet of Colorado River water are used every year to irrigate more than 500,000 acres of lands in the Imperial Valley. Water transfer and the Salton Sea are two issues of major importance to growers and the people of the Imperial Valley and southern California. The recently proposed water transfer draft between the Imperial Irrigation district and the San Diego County Water Authority calls for transfer of up to 300,000 acre-feet annually of Imperial Valley-Colorado River water. UCCE initiated and coordinated meetings between scientists from California Department of Water Resources, University of Baja California, and state of Baja California to install and calibrate two CIMIS weather stations in the Mexicali Valley. UC scientists developed bilingual computer programs and publications that are used to educate growers in the region about how they can improve water use efficiency and increase the availability of Colorado River water to urban areas in Southern California and Northern Baja California.

Impact: The utilization of weather data for irrigation scheduling improves irrigation efficiency and increases the availability of Colorado River water in Mexico and Southern California. The additional weather stations help growers on both side of the border. Growers in California extensively use evapotranspiration information from CIMIS. Parker et al. (California agriculture, 2000) estimated that California growers save approximately \$64,700,000 per year in water and energy savings as well as improve production by using CIMIS. The estimated benefit to growers in the region is \$6,500,000 in water and energy savings. In addition to water savings, reduction in agricultural water use also reduces fertilizer usage and surface and ground water pollution. As a result of these efforts, the best management practices to conserve water and improve irrigation efficiency were included in Regional Water Quality Control Board- Region 7 Silt/Sedimentation TMDL standards. Irrigation scheduling programs that were developed specifically for this region and based on local crop coefficient values are used conserve water on both sides of the border.

Funding Source: Smith Lever and State

Scope of Impact: State and International

Theme: 4.27 Wildlife Management

Title: WILDLIFE AND ENVIRONMENTAL CONTAMINANT INTERACTIONS

Description: In 2005, population monitoring of seabirds continued in the Gulf of California in a collaborative study with the agency, SEMARNAT, and University of Mexico, UNAM, to complete a four-year study on the health and contaminant status of seabirds and sea mammals from the Gulf of California. The first year in a two-year management study of grebes at Clear Lake, California (a site with chronic mercury problems as well as human disturbance) was completed and will continue into 2006. Data on brown pelican population status and population viability will be provided the US Fish and Wildlife Service for use in their determination of proposed de-listing, under the Endangered Species Act. An aerial survey planned for 2005 was cancelled but is planned again for 2006. Data from this survey will be critical in these determinations.

Impact: Data provided in current UC studies is being used by resource managers to make critical decisions on management and conservation of Gulf of California wildlife (migratory species moving into and out of California) and in the final determination of action regarding the de-listing of the California Brown Pelican (*Pelecanus occidentalis californicus*). Information developed continues to contribute basic ecological and behavioral data on the species studied.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.27 Wildlife Management

Title: ECOLOGY AND CONSERVATION OF INLAND FISHES OF CALIFORNIA

Description: (1)A study on the how ocean nutrients from migrating salmon make their way into riparian vineyards and wine was completed and accepted for publication.(2)The study of Putah Creek, a regulated stream, continued, demonstrating the positive effects of enhanced flows on native fishes, including anadromous lampreys and salmon.This study also has demonstrated that it is possible to restore streams while reserving most of the water for agriculture.(3)Year 26 of monthly fish sampling in Suisun Marsh was completed,with showing a leveling of abundance of the fishes.They are continuing to document the impacts of a new invasive shrimp and of poor water quality caused by duck club management.(4)A study of the benthic and planktonic invertebrates of Suisun Marsh has revealed that the system is dominated by non-native species with strong seasonal and distributional variability. UC researchers have documented that increased salinities have been

a factor in the decline of native invertebrate species.(5)The first year of studies on the growth and behavior of different strains of the threatened Lahontan cutthroat trout completed and experimental introductions were made into Sagehen Creek for evaluation.(6)A review paper on fish invasions in California,summarizing the last 10 yrs of study in the UC laboratory, was written and submitted for publication.(7)Two workshops on the ecology and management of Central Valley floodplain were organized, leading to a major review paper(in progress).(8)The Sacramento perch study was extended and additional funding provided to continue the study because the researchers' studies have shown the fish to be in more trouble than once thought.(9)The first year of a study on the health of Sierra Nevada meadows was completed, comparing results from studies of fish, amphibians, and aquatic insects with independent studies of plants. It suggests that many meadow systems are in poor condition from grazing but others are recovering.

Impact: The information obtained from the estuary and floodplain studies are helping agencies develop better management strategies for the Sacramento-San Joaquin Delta. The studies on native fish status and ecology are being used as the basis for new restoration programs (Sacramento perch, Lahontan cutthroat trout).

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.27 Wildlife Management

Title: WATERFOWL PRODUCTION AND CONSERVATION IN THE AGRICULTURAL LANDSCAPE

Description: (1) UC researchers are in the final stages of analysis and write-up of a long-term collaborative project with Central Valley Joint Venture (CVJV) partners to quantify winter habitat needs for waterfowl. This project will determine: (a) the amount of food available in moist-soil habitats and agricultural fields when waterfowl arrive in fall, (b) the rate at which this food is depleted throughout the winter, (c) the minimum food-density threshold required to maintain waterfowl populations and (d) the rate at which seeds decompose and thus lose their energetic value for waterfowl. The results of their study have played an instrumental role in guiding the new implementation plan for the CVJV; this plan will be used to establish wetland habitat goals for the Central Valley for the next decade. (2) They are continuing their research on the effect of land use and agricultural practices on the population dynamics of wood ducks. They are studying several populations throughout the state to evaluate the factors that most influence population viability, focusing on key demographic variables such as nesting success and over-winter survival. They have recently initiated mark-

recapture analyses using their long-term data set to better estimate annual survival. Wood ducks are an excellent species to indicate the health of riparian ecosystems in California, given that they are largely dependent on these habitats for much of the year. The studies continue to provide long-term monitoring of this key natural resource in partnership with the California Wood Duck Program (California Waterfowl Association, California Department of Fish & Game). (3) They are completing their studies using molecular genetic techniques to evaluate the population structure of waterfowl in the Pacific Flyway. They have analyzed DNA samples for populations of Canada geese, wood ducks, mallards, northern pintails and Steller eiders to help determine the appropriate conservation units for these species. For example, they have examined whether populations of some species (e.g. the federally listed population of Steller eiders in Alaska) comprise a homogenous genetic population; if not, such populations may warrant alternative management considerations. They are also undertaking an analysis of the impact of hybridization of introduced mallards with the endangered Hawaiian Duck (Kohloa) on Hawaii using a number of molecular genetic tools. This work will help determine the frequency of hybridization and will provide a method to identify hybrids, enabling local wildlife managers to control introduced mallards. (4) They have completed the field research portion of a project to determine the factors limiting production of mallards in California. In 2004 and 2005, they followed 80 breeding females using radio-telemetry to assess habitat use, nest success and breeding survival. This is the first study of this kind for mallards in California, and will provide essential data to guide habitat restoration efforts for breeding waterfowl in California.

Impact: The studies on the agronomic benefits of providing habitat for waterfowl in the rice-growing region of the Sacramento Valley illustrate the compatibility of agricultural practices and wildlife habitat objectives. This research has provided the necessary information to establish realistic acreage goals for wetland conservation efforts, including key winter and breeding habitats. The UC researchers are developing new management techniques to maximize the quality and productivity of existing wetland habitats.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.27 Wildlife Management

Title: COHO SALMON RECOVERY IN THE RUSSIAN RIVER

The Russian River once sustained thousands of coho salmon, which supported commercial and recreational fisheries. As a result of habitat loss and degradation, only three of 32 historical coho streams in the watershed have coho populations. Coho salmon are listed as endangered species under the California

and federal Endangered Species Acts. To reverse this decline, a coalition of agencies, associations and volunteers collaborated with the California Department of Fish and Game to develop the Russian River Coho Salmon Captive Broodstock Program. Program partners capture yearling fish from Russian River tributaries and raise them in the Lake Sonoma Warm Springs Hatchery for two years until they spawn. The resulting offspring are released into streams in the spring and fall, where they spend their first winter before swimming to the ocean. It is anticipated that they will return to Russian River tributaries to spawn. Cooperative Extension and Sea Grant advisors headed the advisory committee and secured funding through the DFG Salmon Restoration Grants Program. To document the success of this effort, ANR advisors track fish from the time of release until their downstream migration to the ocean, and their hoped-for return from the ocean to spawn. The first stream releases occurred in spring 2004 and returning adults are anticipated in winter 2006. ANR advisors and staff are analyzing data and advising to improve the project's chances for long-term success. Coho survival through the first summer following release in Mill, Ward and Sheephouse Creeks was 56, 12, and 44 percent respectively, which spans the range observed for wild fish during this period. Based on data, rearing temperatures in the hatchery were modified to match in-stream conditions. The size of fish released was also modified to reduce competition and potential predation. Project staff are currently conducting in-stream population estimates for coho released in spring 2006 to document over-summer survival. They will survey streams in winter 2006 for returning adult spawners and to record the number of redds, or spawning sites, created by coho released as part of this recovery program.

Impact: More than 2,500 coho were estimated to have successfully migrated out of the system on their way to the ocean as smolts in 2005. The return of these fish as adults to the Russian River in winter 2006 will be the first step in restoring these locally extinct salmon runs.

Funding Source: Smith Lever, Sea Grant and State

Scope of Impact: State Specific

NATIONAL GOAL 5

Enhanced economic opportunity and quality of life for Americans. Empower people and communities, through research-based information and education, to address economic and social challenges facing our youth, families, and communities.

The changing economic, political and social environments in California continue to have major impacts on the use of human resources and to contribute to unique challenges for California youth and families. Consumer credit indebtedness and bankruptcies are rampant while the personal savings rate is lower than in any other industrialized nation. Surveys indicate that both youth and adults lack the financial knowledge necessary to achieve long-term financial security. Few have adequately prepared to achieve financial goals to fund higher education, retirement, and long-term health care. The 12th annual Retirement Confidence Survey (RCS) reveals that the majority of Americans are not prepared for retirement.

The human resource issues in California cross demographic and socioeconomic lines, affecting all ages, from children to the elderly to diverse cultural groups. Many California communities are experiencing real and pressing needs for research-based information on how to remain viable and provide the necessary services for their residents. For the past year, the human resources program identified a number of pressing issues for emphasis in programming. These included: fostering civic engagement, enrichment programs for youth, exploring the relationships between farm jobs, immigration, and poverty, supporting elders, out-of-school programming, healthy child development, and reaching diverse audiences.

Work during this past year has resulted in the knowledge about mediating exposure to environmental hazards through textile systems; new research on foodbanks and their prevalence in poverty areas; an analysis on sand tray play; knowledge about critical transitions in rural families at risk; research on new immigrant political incorporation patterns and transnational practices of Mexican migrants in California; findings that physical abuse is related to poorer physical health; work that has influenced water governance in river basins; the assessment of institutions that affect the social distribution of environmental opportunities and sustainable environmental conditions in California; work to identify and develop strategies for worker pesticide exposure monitoring; knowledge that the reduced-size container for grapes is becoming an industry standard in California; the use of textile systems to mediate exposure to environmental hazards; findings that are useful for policy, planning, and administrative changes at residential treatment facilities; the development of a data framework that has been widely applied and become an important element of proposed standards for public environmental information; knowledge that the development of learning and processing in children is highly related to their ability

to read with comprehension as adults; knowledge about family and work identities during times of transition; the development of a national partnership for an after-school science program; building life skills through hands-on and cooperative learning; seniors getting education tailored to their own health concerns; development of an early literacy reading program; development of a financial caregiving guidebook for adult children of aging parents; and increased understanding public understanding of agriculture farm-based school programs.

CE advisors delivered 135 local extension programs in this area. In addition, 21 statewide collaborative workgroups composed of both AES and CE academics planned and conducted research and extension projects. UC ANR has two Statewide Programs that bring together AES and CE resources and personnel that addressed critical issues in the state that are included within National Goal 5. California academics received three patents and published 47 peer reviewed articles to address Goal 5 last year.

UC-ANR's Human Resources Programs Covering:

- **Human and Community Development**
- **Economically Viable Families and Communities**

HUMAN AND COMMUNITY DEVELOPMENT

UC-ANR focused its research and extension resources on the need to create supportive environments in which culturally diverse youth and adults can reach their fullest potential and to strengthen the capacities of families and individuals for self-sufficiency and well-being by improving life skills. Programs were delivered by individuals and collaborative groups including 9 statewide workgroups composed of both AES and CE academics. To accomplish this, 166 Extension programs were delivered and 17 Extension and outreach publications and 99 peer reviewed research papers were published.

Research and Extension Performance Goals

- Improve the capacity of targeted communities to provide integrated approaches to support healthy youth development that involve youth, families, and community members, and provide training and technical assistance to family, youth, and community professionals.
- Develop and implement programs that teach and demonstrate collaboration building.
- Improve understanding of multicultural and diversity issues by providing youth and family service agencies with training and technical assistance in issues of diversity and promoting tolerance. Research the parenting practices of California's minority populations to develop and disseminate more culturally appropriate parent education materials.
- Developing and extending curricula on youth career decision making, workforce preparation and entrepreneurship experience to youth agencies in

order to prepare youth for an employable future. Generate new knowledge about workforce preparation strategies by conducting comparative studies.

ECONOMICALLY VIABLE FAMILIES AND COMMUNITIES

UC-ANR focused its research and extension resources on the need to improve the capacity of consumers to efficiently use economic and personal resources and strengthen the capacity of communities, families and individuals to create and maintain sustainable economic growth. Programs were delivered by individuals and collaborative groups including 8 statewide workgroups composed of both AES and CE academics. To accomplish this, 21 Extension programs were delivered and four peer reviewed research papers and 2 other media were published.

Research and Extension Performance Goals

- Develop, test and institute effective educational programs on topics related to economic health: consumer choices, personal and family resources management, employment readiness and training, transition from welfare to work, etc.
- Develop, test, and institute effective economic education outreach models for building community coalitions with emphasis on economic self-sufficiency of individuals and economic development for communities.
- Conduct community level research on the effects of economic changes and decisions on communities and households.
- Perform evaluation research on economic programs that demonstrate effective results for potential creation of economic development models. Develop a "best practices" approach for replication of models that work.

FY 2005-20036 Allocated Resources

Extension Federal Funds (Smith)	Extension State Match	Research Federal Funds	Research State Match
\$ 959,986	\$ 959,986 [26.21 FTE]	\$134,823	\$134,823 [10.60 FTE]

Theme: 5.01 Aging

Title: Davis Longitudinal Study

Description: UC researchers continue to analyze the data, with their students taking a major role. Kelly, Boeninger, Shiraishi, & Aldwin (2003) found that some times of childhood stress did have an influence on adult physical health. While ordinary life events in childhood did not apparently have an effect, abuse did. Physical abuse was related to poorer physical health, while emotional abuse was

related to higher levels of depression. Levenson and Aldwin (2004), organized a symposium of students from their lab at the American Psychological Association who presented different studies from the Wisdom Project. Kelly, D'Mello, & Aldwin (2004) analyzed the DLS data to show that religious affiliation per se was not associated with wisdom, but that spirituality was. This is important because wisdom is associated with less perceived stress and better coping strategies. One student will also be doing her dissertation on the DLS, and has passed her orals. Her topic links three different types of adaptational processes, anticipatory coping (thought to avoid or minimize the occurrence of stressful events), stress and coping processes for a major problem, and stress-related growth. Another student has also been working with this data set, and Shiraishi and Aldwin (2004) presented a poster showing age differences in coping strategies, with individuals in mid-life less likely to use avoidance and negative coping strategies than younger ones. The student will be doing his thesis examining longitudinal change in depression from young adulthood to mid-life in the DLS, and plans to take his orals in February.

Impact: The goal of this project is to understand how stress and coping processes change across the lifespan and affect adult adaptational styles. This will assist psychiatrists, psychologists, and social workers in understanding which types of stressors in particular need to be focused on in therapy. Understanding the natural history of coping strategies will also be of use in assisting therapists in understanding the efficacy and problems associated with different kinds of coping strategies.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.01 Aging

Title: SENIORS GET EDUCATION TAILORED TO THEIR OWN HEALTH CONCERNS

Description: More than 33 million Americans are age 65 or older, and the number of seniors in the United States is expected to double over the next 30 years. In Sacramento County, 15 percent of the population is over 60. An increase in age over 65 may increase the risk of developing chronic diseases such as diabetes, heart disease, cancer and arthritis. Eighty percent of seniors have at least one chronic health condition and 50 percent have at least two. Heredity and lifestyle are two factors that affect the aging process. An associate professor of family and community medicine at UC Davis Medical Center, said healthy aging is 30 percent genetic and 70 percent behavioural. "Over two-thirds of the things that you need to do to age healthfully are within your control," he said. Focus groups were conducted with 57 seniors from two Sacramento

County housing facilities. The participants were asked: What are your major health concerns and what would you like to know more about? Diabetes, heart disease, arthritis and high blood pressure were the most commonly noted major health concerns. The focus group responses were used to create an educational program for senior consumers, which was subsequently presented in English and Russian at the two senior housing facilities. The program increased awareness among seniors of the importance of exercise, nutrition and regular doctor visits. At the end, they were able to identify major health concerns, list steps toward healthy aging, recognize personal areas to change for healthy aging, and discuss risk factors associated with breast cancer, heart disease, diabetes and osteoporosis.

Impact: Senior consumers are concerned about their health. Many of them experience symptoms that may be signs of chronic disease. These seniors are interested in knowing how to prevent chronic disease and to make changes in their behavior to promote healthy aging. Healthy seniors can remain in their homes with little assistance. As health care costs continue to rise, it is imperative for seniors to learn how to promote healthy aging. Comments from senior consumers following the education program:

"I will exercise and try to stay on my diet. Also, I'm going to see a doctor regularly." "Exercise, watch my diet, and increase social communication."

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.02 Agricultural Financial Management

Title: DIRECTING FARMERS TO SUCCESS

Description: Knowledge of farming is an obvious prerequisite for business success. However, just as important are knowing regulatory requirements, having a market for one's crops, securing financial resources and advice, and staying up to date on all the latest farming and pest management practices. Knowing who to call for information or how to find help can be daunting tasks for any farmer, and more so for a new-entry farmer or one with limited English skills. To help farmers, especially those with small operations, limited resources and limited English skills, a unique directory was compiled by UC Cooperative Extension advisors in the Central Coast. To help steer the farmer to the right help, the directory lists agriculture-related agencies and organizations by tasks a farmer might perform, or by topic groupings. There is also a cross-referenced alphabetical listing for all entries. Samples of the twenty-five headings are "Air Quality and Fire Protection", "Education", "Financial Management", "Marketing and Promotion", "Produce Inspection and Certification", "Wetlands and Water

Bodies". The directory is in English and Spanish. This is the second edition of the directory which was originally printed in 1996.

Impact: Farmers and others in agriculture-serving industries and agencies now have ready access to information and contacts for a broad cross-section of research, education support, and regulatory bodies. Given the myriad aspects of farming today, the directory serves as a valuable one-stop resource. Five hundred of the directories have been distributed among Monterey, Santa Cruz, and San Benito County farmers and farmer-serving agencies. Word of mouth had led to more requests for the book, indicating its popularity and usefulness

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.04 Child Care/Dependent Care

Title: Sand Tray Project

Description: The article "The structure of toy attributes in sand play situations: A chain-P technique factor analysis" is being revised. Plans for the future include running more pre-teen and teenage subjects and including their data in a new factor analysis. Individual chain P analyses will be compared to the existing Chain-P results. The new data will improve reliability and validity estimates.

Impact: Data gathered on repeated measures of sand tray play will allow (via factor analysis) a way of making available personality factor scores for individual children. It is planned to link these factor scores to behavioral measures both normal and pathological. The final result will be a non-verbal way of measuring personality in children and the possibility of correlating this with childrens' problems. Many children do not want to talk about their fears and problems but most children don't mind playing in the sand-box. Their creations can thus reveal a lot about their personality and possible pathology.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.05 Children, Youth, and Families at Risk

Title: Critical Transitions in Rural Families at Risk

Description: There were two crucial objectives for the study during the past year. First, analyses were conducted with the goal of confirming the existence of

the intergenerational transmission of economic adversity from the family of origin to young adults. Second, efforts were made to develop a new theory of intergenerational transmission of socioeconomic status. In the first instance, UC researchers investigated the degree to which early life adversities increased risk for psychiatric disorder and physical illness during the transition to adulthood and how these sources of maladjustment increased risk for socioeconomic stress in the lives of young adults. The findings were supportive of study hypotheses (Wickrama, Conger, & Abraham, 2005). The results suggested that economic and related stresses in the family of origin increased risk for young adult maladjustment, including physical health problems and mental disorders. These two forms of maladjustment were reciprocally interrelated, adding to the stress process. In addition, youth who experienced more physical illness and mental disorder were less likely to succeed as young adults and more likely to emulate the low socioeconomic status and life adversities of their parents. The second goal was addressed in a book chapter that reviewed current research and theory on the effects of socioeconomic conditions on families and children (Conger & Dogan, in press). This treatise examined the pathways through which either economic advantage or disadvantage affect the competencies of growing children and their ability to deal successfully with the major task of life. The final theoretical model details how this process unfolds over time and influences the transmission of socioeconomic status from one generation of families to the next generation of families. This model will guide future empirical work on this ongoing project.

Impact: The findings generated from the second year of this project are among the first to demonstrate the major influences of the family of origin on the social development of the second generation of adults and their families. Earlier research in this vein has relied almost exclusively on retrospective reports given by adults recounting the experiences of their childhood. These reports are known to be highly distorted by memory failures and biases created by current emotional state. The results from the current prospective, longitudinal research project overcome these biases and provide much firmer support for hypotheses about the intergenerational transmission of socioeconomic influences. They will play a major role in promoting programs that can overcome the negative consequences of negative life events and parenting problems in the family of origin.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.05 Children, Youth, and Families at Risk

Title: Agricultural and Environmental Literacy in California's Formal and Non-formal Education Systems

Description: There were four objectives established at the onset of this project. Objective 1: Define and measure learner understanding of agri-food system benchmarks related to science and technology education. Funding for the grant entitled: Valuing Food and Fiber Knowledge of Others (Others) was the primary way the UC researchers are at achieving this objective. They completed data collection on the Organic and Mexican participants and are now in the process of writing up a paper on the Organic participants. This paper will be submitted to Agriculture, Food, and Human Values journal in March 2006. Objective 2: Ascertain what teaching practices most effectively foster conversational literacy of agricultural and environmental topics. The researcher will continue work with the California Montessori Project (CMP) garden program. Building on the relationship established in 2003, the researcher wrote a second grant (funded in 2005) for a multi-year research project related to elementary student environmental understandings. As a result, gardens at the school are no longer empty, but rather are filled with winter produce. In terms of research, a lead teacher and the researcher made a presentation at the 16th Annual CRESS Teacher Research Conference: Voice from the Classroom, March 12, 2005. The talk and corresponding practitioner-based materials distributed were well received by the teacher audience. The second way this objective was met was conducting a Delphi Study of sustainable agricultural education stakeholders. UC Davis is planning a Sustainable Agriculture undergraduate major and this work, supported by the dean, has helped shape the content of the curriculum. The researchers conducted a study that they are now publishing on ideas about what content, experiences, and skills should be embedded in such a major. As a result of these efforts, they presented two papers at the Agriculture, Food and Human Values conference. One of these publications has been accepted for publication in the Journal of Agricultural Education and another research paper that will be sent out to the Agriculture, Food and Human Values journal. Objective 3: Determine which agri-food system contexts are fruitful for integration into K-12 science and social studies teaching and learning. In collaboration with a colleague from the UC Davis Children's garden, the researcher is the Co-PI on a funded grant from Food Stamp and Nutrition Education Program from the federal government. Objective 4: Design, conduct, and evaluate educational programs to promote pre-service and in-service teacher capacity programs for teaching through agri-food system contexts. The researcher meets regularly with all the California Department of Education Agricultural Education staff and all teacher educators from the five universities that have Agricultural Education programs to discuss current and future issues in agricultural education. To this end, the graduate students and the researcher are writing up several research reports from a Delphi study on issues of importance to teachers in California.

Impact: The impacts toward meeting the objectives are detailed below. Objective 1. The results from the Others project has the potential to include non-traditional ideas and values in the public school agriculture education agenda and increase the diversity of thought. Objective 2. The immediate impact of this work in public

schools is to increase the visibility of UC Davis researchers in California public schools. The long-term impact through this type of action research is to determine methods that foster conversational literacy about ag and environmental topics in public schools. With regard to the Sustainable Agriculture Education delphi results, the impact was great. The committee developed the major and used the research conducted to shape it. The researcher remains engaged in this process and presents the findings to academics concerned about the implications of this novel major. Objective 3. The potential impact of these efforts are great. If the grant efforts help teachers integrate school gardens into the curriculum and childrens eating habit change while they learn about agriculture, then this has tremendous implications. Objective 4. The work with the California agriculture teachers yields significant impacts. State department of education staff have a clear idea of what teachers in the state need. This work with California teachers was noticed by others nationally, and the researcher was asked to attend a meeting sponsored by the American Association for Agricultural Education to set a national research agenda in the field.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.07 Community Development

Title: Environmental Informatics

Description: In 2005 the Information Center for the Environment (ICE) at UC Davis had approximately 25 funded cooperative research and outreach agreements with public (and several private) natural resource agencies and organizations addressing biodiversity, land use, and water in California, the US and globally. The main international activity has been a collaboration with The Nature Conservancy to develop a global assessment of conservation and land protection priorities in Mediterranean ecosystems around the world. An ICE postdoc has helped run workshops in Europe and Australia, and begun a global GIS of indicators of biodiversity values, ecological services, and anthropogenic threats, along with some preliminary testing of analytical methods. The Mediterranean Assessment is the pilot step for a TNC global assessment to be carried out over the next decade. In national activities, ICE hosts the CA Node of the National Biological Information Infrastructure, and has led NBII in adapting next-generation geospatial and semantic web technologies. Other Federal grants and contracts completed include a project with the Smithsonian to bring the ITIS database for 'official' vertebrate scientific names up to date, an assessment of biodiversity information in protected areas in central South America, and consultation with the Global Invasive Species Information Network on data exchange standards for information on noxious weeds, wildlife and plant diseases, and other invasive species. ICE completed a project with the Fish and

Wildlife Service to modernize the National Wetlands Inventory for much of the north coast of CA. ICE has numerous new CA interagency agreements, including the fourth year of a \$15 million umbrella agreement with Caltrans for cooperative state-university analysis of environmental planning issues. Agreements underway assess potential biological impacts of new roads to improve and streamline the existing environmental planning process. Another Caltrans project is to develop an analytical GIS framework for identifying opportunities to assess cumulative environmental impacts of highway project and assess the options of developing large regional mitigation activities. The researchers also administer projects on air quality, cultural resources, endangered species, and land-use planning. Under EPA and State Water Board funding, they completed GIS and remote-sensing studies used by water regulators to address non-point- source pollution issues under the Clean Water Act in two No. Coast watersheds. With Heath Services, they completed software and risk assessments required under its Drinking Water Source Protection program, and have entered and geospatially validated data for essentially all of the 17000+ drinking water sources in California. A public outreach site showing all non-sensitive drinking water data will be released soon. ICE leads a \$2.3 million grant to for a watershed assessment of the Cosumnes River floodplain and watershed. A UC researcher represents the university in the Bay-Delta Science Consortium, which also recently sponsored the first fully electronic peer-reviewed journal to be published by the UC Library System. He is a co-editor-in-chief. Results of other projects can be viewed on ice.ucdavis.edu.

Impact: The data framework developed by ICE has been widely applied in state, national, and international agencies and programs, and has become an important element of proposed new standards for public environmental information. All contribute to both more informed and more streamline environmental analysis. The ICE website is one of the most visited sources of on-line environmental

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.07 Community Development

Title: New Immigrant Political Incorporation Patterns and Transnational Practices of Mexican Migrants in California

Description: Additional ethnographic and elite interviews were conducted with leaders of the Zacatecan Federation of migrant home town associations in Southern California about migrants' contributions to economic development in communities of origin, involvement in state and local electoral politics in Zacatecas, and participation in political life in the US, in California, and in urban

politics in Los Angeles and other cities in Southern California. Several publications presented key findings of this research.

Impact: The study assesses the consequences on both sides of the U.S-Mexican border of emerging practices of dual-citizenship. It informs researchers and immigration policy-makers by identifying important new forms of transnational community economic development, electoral politics, and interest group politics. Findings show that migrants' civic engagement in Mexico actually generates social and political capital that enhances the migrant network's effective engagement in national, state, and local politics in the US.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.07 Community Development

Title: Welfare Reform and Civil Society in California

Description: The research on foodbanks is about to conclude. A final theoretical paper (1) has been re-submitted to the Journal of the Agriculture and Human Values Society. A second, more empirically oriented article (2) is about to be submitted for publication. (1) Summary findings of the article 'Foodbanks Forever?': This article advance answers to the question how one can explain the establishment of a social institution that considers itself a temporary answer to a transient crisis, as a short-term measure where the ultimate goal is to work towards its own obsolescence? The main thesis is that foodbanks and by extension many other private voluntary organizations are not temporary answers to an unbalanced and deficient welfare policy, but an appropriate expression of more general social development that is locked into a distinctive institutional framework of an American-style democracy. These considerations set the foodbank issue in dialogue with the literature on social exclusion/inclusion and the literature on 'entitlement crisis,' a notion introduced by Martyrs Sen explaining the three most devastating famine of the 20th century. (Sen 1981). On the basis of this argument, further reflections are developed to ascertain why this diminishing of entitlements seems to be so difficult to halt or reverse. A UC researcher will explain this impasse with the theoretical tools developed in the literature of 'Second' or 'Reflexive Modernity' which posit that the late capitalist societies are marked by the development of 'individualization' in which the classical (traditional) forms of solidarity and polity formation are not any longer available. These classical social formations were the repository of such inclusionary norms of entitlement. Tying these strands of argumentation together in the final section, the researcher suggest that given the forms of political decision making in the USA, foodbanks-and hence also the ever increasing role of citizens' organization in coping with social ills-is here to stay. Therefore, he

sees only one structural opportunity out of this impasse: civic associations have to understand their role in society as being ultimately political associations and as such will need to rethink, if not claim, their legitimate political space in which they are directly involved in the democratic decision making processes.

Impact: (2) The article 'Crumbs of Compass' summarizes the findings of an empirical inquiry into 9 Californian foodbanks along the I-80 Corridor. The size of operations, impact and embeddedness into the local social welfare activities are assessed. The study confirms the known trends in the food insecurity literature as advanced by the Economic Research Service of the USDA and the applied research of foodbank organizations about the increase of need with a simultaneous decrease of voluntary commitment. The article furthers also the observation that foodbanks have become a bureaucratized arm that function similar to state offices (bureaucratic Samaritans). Finally, based on a small sample of nine foodbanks, the article advances the hypothesis that foodbank operations are dependent on the incidence of high inequality and not the level of need in a county. Put differently, only in communities where one finds a sizable segment of persons distinguished by their high income versus a visible segment of people in need, will one find foodbank operations in place. The poverty level of one locale is not sufficient to explain the existence of foodbank operations. Further research needs to be done to assess the implications of this hypothesis.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.07 Community Development

Title: NATIONAL ISSUES FORUM TO DISCUSS HEALTH ISSUES

Description: A tuberculosis scare had prompted citizens to demand more information on what was happening in their community related to communicable disease outbreaks. The newspaper wanted to hold a forum on the issue of health privacy and the public's right to know. A small discussion guide was created by local NIF framers and a community forum was held at the library. The Vacaville Reporter has supported NIF activities, albeit somewhat on the fringes. The editor prints editorials and meeting announcements about forums held in the community and, more recently, to send reporters to cover forum conversations held at the local library or at the UCCE meeting room. In the summer of 2003 the newspaper sent two participants to a week-long training experience sponsored by the Associated Press. Held in Evanston Ill., the local team was immersed in issues of freedom of the press and free speech. Their responsibility, as "payback" for the training was to conduct a local forum focused on the issue of freedom of the press. The Library Literacy Director participated as the facilitator. She was well

suited to the role, since she is also a seasoned faculty member of the Public Policy Institute. The reporter, returned to Vacaville with a plan in mind.

Impact: Sixty Vacaville residents participated in the forum. Stakeholders such as the Superintendent of Schools, Mayor, Medical Director for the Solano County Health Department, parents of students affected by the crisis, Fire and Police representatives and local medical doctors voiced their feelings about the communicable disease issue and how it was handled by all involved. Evaluation results of the forum indicated a high degree of satisfaction with the National Issues Forum (NIF) type process. The Vacaville Reporter is utilizing the local NIF team to frame the issue of problems faced by families who have spouses/relatives at the Vacaville Medical Facility. Following the forum a community communications task force was put in place by the city and the newspaper was included in this group. The Vacaville Reporter was awarded a 2nd Place recognition in national standing by the Associated Press for the community forum.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.07 Community Development

Title: INCREASING PUBLIC UNDERSTANDING OF AGRICULTURE FARM-BASED SCHOOL PROGRAMS

Description: Literature regarding agricultural education provides evidence that the agricultural literacy of the general population has been limited, and a need exists to educate all school-age children about agriculture. On-farm learning experiences serve to create emotional connections as well as increase knowledge. A long-range goal is that every student in the county will have several opportunities to visit the farm in their school career. The first Seeds of Knowledge field trips were piloted in 2003, and were developed utilizing the historic setting of the farm, and with volunteers providing research and creative input. These comprehensive units provide pre and post-visit curricula and were targeted for 4th - 5th grade students. A second type of less labor-intensive Harvest field trip was designed for 3rd grade to allow for more students per visit, and to augment the Farm to School Program. On-farm Career Days were held in conjunction with the School-to-Career program of VCSS, which highlighted higher education as well as job opportunities in agriculture. A summer internship program was piloted in 2004. Trained volunteers assisted with implementation of these programs.

Impact: Four Seeds of Knowledge (SOK) and two Harvest field trips were conducted in 2003, the pilot year; and nine SOK and seven Harvest field trips in 2004. This resulted in approximately 815 students experiencing on-farm visits that included academic lessons covering multiple standards (science, math, language arts, social studies) and hands-on investigations, harvesting or planting experience. Teachers, students and parent chaperones frequently proclaim this as their best field trip experience ever. The Career Days were successful, and attendance grew from 65 students in 2003 to 120 students in 2004. Surveys indicated most students' knowledge about agricultural careers was increased, and a small percentage (4%) reported a shift in attitude whereby they might consider a career in agriculture as a result of the event. The Internship program gave two students experience taking a crop from Seed to Table, including all tractor work. They returned with fellow ag students to harvest the seedless watermelon crop, which was served in the Farm to School salad bar the following day. This was particularly exciting because the two students were female. The fruits of these endeavors may not be known for years, as the students consider career choices, and become part of the voting public. For now, their parents and teachers exhibit attitude changes, hopefully positively benefiting policy decisions concerning agriculture.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.07 Community Development

Title: AG FUTURES ALLIANCE OF VENTURA COUNTY

Description: The Ag Futures Alliance (AFA) was formed in 2000 as an innovative way to bring historic adversaries together to find common ground and, if possible, consensus on important issues affecting agriculture. The purpose of AFA is "to support and enhance an interdependent and viable agriculture in Ventura County in perpetuity through an alliance that values dialogue and cooperation and where a diversity of affected views and interests are represented." A coalition of sustainable agriculture funders, Roots of Change, awarded Ag Innovations Network a grant to make efforts to initiate AFA's in 3 other counties in 2004. The AFA identifies critical issues affecting agriculture, and assigns committees to develop work products that compile or add to the knowledge base and deliver recommendations to various decision-makers. Issues this review period included farm worker housing, land use and stewardship. In late 2004 discussions began on health coverage for agricultural workers.

Impact: Ag Futures Alliance (AFA) is recognized throughout the county as the leading organization dealing with critical ag issues, and three new AFA's were

started in other counties based upon the initial success in Ventura. Farm worker housing task forces are active in 5 communities, and the committee raised \$30,000 to support continued work. The county and at least one city are asking AFA to provide even further information based upon the Land Use paper. Awareness of farm worker housing issues has increased dramatically, and the first units have been built. Buffers at the ag/urban interface are now required in many general plans, and other principles are incorporated as well. The first statewide AFA meeting will be held in December 2005. In 2003 the farm worker housing paper was presented to the Ventura County Board of Supervisors, and articles and editorials highlighted findings. A conference sponsored by AFA organizations also highlighted the issue and presented solutions. A video *Mi Casa es Su Casa* was produced to showcase the issue, and was aired at the conference. The Land Use paper was sent to all city and county planning departments, and visits with most have provided follow-up.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.11 Family Resource Management

Title: FINANCIAL LITERACY FOR LOW-INCOME FAMILIES IN COACHELLA VALLEY

Description: This project was conducted in conjunction with the Altura Credit Union (formerly Riverside County's Credit Union) and DACE (a nonprofit organization serving low income families in Coachella). The project is a collaborative effort involving 4 partners: Altura CU, UCR Consumer Economics, UCCE Riverside County and DACE, to provide financial literacy education to low income individuals in Coachella Valley. Through a grant from the National Credit Union Foundation, Altura CU provided UCCE Riverside with a contract to hire existing staff to teach financial literacy classes using the Gateway to a Better Life curriculum (Making Every Dollar Count) and Money Talks – Should I Be Listening? DACE provided meeting room and helped recruit participants. A series of two financial literacy classes were provided to DACE participants on a monthly basis. An existing Adult FSNEP staff in Coachella Valley (Indio Office) was hired to teach these classes. The presentation included overhead transparencies and handouts from Making Every Dollar Count unit of the Gateway to a Better Life curriculum. In addition, an existing Youth FSNEP staff in Indio Office was hired to teach financial literacy to high school students. A series of four Money Talks –Should I Be Listening? classes were presented at Coachella Valley High School and other organizations serving at-risk youth

Impact: The program was evaluated by using a pre-test and post-test, and an evaluation form given to participants at the end of the class. DACE participants

who completed the Making Every Dollar Count classes were given a certificate of completion from UCCE and a certificate of free membership from Altura Credit Union. Two focus group interviews were conducted with DACE participants as part of program evaluation. Program evaluation and focus group interviews were conducted by the UCR Consumer Economics department. Adult participants learned about financial responsibilities and the consequences of having a bad credit. They also learned about different types of financial institutions, and how to open and manage a bank account. Youth participants learned about their money personality and how to shop wisely and save money.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.13 Fire Safety

Title: Mediating Exposure to Environmental Hazards Through Textile Systems

Description: This year's work in cooperation with the California Department of Forestry and Fire Protection (CDF) involved testing of 12 protective clothing systems at the Protective Clothing and Equipment Research Facility, University of Alberta, Edmonton, Alberta, Canada. The objective of the testing was to evaluate how the presence or absence of logos and moisture affected the thermal protection offered by a two-layer clothing system. Preliminary analysis suggests that moisture is an important factor in increasing the extent of second and third degree burns as measured by the mannequin's sensors. The difference between wet and dry conditions was greatest for the logo on jacket/logo on t-shirt condition. Regarding progress on the pesticide protective clothing project done in cooperation with a colleague from Cornell University, 18 pesticide applicators working in California were interviewed, given questionnaires, and photographed while engaging in pesticide application activities. The data have been forwarded to the Cornell colleague for comparisons with data collected in New York.

Impact: The testing of thermal protective clothing systems under both wet and dry conditions can guide fire fighting units in selecting ensembles that will be most protective under both wet and dry conditions. The pesticide protective clothing project will enable the redesign of protective coveralls so that they are both more protective and more comfortable.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, CO, IL, MN, MO, NYC, OK, TX, University of Maryland-Eastern Shore

Theme: 5.13 Fire Safety

Title: Mediating Exposure to Environmental Hazards Through Textile Systems

Description: In the continuation of the study on protective clothing for first responders, a novel technology that can prepare self-decontaminating fire fighters' uniforms has been developed. Nomex fabrics, widely employed in firefighters' uniforms, can be directly chlorinated in a simple wet treatment, and the finished fabrics exhibited rapid and rechargeable antibacterial functions. The fabrics can inactivate both Gram-negative and Gram-positive bacteria in a short contact time, but without rendering any existing mechanical and fire resistant properties. These fabrics are the best materials so far for protective clothing and military textiles. These materials will significantly improve protective functions of the currently used materials and provide better protection for first responders. This research has resulted collaboration with National Personal Protective Technology Laboratory (NPPTL) of NIOSH. In addition, one of the antibacterial technologies resulted from the research is tested by the US Air Force for antimicrobial underwear and uniforms. Another technology is applied in production of biocidal hospital linen products. GenTex Corporation is applying the biocidal Nomex IIIa fabrics for Air Force rescue isolation devices.

Impact: The results of this research demonstrated a new chemical wet finishing process of incorporating biocidal functions onto the textile materials. The new technology has already attracted interest from manufacturers of protective clothing for first responders and military personal.

Funding Source: Multistate Research and State

Scope of Impact:

Theme: 5.20 Parenting

Title: The Development of Learning and Cognitive Processing in Children

Description: An understanding of attachment and temperament interactions is vital to the development of educational strategies that are sensitive to individual processing differences and the eventual successes of children from impoverished developmental environments. A developmental movement from the right to left hemisphere was found in 4-5 year old children (as measured by EEG alpha suppression from both temporal and parietal leads). Pre-readers viewed the printed word in the same manner as they did 3-dimensional objects and drawings of objects. As they began to learn to associate print with spoken language, they shifted to processing the print in the left hemisphere (Porta,

2004). This shift was stronger when reading words which did not have a strong emotional component. Adults also read emotionally laden prose with greater right hemispheric activity than when reading abstract articles (Grimes, 2004). Children and adults also processed relationship-related words in their right hemisphere compared to the left hemisphere for words in general (Davis et al, 1998). This difference was magnified for those children who had problems regulating their emotions. And emotional regulation strategies were highly related to whether or not individuals had attachment issues with significant others (Davis, 2003). The prefrontal areas were more heavily involved when processing emotionally laden scenes. Those children and adults who tended to respond to difficult attachment issues by denying that there was an issue showed much higher physiological stress response (galvanic skin response) than others (Davis, 2003; Stanley, 2005). Those children and adults who demonstrated a slow and easy temperament on the rhythmicity dimension; also had less right temporal and prefrontal activity when viewing emotional and attachment-laden stimuli (Davis, 2003; Stanley, 2005). Finally, positive words were responded to faster than negative words. Highly anxious adults were slower when responding to emotional items that presumably evoked the attachment system. This may be indicative of a more cautious approach to attachment-related stimuli, or of increased attention to such stimuli compared to other forms of stimuli. (Hafer et al, 2005).

Impact: The development of learning and processing in children is highly related to their ability to learn to read and to read with comprehension as adults. It is also related with their ability to interact with others, to increase emotional regulation abilities and determine whether each individual approached information in an impulsive manner. These studies also point out significant temperamental factors which arise in childhood and continue through one's life.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.20 Parenting

Title: Thriving in Mid-Adulthood: A prospective longitudinal study from middle childhood to adulthood

Description: 1. Revised hatch project and got IRB approval to collect longitudinal data. 2. Prepared a chapter, now in press, addressed to therapists who work with teenagers as these youth consider seeking employment during the academic school year. The quality of the work environment, the number of hours, the teen's age, and the student's current level of functioning are four major issues to consider when making decisions about teen employment. 'Naturally' occurring employment is fraught with considerable cautionary considerations, whereas planned youth employment programs and volunteer work appear to be

less risky and more beneficial for youth. A checklist was developed to enable parents and youth to evaluate the available work opportunities. 3. Prepared a literature review directed toward researchers. In this manuscript, currently under review, UC researchers developed a model of parenting during middle childhood and adolescence in relation to vocational development. In this model developmental processes mediated the relationship between parenting and vocational outcomes. These developmental foundations of vocational development included occupational knowledge and beliefs, exploratory processes, academic and occupational aspirations, self-efficacy, and academic planning and attainment. 4. Together with Zvonkovic and Reynolds, they presented a poster titled 'Family culture influences on vocational development' at the Society for the Study of Human Development. Here they began to extend the above stated model with considerations of culture, including immigration and acculturation. (October, 2005).

Impact: 1. Adolescents will learn what their parent's (or both parents') job means to their parent(s). Parents, likewise, will learn what a job means to their teen. 2. Parents and teens will examine various financial purposes for earning money. 3. Parents and teens will examine three types of work experiences available to teens and learn about the costs and benefits that have been found with respect to teen work experiences. 4. Parents and teens will learn how to evaluate specific job opportunities. 5. Parents will learn what kind of monitoring of their teen will be helpful in making decisions about teen employment and development.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.20 Parenting

Title: PARENT EXPRESS GUIDES PARENTS THROUGH BABY'S FIRST YEAR

Description: The care and guidance children receive during their first few years determines, to a large extent, whether they will become loving, confident, competent young people and adults. To promote early development, parents need to know how infants grow and change. They need to know the importance of responding warmly and consistently to their baby's need for comfort and support. Parents need to understand the value of encouraging their infants to explore, of providing good nutrition and of maintaining a child-safe environment. They also need reassurance that they are capable of being good parents.

Impact: Of the 101 parents surveyed in 2003, 95% said reading Parent Express helped them learn about how their baby grows and develops.

92% said reading Parent Express made them feel more confident as a parent.
100% rated the booklets as helpful and thought it worthwhile to send Parent Express to other parents.
77% used the suggestions to promote their baby's growth and development.
More than 90% found the information on infant development, health and safety and infant nutrition helpful.
More than 70% found the information on handling stress, guidance and discipline and games and toys helpful.

Parent Express is a cost-effective way to provide the parents who most need it easy-to-understand information that helps them promote their baby's development. The publication will become available through ANR Communication Services in late 2006.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.21 Promoting Business Programs

Title: Business Process Offshoring and Non-Metropolitan America

Description: During the last year, a UC researcher conducted interviews in India regarding outsourcing of service work. This consisted of 40 interviews with executives. The researcher also has been examining the Census of Manufacturing data to distinguish between metropolitan and non-metropolitan counties and the types of service work being undertaken in both. Unfortunately, the data on service activities is quite weak. He also conducted interviews with in a Yolo county economic development director on the significance of service activities such as call center provision for the county economy.

Impact: Remote service provision particularly call centers and data entry operations has become an important economic development strategy in non-Metro counties. Globalization threatens this strategy because remote locations with lower labor cost threaten to replace US non-Metro workers with lower-cost workers overseas. In terms of call centers the threat appears to be Canada and the Philippines, whereas for data entry India may be a more attractive alternative. The results of this research will be of value to economic development directors in non-Metro and Metro counties.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.22 Promoting Housing Programs

Title: Toward a Modified Rural Focus for California Planning and Design

Description: Marking the shift in focus of the new project, the PI organized a national symposium, Designs Diaspora, addressing new community and regional dynamics associated with the global movements of people. The symposium held on the campus of the University of California at Davis, October 28-31, 2005 was supported by a \$25,000 grant from the Landscape Architecture Foundation and matching funds from the College of Agriculture and Environmental Sciences and the Department of Environmental Design. Speakers included internationally renowned architects Emilio Ambasz and Michael Sorkin, landscape architects Walter Hood and Tom Leader, public artists Lily Yeh, Doug Hollis, and Ann Chamberlain, critic Lucy Lippard, and others. The presentations and discussions at the symposium addressed issues identified in the new Cultural Differences and Regional Change Experiment Station Project including: creative adaptations of new immigrants, and critical evaluation of new models for landscape architecture, architecture, and urban design. Earlier in the year, the P.I. was invited to Athens, Greece to deliver four lectures on new directions in community design, public art and regional development, and design for tourism. He also traveled to Barcelona in Spain to deliver a conference keynote address on the social and economic impacts of the new Frank Gehry designed museum in Bilbao. In the spring they completed their research at Walters House residential drug treatment facility in Woodland and submitted the final report to the California Endowment. Their study was designed to measure the causes of homelessness and addiction in the severely distressed population in residence at Walters House.

Impact: The impact of Designs Diaspora has not been measured. Informal responses from attendees suggest that the symposium successfully highlighted a number of issues in cultural differences and regional change and inspired students and colleagues to pay more attention to these issues in their design and community development work. The research at Walters House had a number of measureable impacts on the treatment of severely addicted populations both at WH and in other facilities. The researchers found that faith-based programming was effective only with those addicted to a single drug who were capable of maintaining sobriety without professional help for periods of one month or more. Residents addicted to multiple drugs for long periods (study average was 18 years) and incapable of maintaining sobriety were non-responsive to faith based programming and needed science-based secular interventions. A number of other findings useful for policy, planning, and administrative changes at residential treatment facilities are in the final report.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.25 Tourism

Title: AGRITOURISM MANUAL HELPS CALIFORNIA FARMERS GROW ECONOMICALLY

Description: A 1999 survey of California farm operators revealed a growing need for materials on two increasingly profitable industries: agritourism and nature tourism. Farmers and ranchers have heretofore lacked a centralized resource for obtaining such materials, in a time when opportunities abound for tourist ventures to take root. The UC Agriculture and Nature Tourism Workgroup had a goal: to produce a comprehensive manual, providing information on starting, maintaining and expanding an agritourism or nature-tourism venture. The result is a 250-page manual covering such myriad topics as assessing one's business, marketing and promotion, employee management and relations, regulatory compliance, and business-plan development. Widely considered the definitive guide for California agritourism and nature tourism, the manual is currently being used by several organizations involved with economic development in the state's rural and agriculturally depressed regions. Completed in 2002, the UC manual sold out in only six months. However, an updated, fall 2005 edition is currently available, published by ANR.

Impact: The UC Workgroup has trained over 900 farm operators across California in diversifying their businesses with tourism. Using the UC manual as a guiding tool, ranchers and farmers in diverse communities are taking preliminary steps toward embarking on new tourist ventures. Workshop attendees rave about the UC manual as a resource for tourist business planning. One participant from a 2004 workshop in Paso Robles says, "Chapter Two on 'Assessing Your Potential' really helped my husband and me refine their vision and get started. It made us aware of ALL the components that must be addressed." Another participant from a 2003 workshop in Reedley says, "I used the information in the manual to prepare my expansion and my plan to meet with county staff, before I submit an application."

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.27 Workforce Safety

Title: CALIFORNIA AGRICULTURAL ERGONOMIC INTERVENTION PROJECT

Description: The use of the smaller grape tub continues to grow. Evaluation of the harvest of 12 fresh market tree fruit crops has been completed and the

project has moved to the development of interventions to address specific ergonomic problems in the orchards. Intense work schedules coupled with ladder-bag issues dominate the high risk activities throughout the fruit harvest spectrum. Work has been completed on evaluating a variety of interventions in the nursery propagation rooms. Designs to correct postural issues and to give workers some flexibility in their work schedule have been very effective in both reducing the incidence of persistent pain and improving productivity. Powered shears have been shown to be advantageous when cutting woody plants.

Impact: The reduced-size container for grapes is rapidly becoming an industry standard in California. The nursery propagation room changes show the potential for minimizing injuries related to cumulative trauma injuries while increasing production at reasonable costs.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: Developing and Testing Culturally Diverse Arts Expressions in Computerized Learning Packets for CA K-12

Description: 3 learning units created: a. Shining Cloth; b. Spirithouses, Shrines & Altars; c. Southeast Asian Baskets: Ethnobotany, Agriculture & Design for 4th - 7th grade students, teachers. P.I. curated 3 exhibitions on culturally diverse design (a. Shining Cloth; b. Southeast Asian Baskets; & c. Art under Wraps: Fukusa of Japan, each had accompanying text & learning materials. Public training session on c. conducted & evaluated by Tumblewords Program, Nevada Arts Council. Unit c. tested in 2 rural KY classes for effectiveness in teaching children about baskets related to agricultural life & knowledge of diverse cultures. Learning units a. & b. disseminated at State Cooperative Specialist meetings & offered as on- line supplements to after-school programs. Unit b. created in collaboration with 5 teachers from 2 UC Partnership schools. Teachers tested unit. P.I. worked with UC Davis Center for Youth Development to develop training session & test. Two learning units distributed for testing - training to 50 regional teachers revealed technological problems accessing P.I.s Web sites, CD ROMs in classrooms. Unit Web sites and CD ROMs evaluated by Sacramento computer-learning specialist. Tests incomplete due to teachers technological problems, problems corrected in next materials. Learning materials a.& b. evaluated for alignment to CA education standards determined teachers lack time for units until post-testing & lack computers, on-line access, financial resources to attend exhibitions. 3rd learning unit c. presented in booklet format only. Exhibition b/ unit c Southeast Asian Baskets: Ethnobotany, Agriculture and Design researched overseas. P.I. collected & researched 200 SE Asian artifacts.

Exhibition held in Design Museum, UC Davis & learning unit prepared, curatorial lecture delivered, public & teachers, school children docent-led. Unit themes focused on relationship of people & plants, rice cultivation, culture conveyed through rice & food, & basket design evolving from form meeting function. 2 project goals: boost students computer literacy & augment teachers pedagogy with global arts & design materials met, however students are computer literate and schools lack digital equipment & teaching time for units. P.I. will not create Web site, CD ROMs of units, & focus on publishing & circulating booklets. P.I. will plan learning events after Spring testing is completed & build targeted partnerships with alternate learning environments: after-school programs, 4-H, Girl & Boy Scouts, home- schooled, magnet, Montessori & Waldorf schools. P.I. continues to develop, distribute & test culturally diverse learning materials. Immediate plans to expand unit c. Gift Covers of Japan with readings & assignments on gifts, gift giving & presentation among diverse cultures. Booklet to be published, circulated. SE Asian Baskets learning unit distributed in limited quantities 2/05, & republication of units a. & b. to be prepared for teacher training. Materials distributed to expanded target user groups to be tested & results published.

Impact: Project improves understanding of multicultural issues by promoting increased knowledge & generating appreciative attitudes toward diverse cultures. Learning packets yield positive impact on students' learning & computing skills; improve cross-cultural competence; improve teachers' pedagogy with globally diverse arts & design material. Units useful to after-school programs & other learners.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: IMPROVING SCIENCE LITERACY IN CALIFORNIA'S ELEMENTARY SCHOOL CLASSROOMS

Description: Science literacy among school-age children in the United States is poor. In part, this is due to the fact that classroom science instruction is often marginalized, with the majority of instructional time dedicated to language arts and math. Another concern relates to the manner in which science is taught. Most teachers use didactic methods that do not engage children in active discovery. Learner-centered, inquiry-based instructional methods can catalyze children's innate curiosity and open their minds to the exciting world of science! A Cooperative Extension Specialist, and a Staff Research Associate, engaged in a one-year study of Animal Ambassadors, an inquiry-based science education program conducted in school settings. Funded by the UC Davis School of

Education and the School/University Partnerships Program, the study measured changes in science literacy among urban third grade students. Children engaged in the Animal Ambassadors curriculum developed a more comprehensive understanding of wild and domesticated animals and the relationship of animals to humans. The curriculum, which allowed children to work in cooperative learning groups, used no live animals. Activities were designed to engage children using man-made materials including imitation animal coats, foot models and tooth models.

Impact: Results showed statistically significant improvements in science literacy among those students who participated in the curriculum. Specifically, these students improved their acquisition and use of scientific thinking processes (observations, comparisons, and inferences based on observations), and their acquisition and use of animal-related science concepts. After reviewing the results of this study, the participating school district's Board of Education adopted the Animal Ambassadors curriculum as a supplement to their third grade science offerings.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: VETERINARY MEDICINE PARTNERS WITH 4-H YOUTH DEVELOPMENT

Description: There is a shortage of veterinarians in California, and according to the Bureau of Labor Statistics, there will be 28,000 veterinary job openings nationwide by 2012. While all types of veterinarians are needed, the need for livestock veterinarians is greatest. The American Association of Veterinary Medical Colleges has recommended the development of programs to promote veterinary medicine to a diverse population. It also recommended developing meaningful mentoring relationships with youth to better promote the veterinary profession. The UC Davis School of Veterinary Medicine Vet Student Outreach Club hosted a one-day interactive Veterinary Science Education Outreach event for 4-H members. 4-H members compared healthy and diseased organs of different animals in the anatomy lab. They viewed the internal organs and skeletons of a diverse array of animals. The youth saw demonstrations on electrocardiograms and learned techniques used to read x-rays. They concluded with an in-depth tour of the UC Davis Veterinary Medical Teaching Hospital.

Impact: More than 80 4-H members, ages 9 to 18, and adult volunteers from Sonoma and Lake counties learned about the increasing need for livestock veterinarians and about what it takes to become a UC Davis veterinary student.

The group got an in-depth view of what a veterinary student does on a day-to-day basis. The youth left understanding the need to work hard and to take the right coursework as early as high school to achieve a career in veterinary medicine.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: ANIMALS AND CHILDREN

Description: Children have a strong interest in animals and they are important in their lives. Experiences that children have with pets and wildlife help them develop positive attitudes toward animals, help instill a sense of caring and responsibility, and can provide them feelings of love, reassurance, and emotional support. Unfortunately, children have increasingly limited opportunities to have direct interactions with animals. Although pets are common in US households, their increasingly metropolitan society has limited or no exposure to or contact with agricultural animals or wildlife. Furthermore, exposure to live animals through schools and community-based programs is more limited in urban areas due to logistical and budgetary restrictions. It is essential for children to gain an understanding about the diversity of animal life. By taking full advantage of children's natural attraction toward animal life, engagement with the world of animals at this time in their lives can deepen their connection to other species and develop a sense of stewardship. In California where over ninety-five percent of the population is found in metropolitan areas, the challenge has been finding effective teaching tools and strategies to help increase children's knowledge and improve their attitudes toward animals.

Impact: A collaborative research project with urban elementary schools in Sacramento measured children's perceptions of their relationship to animals. Changes in self-animal perception were assessed in third grade students who participated in a 20-week implementation of the Animal Ambassadors curriculum and in a control class that did not participate. Self-animal perception was analyzed from children's drawings; changes in scores over time were analyzed statistically. The central prediction of this study was that children who participated in Animal Ambassadors would show significantly greater improvements in their perceptions of their relationships to animals than their counterparts in the control group. This prediction was supported by the results. Using the Draw-Yourself-with-an-Animal assessment tool, it was shown that children who received the Animal Ambassadors curriculum intervention program moved from more negative, neutral, and indirect relationships toward animals, to

relationships that were more positive and direct in nature. These outcomes demonstrate that improvements in children's perceptions of their relationship to animals can be effected through participation in an education program that uses animal alternatives in its instruction.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: EFFECTIVE TRAINING FOR SCIENCE EDUCATORS OF YOUTH

Description: Science literacy of children in California is among the lowest in the nation. In order to develop a scientifically literate population, it is crucial to engage children in science activities at a young age. Unfortunately, most educators who work with young children feel unprepared to teach science, and it is imperative that they be trained and supported effectively. In order to train educators effectively, it is important to provide ongoing, sequential learning opportunities. Trainings that are discrete events are ineffective. Furthermore, hands-on training programs in which educators experience science activities in a manner that models how children will receive them helps to build confidence and competence in the subject matter. The "Step-Up" Incremental Training Model was designed through collaborative efforts between a CE Specialist in Veterinary Medicine Extension, and a 4-H Youth Development Advisor in San Luis Obispo County. The training model involves a sequence of three hands-on workshops that help educators grasp mastery of content and methodology. It also provides an opportunity for group reflection and feedback. Key elements in the model's design include workshop organization, multiple increments, effective modeling and practice, and a "safe" environment for reflection and review.

Impact:

The "Step-Up" Incremental Training Model has been used to train 4-H teens as cross-age teachers, 4-H staff and adult volunteer leaders, and classroom teachers. Research results from three studies using post-project surveys, focus group interviews, and observations have shown statistically that educators have improved their understanding and use of inquiry-based teaching methods, effective questioning strategies, and science process skills. Furthermore, additional outcome data showed that these educators were effective in implementing an inquiry-based science curriculum with their target youth audiences. Results showed statistically significant improvements in the children's acquisition and use of science process skills and curriculum content knowledge. The developers of the "Step-Up" Model believe that it would be transferable to other Extension programs.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: SANTA CRUZ COUNTY PART OF NATIONAL PARTNERSHIP FOR AFTERSCHOOL SCIENCE PROGRAM

Description: Research in formal education indicates that occasional or one-shot training has little impact on the way teachers present science material to their students. With this in mind, a California county 4-H youth development program is engaged in a three-year research project with after-school providers in two locations to measure how participation in on-going science training impacts the ability of after-school providers to successfully deliver science in after-school settings. Each month, after-school providers spend three hours in training with county 4-H staff learning how to facilitate open-ended and guided explorations of science and engineering topics. The trainings give after-school providers an opportunity to gain experience being “learners,” as they actively engage in chemistry, physics and electricity lessons, as well as get instruction about hands-on learning, lesson plan development and questioning strategies.

Impact: During the initial five months of the project, providers participated in 15 hours of training and they delivered 115 hours of hands-on science education to 240 kindergarten through fifth-grade youth at 7 after-school sites. In assessing provider confidence in teaching and explaining science content to students, 18 providers were asked to rank their confidence levels before and after the trainings. Sixty-four percent indicated an increase in confidence from either “only a little confident” or “somewhat confident” to “very confident” or “extremely confident.” When providers were asked to rank their confidence levels in the area of facilitating longer-term science projects with students, 92 percent of the providers indicated an increase from either “only a little confident” or “somewhat confident” to “very confident” or “extremely confident.” Ninety-four percent of providers ranked student enjoyment in the “some” to “a great deal” range. Eighty-three percent reported doing “more” hands-on science activities with students as a result of this project.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: BUILDING LIFE SKILLS THROUGH HANDS-ON AND COOPERATIVE LEARNING

Description: Life skills give children the tools they need to respond to a diversity of life situations and to achieve their personal goals. Well-developed life skills are associated with a higher sense of self-worth and competence, and an enhanced ability to work well with others, express feelings, solve problems and welcome new experiences. There has been some debate among experts about the process through which after-school programs benefit child development and life skill acquisition. The UC ANR After School Workgroup adapted a Web-based evaluation tool that was developed by Washinton State University. The survey measures the effectiveness of after-school programs in assisting youth in the acquisition of life skills. A pilot study of the evaluation was administered to 363 children ages 5 to 13 who were enrolled in 4-H after-school programs in Placer, Nevada and San Diego counties. Decision making, communication skills, accepting differences and making healthy choices were some of the life skills measured. The workgroup was also interested in developing a user-friendly evaluation tool that could aggregate data from multiple programs. The use of this survey format and Web-based data entry was studied and found to be an easy process for after-school program staff to use to measure their students' life skill acquisition.

Impact: The new evaluation revealed that participation in after-school programs that use hands-on and cooperative learning and that provide interaction with competent adults enhances children's life skills. The study also found that the gains over time differed depending on the children's age, gender and ethnicity. For example, the study found that Hispanic children achieved greater gains in making healthy choices because of the program than all other children surveyed. In addition, as a result of this project, UC's 4-H Youth Development advisors and other youth program administrators all over the state now have access to a pilot-tested life skill evaluation survey they can use to measure the effectiveness of after-school programs.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: IMPROVING YOUTH PROGRAMS

Description: This program is based on a needs assessment survey to ascertain youth serving agencies' topics of interest and preferred delivery systems and teaching strategies. There is also a research component within this program to:
1) better understand the underlying operational strategies (theories) among youth

development workers; 2) gather demographic data about youth workers to get a better understanding of the current status of the field; and 3) gather information on the needs (learning styles, informational, theoretical, etc.) of youth workers. A team of Youth Development Advisors have worked together on this project that offers 26 workshops in youth development program management, foundations of successful programs and curricula for use in after school and other community youth development programs. The objective of this project is to improve the quality of out-of-school programs.

Impact: Based on the needs assessment, advisors develop workshops based on the latest research. Workshops, including handouts, are peer-reviewed by the team members. Approved workshops are described in their brochure, *How to Improve Your Youth Program*, and distributed to out-of-school program staff. Program staff selects desired workshops and requests training. They consult with the staff, tailor the workshops to fit the agency's specific needs, and travel to the agency site and deliver the workshop. Each workshop is evaluated using a retrospective pre and post test. Results from the evaluation show that of the 24 participants, 24 (100%) showed growth in at least one area and 18 (75%) improved in all five of the following areas: 1) know the difference between service-learning and community service; 2) know five elements of high quality programs; 3) have ideas how to increase the educational value of a project; 4) have ideas how to increase the service value of a project; 5) have a rough plan for beginning a project.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: PROJECT LEARNING TREE, PROJECT WILD, AND PROJECT WET

Description: The "Projects" (Learning Tree, WILD and WET) are interdisciplinary, supplementary conservation and environmental education curriculums for educators. The concepts in the Project curriculums provide learners with opportunities to engage in hands-on learning experiences that demonstrate the direct relationship to assessing environmental health through the study of forests, terrestrial and aquatic wildlife and water.

Impact: The city of Marina California is approximately three miles from the shore of the Pacific Ocean, and is statistically recorded in the Cal 4-H enrollment system as a suburb. Educators indicate that the 77% non-Caucasian student enrollment at the site rarely take advantage or has the opportunity to take advantage of the natural environment at their doorstep. Through the implementation of the Project WILD program, students have utilized their own

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community as a living laboratory to gain an awareness and understanding of their natural environment and to actively participate in the discovery of new ecosystems and environments. To date 2 sites have been trained on the "Projects." In total, 7 adults have provided over 95 children with hands-on experiences to assess environmental health through the study of forests, terrestrial and aquatic wildlife and water.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

SECTION B. STAKEHOLDER INPUT PROCESS

The University of California Division of Agriculture and Natural Resources (UC ANR) continued to use a variety of mechanisms to seek stakeholder input on the development of Division program priorities and use of its research, extension and education funds. In addition, CE advisors delivering programs in 57 California counties receive input on local needs from their local clientele on a daily basis. All of the input received from stakeholders is used by ANR members in program planning and implementation at the local, regional, and statewide level.

UC ANR Workgroups

Division program workgroups are a primary mechanism for accomplishing ANR's high priority research and extension goals through grassroots leadership. They bring together Agricultural Experiment Station (AES) and Cooperative Extension (CE) personnel along with non-ANR partners to work on emerging and continuing priority issues in Division program areas. There were 74 Divisionwide workgroups and 11 Coordinating Conferences with a total membership of over 2,200 individuals.

Non-ANR participants are identified by the scientists, advisors and specialists working in the specific program area and invited to participate in workgroup activities, including needs assessment and issue identification and evaluation and reporting of program results. ANR workgroups involved approximately 1,200 external stakeholders in their program planning process and workgroup activities and projects. The involvement of external stakeholders in the workgroups ensures that real world needs are brought to the attention of University scientists and extension specialists and advisors as programs are planned and implemented. External stakeholders on the workgroups include individual producers, representatives from local community groups, state and federal agencies, industry groups, consumer groups, and colleagues from other higher education institutions.

The California Alfalfa and Forage Systems Workgroup is an excellent example of the involvement of external stakeholders in ANR program planning and deliver. This workgroup addresses educational, research, and grower/public outreach needs for the state's alfalfa and forage crops which occupy more than 2 million of the 8 million irrigated acres in California. The workgroup coordinated research and educational activities focused on areas identified by stakeholders, including alfalfa pest management, water resources, irrigation, silage systems, forage quality, cropping systems and economics, alternative forages, seed genetics, biotechnology, and environmental issues. The workgroup envisions more sustainable, lower impact forage systems for the future.

This workgroup engaged fully with growers and public agencies and the general public to address public issues. The workgroup continued to have a tremendous impact upon the forage systems here in California. In terms of grower liaison

with the University, the Alfalfa Workgroup has taken a role of genuine leadership. The workgroup interacted with the California Alfalfa and Forage Association (CAFA), on several projects, and growers are frequent attendees of the workgroup symposium and other CE activities. Workgroup members are actively working with CAFA to develop long-term sources of funding for University research, and on vital water quality problems facing the industry.

The workgroup organized, sponsored, and provided the leading role for the California Alfalfa Symposium, held in Visalia, CA, December, 2005. Over 550 people attended. Water issues, water quality issues, economics, and pest management issues were addressed by experts from California and neighboring states. Growers, Pest Control Advisors, educators, and industry members attended, and the conference was widely appreciated by attendees. The California 2005 Alfalfa Symposium Proceedings, compiled and made available on the Internet by a workgroup member provides a rich source of information about western-grown forages. This publication along with the 'California Forages' website continues to receive many hits from the public. In 2006, publications on the Coexistence of Biotech Alfalfa were completed and the publications of the Intermountain Alfalfa Manual, and the Overseeding and Companion Cropping, Alfalfa and Wildlife publications, published in the 1990s through present times, continue to have impacts.

Plans for the 2006 Western Alfalfa Symposium, led by members of the California Alfalfa Workgroup are underway. The program for this has now been developed in cooperation with colleagues from 11 other western states.

UC ANR Coordinating Conferences.

Coordinating conferences bring together Agricultural Experiment Station (AES) faculty and Cooperative Extension (CE) specialists, CE advisors, and selected clientele into a Divisionwide forum to promote effective communication and interaction among the members and to promote statewide programmatic coordination of research and outreach activities relating to a major subject matter or commodity area. The nine coordinating conferences:

- Foster interactions, communication, and collaboration across traditional inter-campus, interdisciplinary and inter-departmental boundaries, and among campus and county-based academic staff
- Create a more visible and active focal point - both within and outside the University - for research and outreach activities
- Facilitate the formation and activities of appropriate workgroups addressing targeted areas within the overall programmatic area
- Provide leadership for addressing crosscutting issues

The Water Resources Coordinating Conference (WRCC) was held April 26, 2006 in Woodland, CA. The meeting was held in conjunction with the Surface Water

Quality Workshop on April 27. The purpose of the WRCC was to provide a "big picture" view of water issues facing California and discuss how the University of California fits into that picture. The conference was intended to provide attendees with insight on how farm advisors, specialists, and faculty respond to issues; identify current priorities on water resource issues in California; and present information on emerging water resources policy issues. Specific topics addressed included the 2005 Water Plan Update for the State of California, climate change and its impacts on the state's water resources, agricultural discharge waivers, and TMDLs. There were 94 people pre-registered for the meeting, 60 of whom are ANR members.

The WRCC provided an opportunity for ANR members to hear from experts and policy makers on California's TMDL goals and research needs (presentation by Craig Wilson, State Water Resources Control Board), agricultural discharge waivers in the Central Valley (presentation by Diana Messina, Central Valley Regional Water Board), and how agricultural water users will be affected by changes in water policy due to population growth and climate change. Presentations during the WRCC were given by faculty, farm advisors, and specialists to provide a variety of perspectives on what work is being done, and inspire ideas for collaboration. Presentations were also given by representatives from state regulatory agencies (State Water Board and Regional Water Board) and a policy analyst (Public Policy Institute of California) to provide the perspective of those outside the university and have them tell us what they need from us (TMDL Research Needs by Craig Wilson).

With a goal of providing a big picture view of California water resource issues, the WRCC attracted a variety of attendees from different backgrounds. Many comments provided on the conference evaluation form indicated that the diversity of speakers and the range of topics was appreciated. The policy related issues highlighted in the opening session were of particular interest to many due to their lack of general familiarity in the background of economic and policy decision making processes. The evaluation form asked attendees to suggest topics to be covered in future meetings. Suggested topics are varied, ranging from more coverage of economic issues and water quality modeling to specific contaminants such as pathogens and pharmaceuticals. These will be used to develop a plan for a future meeting to address some of the issues of concern.

The presentations given at the WRCC were well received. The agenda for the day's events is available online and PDF versions of the presentations will be posted. The goals of the conference, as outlined in the original proposal, were presented to attendees as statements of accomplishment to which they were asked to agree or disagree. Evaluation responses indicate that these goals were met (see table below).

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The WRCC...	Agree Strongly	Agree Somewhat	Neutral	Disagree Somewhat	Disagree Strongly
Helped me to gain a more comprehensive understanding of water resources issues in California.	12	8			
Provided insight on how farm advisors, specialists, and faculty respond to issues	12.5	5.5	2		
Identified current priorities in water resources issues in California	11.5	5.5	3		
Presented information on emerging water resources policy issues	9.5	9.5	1		
Presented useful examples of effective natural resource programming	8	6	4		

Formal advisory groups

The President of the University chairs the President's Advisory Commission on Agriculture and Natural Resources to identify the education needs of California's agricultural, natural and human resources interests and advise him on how the University can best meet these needs through its science-based research, classroom instruction and educational outreach. The members represent 28 business, consumer, youth and government leaders from throughout California and meet twice a year to provide input. The Vice President - Agriculture and Natural Resources participates as a member of this Commission and brings the Commission's advice to the Executive Council, the Division's administrative group charged with Divisionwide strategic planning.

Each of the three colleges at Berkeley, Davis and Riverside and the School of Veterinary Medicine at Davis, have external stakeholder advisory councils that meet at least annually to provide feedback on their research, extension, and teaching programs. Members of these councils represent the spectrum of clientele who use the Division's programs and who have expressed interest in providing input to the college/school planning efforts.

Several of the Statewide Special Projects and Programs have external Advisory Councils that meet at least annually to review progress and offer recommendations for future program direction.

Commodity Organizations/Marketing Order Boards

Members of these organizations provide annual input on research and extension needs for their commodities to UC ANR members through regular meetings and discussion of funding for research projects. These individual groups also come together on an annual basis to form the California Commodity Commission. This Commission meets with the Vice President and offers specific recommendations on program planning and funding issues.

SECTION C. PROGRAM REVIEW PROCESS

There has been no significant changes to the California program review processes since the UC Plan of Work Update, submitted in July 2000.

SECTION D. EVALUATION OF SUCCESS OF MULTI AND JOINT ACTIVITIES

(1) Did the planned programs address the critical issues of strategic importance, including those identified by the stakeholders?

California's research and extension professionals planned and delivered programs that addressed the critical issues facing the state in the areas of agriculture, natural resources and human resources by pooling the expertise of California AES and CE academics, by collaborating with colleagues in other institutions, agencies, and states and by consulting and working with the external stakeholders. As described in the Planned Programs narratives in Section A, University of California research and extension programs addressed critical issues facing the state such as invasive pests, water quality and water distribution, and food security. Below are a few examples of UC research and extension programs addressing the critical issues identified by California stakeholders:

Theme: 1.03 Agricultural Profitability

Title: Economic Study Helped Determine Growers' Compensation for Vineyard Losses

Description: Beginning in 1998, over 40% of the Temecula Valley vineyards were pulled out due to Pierce's disease spread by the GWSS. As part of the federal law passed in the year 2000, the California Department of Food and Agriculture (CDFA) received money to help/compensate growers for grapevine losses resulting from the disease. Information on costs of establishment for areas impacted by the disease was needed to determine the amount of compensation/help to growers. An economic study analyzing the costs of establishment and production was developed for wine grapes in Temecula, Riverside County. This study detailed production practices, and estimated and analyzed the capital needed to establish vineyards and produce wine grapes in the area. The study was developed in cooperation with growers using the practices and costs of their vineyard establishment and production. The values and analysis in the study were used to determine the amount of compensation that growers could receive. The costs of establishment and production provided both growers and CDFA the detailed cultural practices and economic basis for discussion and determination of a fair compensation.

Impact: Wine grape growers in Temecula received \$5.6 million dollars compensation from CDFA for vine losses. This compensation enabled many of the growers to replant their vineyards and stay in the business of wine grape production. Today, the Temecula wine grape industry has recovered many of its losses and continues to build the economy of the community. In 2005, the industry contributed about \$4 million in crop value to the economy. The revival of the industry also restored employment in agriculture and service industries. It enabled the wine industry to stabilize and continue generating income to the community through tourism

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: Cotton Management Practices, Variety Choices for Quality and Production Efficiency Improvements

Description: Grower choices in crops, varieties and production systems are changing in many agronomic crops, including cotton, due to numerous production concerns. The considerations include rising production costs, stagnant commodity prices, potential for improved yields with changes in type of crop, impact of crop quality characteristics on price received, and input constraints such as higher cost fertilizers and water, or reduced availability of good quality water. Variety trials included different cotton types (Pima, CA Upland, Acala), with evaluations of growth, quality, disease resistance (Fusarium or Verticillium wilt), and field evaluations of newer-generation herbicide or insect resistant transgenic varieties. Research identified yields and fiber quality differences that impact grade and price. Planting date, growth regulator and water management studies in Acala and Pima cotton demonstrated significant differences in crop growth and gas exchange responses to timing and degree of water deficits. Trials have shown changes in crop growth, consistency in plant emergence and survival under different seed fungicide treatments, under different bed planting patterns (double-row, conservation tillage), reductions in number of tillage passes, and utility of herbicide-resistant transgenic varieties in these alternative systems. In long-term evaluations of double-row plantings, yield increases of 4 to 15 percent occurred with double-row compared with single row in about one-half tested locations, with no significant impact at remaining sites. Yield increases were consistent typically at sites where plant vigor was lower and plant size limited yield potential. In field trials, tested transgenic herbicide resistant varieties with an extended allowable application period (glyphosate resistant) provided yields and fiber quality statistically the same as conventional, closely-related cotton varieties. Long-term trials evaluating feed-back nitrogen management approaches for Acala cotton (soil, plant tissue testing and plant mapping) demonstrated an approach to use in decisions to adjust fertilizer nitrogen application rates to avoid unnecessary applications. A race of Fusarium, which can cause fungal disease in susceptible varieties, was identified as newly-recognized race (race 4) with potential to seriously impact susceptible varieties. Disease screenings to evaluate plant survival, foliar and root damage were done at 2 grower field sites and one greenhouse site. Information on varietal susceptibility and relative damage was produced, indicating existence of highly susceptible and highly-resistant varieties in Pima, including commercially-available and experimental entries. Results were less definitive in Upland cotton, where tested varieties ranged from moderate to severe in percent infected, but with less severe impacts on plant survival, plant growth and vigor in most tested varieties. Late season foliar decline symptoms were investigated and found related to multiple nutrient deficiencies late-season, but with severity of symptoms and yield losses more related to root system limits in depth or density.

Impact: Grower interest in changes in practices (reduced tillage, bed configurations, cotton types, irrigation systems) is high due to potential to impact production costs, environmental protection or improve yields. Options tested include double- row beds, transgenic herbicide tolerant varieties. Trials showed system changes often reduce some costs and tillage pass number, but yields and crop earliness were improved mostly under conditions with less vigorous plants. Reduced costs, reduced tillage must be balanced against some increases in planting and harvest expenses. Studies evaluated residual soil nitrate sampling, crop nitrogen (N) status, plant growth, fruit retention monitoring to provide information to improve N use efficiency and reduce losses. Data on best-performing varieties, irrigation, nutrient management in Acala, Pima, Uplands in multi-county tests helped growers with variety decisions impacting yield, quality, profitability. Disease problems (Verticillium, Fusarium) were investigated to give growers updated information to reduce disease impacts. A newly-described race of Fusarium was described, and screening work continues to provide growers with information on varietal differences in resistance. Problems in Pima called early decline and late season potassium deficiency problems in Upland cotton both were found to slow vegetative growth rates earlier than typically desired, with foliar damage shown to be correlated with potassium or nitrogen deficiency, and foliar symptom severity and growth reductions related strongly to rooting depth and distribution limitations.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability

Title: Agronomic Practices Affecting Yield, Forage Quality, and Sustainability of Irrigated Alfalfa

Description: This UC research focuses on agronomic practices, water-use efficiency, irrigation management, variety adaptation, forage quality and pest management of alfalfa, and the interaction of forages with environmental and resource-use issues. A 3-year trial on cutting schedules and varieties was completed in 2005, and they reported the final data for the yield-quality tradeoff in alfalfa, and its implications for harvest management, variety selection, and stand longevity. Economic tools to judge that tradeoff have been provided, and the data reported in the California Alfalfa Symposium Proceedings. Variety trials conducted at UC A wide range of environments are included including desert environments, Mediterranean environments, and intermountain environments (see <http://alfalfa.ucdavis.edu>). Continuing studies on improving IPM thresholds for alfalfa weevil have resulted in a re-examination of these thresholds; they should be coming out with revised thresholds during 2006. A project on the effect of deficit irrigation of alfalfa on grower's fields and in small-plot studies documents yields losses of 1-2 Mg in yield during late-summer deficit irrigations, but this did not occur at all locations. Where high water tables contributed to ET, yield losses were negligible. At one location, where ET was measured, differences in ET between fully watered and deficit trials were approximately 28 cm in water savings. There is a need for better understanding of the yield losses

associated with deficit irrigation, methods for approaching deficit irrigation, and the economics of water use efficiency. Studies on the sampling and measurement of the Roundup Ready Trait in alfalfa hay were conducted during 2005; they sampled field-grown crops with 0,1%,5% and 10% adventitious presence of this genetically modified trait. Two commercially available test strips were always able to detect AP at 5%, and sometimes 1%. Methods to enable coexistence of biotech and non-biotech traits in alfalfa were described. A new project was initiated in 2005 to study the nutritional value of hydrolyzable tannins in alfalfa for increasing protein utilization efficiency and reduce the environmental impact of dairy wastes. Studies were conducted on alternative forages in 2003 including ryegrass, sudangrass and BMR sorghum crosses, and various cool-season perennial grasses.

Impact: Their research on varieties is worth between \$50-\$400 million/year to CA growers due to increased yields. They have enabled a scientific evaluation of the yield-quality tradeoff with varieties and cutting schedules, very important to growers. Deficit irrigation work on alfalfa may enable orderly voluntary water transfers in future droughts.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.11 Biotechnology

Title: Engineering Crops Resistant to Abiotic and Biotic Stress with Improved Growth and Enhanced Quality

Description: 1. Development of salt tolerant crops. The UC researchers have completed a number of field trials aimed to characterize the ability of transgenic tomato, rice and cotton to grow at high soil salinity conditions. Some of the trials show encouraging results, showing the ability of rice and cotton to produce significant yields at conditions where the wild-type plants were severely reduced by the environmental conditions imposed. 2. Development of drought tolerant crops. They have generated transgenic tobacco plants that show enhanced tolerance to severe drought conditions. These plants have been modified in order to strengthen source tissues and produce sinks able to withstand complete dehydration. They are now in the process of demonstrating in the greenhouse the ability of these plants to produce high yields under extremely low watering regimes. The trait is being introduced in cotton and rice and they expect to have homozygous transgenic plants in the next granting year. 3. Global gene expression analyses under salt stress. They have identified and characterized a T DNA insertion knockout mutant of the vacuolar sodium/proton antiporter in *Arabidopsis thaliana* and used these mutant lines and also lines overexpressing the antiporter to analyze global gene expression under salt stress using DNA arrays. They are now in the process of submitting their results showing the molecular network that is affected by ion and pH homeostasis. 4. They have made significant advance in the characterization and identification of the key enzymes and transporters controlling the sugar to acid ration in citrus fruits. They have also identified molecular determinants that control the final sugar concentration in the fruits and started experiments aimed at altering the

sucrose/fructose ratio during the post-harvest process producing sweeter fruits with a high marketing capacity.

Impact: Environmental stress due to salinity and drought is one of the most serious factors limiting the productivity of agricultural crops, which are predominantly sensitive to the presence of high concentrations of salts in the soil and low water availability. California crop production in both the Imperial Valley and the San Joaquin Valley is particularly affected by drought and soil salinity. Their work has generated a number of patents that have been licensed by the California biotechnology industry to develop cultivars that will produce better on saline soils and/or low water availability. Substantial water savings could be realized by reducing or even eliminating the need to either over water or leach to remove salt from the soil profile; this further savings of water will also contribute to balance state watersheds that are largely dependent on water imported from other regions.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.12 Bioterrorism

Title: Virulence Factor Secretion by Pathogenic Bacteria

Description: The UC researchers have expanded their studies of how virulence factors are secreted by pathogenic bacteria. Significantly, both flagellar and contact-dependent type III secretion systems were demonstrated to display conserved requirements for polypeptide targeting. They have additionally made strong progress toward defining the role of the Ysa type III secretion systems in the pathogenesis of food-borne illness. Their recent results indicate the Ysa type III secretion system is important for bacterial survival in the small intestine.

Impact: Food-borne illnesses have a direct impact on human health and economic productivity of California and the United States as a whole. Most food-borne illnesses occur as a result of accidental contamination, but there is growing concern that food may be used as a vehicle for delivery of a bioterror agent. This research positively impacts the stakeholders by providing a clear understanding of how food-borne pathogens survive and promote disease.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.15 GIS/GPS

Title: Monitoring and Control Measures for Pierce's Disease in Kern County

Description: Pierce's disease (PD), caused by the bacterium *Xylella fastidiosa*, is a killer of grapevines. Significant vine loss from PD has occurred in Southern California, North Coast and portions of the southern San Joaquin Valley including Tulare and Fresno counties over the last 100 years. However, the arrival and spread of the glassy-winged sharpshooter (GWSS), a more effective vector of the disease, caused devastating losses in the wine-growing regions of Temecula and threatened Kern County, a major grape production area of the state with more than 87,000 bearing acres and a farm gate value of approximately \$438 million dollars. A large-scale, joint research project was initiated in 2002 between

the UC Cooperative Extension and the California Department of Food and Agriculture to map the incidence and track the spread of Pierce's disease (PD) within 215 vineyard blocks in Kern County. The area was selected for evaluation because of its importance as a major grape production area and its short history of GWSS infestation. The acreage surveyed within the project represents over 4,000 acres of grapes or, roughly 5% of the total bearing grape acreage in the county and 15 cultivars of varying ages were examined.

Impact: This project has provided multiple positive impacts to grape growers, public agencies working to reduce the populations of GWSS and limit the spread of PD and to those in the research arena. First, the benefits to growers included one-on-one education about the disease and a three-year personalized data set revealing the PD status of individual vineyards and the locations of affected vines for more than 30 growers that cooperated in the project. This data set was used to encourage growers to pull out diseased vines in order to eliminate sources of the bacteria for spread by the GWSS. Since the inception of the project, they have observed an 83% reduction of PD from 2002 to 2003, and a subsequent decrease of 60% from 2003 to 2004 in the vineyards located in the General Beale Pilot Project, an area where the GWSS was first discovered and significant vine losses had occurred due to PD (see photo above). Secondly, the data set provided an essential layer of information to the USDA Area Wide Management of GWSS Project on the history and location of PD in Kern County. This information was used to designate treatment zones in which it was absolutely critical to keep GWSS populations down to slow the spread of PD. The information generated from the project was modified for presentations at several field meetings to demonstrate that effective PD control can be obtained with a combination of areawide GWSS treatment program and monitoring for and removal of infected vines. Finally, the data, maps and information has been shared with UC Riverside and UC Berkeley researchers to maximize the opportunity for generating projections of economic loss and new methods of disease management and sampling. The project has generated multiple hypotheses regarding the factors that contributed to the spread of PD in Kern County. There are three projects being conducted at Riverside and Kearney Research & Extension Center to test these hypotheses.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 1.23 Organic Agriculture

Title: UC 'Organically Grown' Help

Description: With the US market for organic products expected to top \$20 billion in 2006 and national organic standards in place, many farmers and consumers are looking for clarification on what constitutes "organic" and how to grow it. ANR is responding to these questions through local research and extension programs, publications and online resources. UC SAREP provides an organic farming information Web site with valuable information for growers involved in or transitioning to organic production. Two key resources on the Web site include: 1) UC Organic Farming workgroup directory, which lists contact information and

areas of expertise for UC faculty, UC CE specialists, and UC CE farm advisors working in organic research and extension; and 2) Online Organic Farming Compliance Handbook with information on principles of organic production, National Organic Program standards, materials compliance, organic marketing and economics, and extensive links to other resources and organizations. With a grant from the Clarence E. Heller Charitable Foundation and the True North Foundation SAREP also supported county level activities in organic research and extension in 11 California counties (Marin, Humboldt, Ventura, San Diego, Santa Barbara, Fresno, San Joaquin, Sonoma, Mendocino, Sutter-Yuba, Pacer-Nevada). With support from a CDFA Buy California Initiative grant, SAREP is working on a series of organic production manuals for four crops: olives, winegrapes, vegetables and strawberries.

Impact: The dramatic increase in California organic growers (more than 2,500 are officially registered on more than 200,000 acres) is beginning to be served by UC CE advisors and research. Client growers are applying what they have learned from on-farm research plots in soil fertility management, pest control, plant pathology, productivity, cover crop evaluations, biofumigation, compost effectiveness and weed prevention. Growers have also used information on medicinal herb farming, natural and organic beef, farm diversification, organic strawberry production, organic livestock opportunities, direct marketing, farmstead cheeses, specialty crops and organic transition and certification.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Integrated Canopy Management in California Nut Crops

Description: Objective 1- Original objective has been completed. Final results were presented in 2003 and final reports are listed below. New work is being conducted on influence of pruning or non-pruned treatments on growth and productivity of young Howard walnut trees. Objective 2- This project was initiated to investigate the dynamics of spur renewal, fruitfulness and longevity and to determine how these are influenced by nitrogen and irrigation. Monitoring will be carried out for 6 years to quantify the impacts of treatments on spur longevity. In 2005, all three deficit treatments had significantly lower midday canopy light interception than the control throughout the season. Once again, midday stem water potentials were maintained near target levels throughout the 2005 season. All three deficit treatments led to significantly lower yields in the fourth year of treatment imposition. However, if yields per unit light intercepted was calculated, all three deficit treatments had significantly higher yields than the control in 2004 and equivalent yields to the control in 2005. This suggests that if deficit irrigated trees had been planted closer together, they might have had higher overall yields compared to the control. Incidence of kernel mold has continued to be less in deficit irrigated trees. Significant changes in leaf specific area (a measure of spur quality), particularly in inner canopy positions in the deficit treatments, may lead to improved spur longevity and shifts in canopy nut production patterns in the coming season. Objective 3- The emphasis for this work has shifted somewhat

and preliminary work is now being done in studying role of water stress in seasonal variations in plant protective compounds in walnut as well as interactions with mold. In addition, work is being done on influence of deficit nitrogen and water treatments on shell seal and resulting potential for insect damage and microbial contamination potential.

Impact: Deficit water management combined with selective pruning has been shown to have applicability in managing dense plantings, if trees have filled in allotted space when deficits are imposed. In addition to providing canopy management benefits, deficit irrigation management may make the orchards less susceptible to insect and/or fungal pests. By minimizing irrigation events, pruning tower use and spraying operations, reliance on fossil fuels can be decreased while minimizing pesticide usage. Employing these techniques would provide direct benefits to growers by decreasing costs of production and reducing potential for worker and environmental pesticide exposure while producing products with the lower pesticide residues consumers' desire. Preliminary data suggests that deficit water and nitrogen treatments in almond may allow an equivalent or more productivity as the orchard matures. This information has been extended at numerous industry conferences as well as UC CE farm advisor's county meetings.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency

Title: Rootstock and Interstem Effects on Pome and Stone Fruit Trees

Description: Apple: A Fuji rootstock trial was initiated at the UC Kearney Ag Center in 1999 with six single tree reps of 21 rootstocks. Valuable information regarding fireblight has been obtained. A total of 14 trees have died so far, presumably from fireblight. Thirteen of those were on the standard rootstocks M9 and M26. Of the experimental trees, only one on Supporter 1 has died. All of the Cornell-Geneva series (which were bred for fireblight resistance) have survived so far. A second NC-140 apple planting was initiated in 2003. The scion is Golden Delicious and there are 23 experimental rootstocks. Once again, fireblight has killed about 20 M9 and M26 trees but none of the experimental rootstocks. Peach: A NC-140 peach rootstock trial was planted in 2001. Fifteen rootstocks were planted in California and about 18 other states for evaluation. Of the semi dwarfing stocks, Bailey and Hiawatha looked the most promising. Both had good production and fruit size in 2005. Pumiselect had small fruit size and was not very productive. Of the dwarfing rootstocks VVA-1 looked the most promising. An ongoing evaluation program for peach rootstocks is now entering its final stages of evaluation. Initially, over 80 items were evaluated for compatibility, productivity, dwarfism and root sucker production. Ten rootstocks showed promise and were put into a replicated trial at two different spacings with two different scion varieties. Two selections have continued to meet the criteria for commercial peach rootstocks and have been patented. Both are semi-dwarfing rootstocks with no root suckering, compatibility with a range of scion varieties and good productivity. An ongoing breeding program for stone fruit

rootstocks will continue with the objective of combining tree size control with resistance to important diseases and pests including nematodes.

Impact: The fruit growers in California have rated dwarfing rootstocks as one of their highest priorities. There is the potential for greatly reducing labor costs and disease resistance rootstocks can also reduce labor and pest management costs as well as improve productivity. Therefore, they are very interested in the potential this project offers for the future survival of their industry. For the apple industry, there are some very promising dwarfing rootstocks with good fireblight resistance. This will improve tree survival in the orchard and could eliminate such cultural practices as cutting out fireblight strikes. For the peach industry, currently there are no commercial dwarfing rootstocks. This project provides information on some very promising dwarf and semi-dwarf rootstocks that could greatly reduce labor costs in the orchard by eliminating much ladder work.

Funding Source: Multistate Research and State

Scope of Impact: AR, Arkansas Cooperative Extension, CA-D, California Cooperative Extension, CO, GA, IL, IN, IA, KY, ME, MD, MA, MI, MN, MO, NJ, NYG, NC, OH, OR, PA, SC, TN, UT, VT, WA, WI

Theme: 3.03 Human Nutrition

Title: The Impact of Eliminating Sodas in the School Environment on the Calorie and Calcium Intake of Adolescents

Description: Initial work includes a phase for the development of a nutrition and health policy with selected schools and school districts to encourage the establishment of a healthy school environment. A current challenge that this project addresses is the pressure on the school system to adopt established national and state academic content standards, align local curricula and student assessments with the standards, and be accountable for improved student outcomes as measured by standardized student examinations. Knowledge and skills are often considered appropriate primary outcomes. These include behavioral capabilities or the information and skills needed to eat a more nutritious diet and the critical thinking skills and procedural knowledge needed to analyze and make informed judgments on complex food and nutrition-related issues. As part of this project, the UC research group has developed a model program that incorporates agriculture into the school environment. It includes every part of the school environment, from gardens, to the cafeteria, to the classroom, as part of a consistent and repetitive message to students, that healthy eating habits can be learned through participation in the full cycle of life from seed to table and back again. California principals and teachers have been surveyed with respect to their use of gardens as part of the school environment. Results from these studies suggest that fourth grade teachers predominately use school gardens to enhance academic instruction, which is in strong agreement with principal responses obtained previously. The model program will be implemented and evaluated in selected schools in California and will include teacher and staff training to establish the following program components: 1) salad bars, 2) nutrition and gardening education, 3) composting and waste reduction and 4) development of a school food, nutrition and health policy. As

part of the nutrition education portion of this project the UC research group is developing and assessing nutrition curriculum materials for multiple grade levels. Reading Across My Pyramid (RAMP) is a literacy promoting nutrition education curriculum targeting lower elementary students. Through the use of nutrition related books, RAMP aims to increase the nutrition knowledge of students while fostering the development of reading skills. As part of the evaluation, a short survey based on topics covered in RAMP lessons was developed and tested for clarity. Revisions were made accordingly and the survey was used in Contra Costa, Fresno and San Diego Youth FSNEP (N = 62) to evaluate RAMP. A parent survey was also used to determine correlations between the responses of children and their parents. Data showed RAMP to be effective at increasing the importance of exercise in the minds of children, knowledge that the heart pumps blood through the body, and knowledge that computer use and television watching are not exercise. A correlation was also observed between parent reported hours of television watching by their child and the child's knowledge that computer use and television watching are not exercise.

Impact: A comprehensive school health program, that includes involvement from families, communities, and health professionals, may be able to overcome obstacles, such as lack of parental involvement or classroom time, by bringing individuals together to support a common vision, therefore facilitating efforts focused on a sustainable healthy school environment. Their long-term project goal is to evaluate the efficacy of using the school environment to link schools with families and communities to promote healthy lifestyles that will assist in the reduction of obesity prevalence among children. Specifically, they will introduce a comprehensive school health policy that envisions every part of the school atmosphere, from the playground to the cafeteria, to the classroom and then to the community, as part of a consistent and repetitive message to students; that healthy lifestyle habits can only be taught to children when there is participation of the entire community.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Changing the School Environment Increases Awareness about Healthy Habits

Description: In the past, people were aware of the important role farming played in their lives. Children, especially, have lost touch with how and where food is grown. They lack an understanding of the ecosystems, the land, the people, and even the plants that produce their food. Many school districts throughout California have shown an interest in "stepping out of the box" of traditional teaching methods to incorporate agriculture into several aspects of the school environment. This provides an excellent avenue in which to discuss food – where it comes from, its health benefits, how to choose healthy foods, factors contributing to human health, as well as concepts important to planetary health, such as, composting and recycling.

Impact: Kindergartners participating in this project learned to identify that MyPyramid is a tool to assist with dietary choices, what plants need to grow, why milk is important, and that dancing, not computer use or television watching, is a form of exercise. The kindergartners also decreased their soda consumption. Fourth and fifth graders participating in this project learned what foods are flowers, what nutrients provide their body with energy, why calcium is important, how many food groups are in a particular meal, messages from MyPyramid regarding grain and vegetable choices, what measuring your pulse tells you, what aerobic exercise is, what a healthy goal is, and how to identify food marketing schemes. The fifth graders also increased fruit and decreased cookie consumption. The results show that this school wellness program can be a successful means by which to increase awareness about the importance of proper nutrition and physical activity among participating students.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 4.09 Forest Resource Management

Title: CALIFORNIA HARDWOODS PROVIDE ECONOMIC DEVELOPMENT OPPORTUNITIES

Description: California hardwoods are an underutilized natural resource. California is a major consumer of hardwood lumber (20 percent of nation's production) but the hardwood lumber production industry in the state is almost non-existent; this is in spite of a sizable hardwood tree resource (12 billion cubic feet of timber growing stock). The economic viability of a native hardwood lumber industry depends on a thorough understanding of the lumber recovery and grade yield expected from the resource and a solid knowledge of wood properties and manufacturing characteristics. The focus of this effort is to encourage a sustainable California hardwood industry by identifying basic industry needs, raising the awareness of the potential for value-added products, developing good manufacturing practices, and providing technical assistance. The ANR wood resources group analyzed the structure of the existing hardwood industry in California, identified the needs of the industry to sustain growth, studied the properties and unique characteristics of native hardwoods, and through research developed recommended manufacturing techniques. Direct technical assistance for small businesses and a series of processing workshops were used to deliver this information throughout the state. Three regional meetings were conducted with the primary stakeholders and other interested parties. Research and training needs were assessed by meeting with collaborators and by conducting a formal survey of the existing and potential hardwood industry in the state. The information obtained was used to identify gaps in knowledge, design the research effort, and develop training materials.

Impact: This project clearly demonstrated that utilization of some of the native California hardwood species have potential to create new jobs. Presentations to forest product industry representatives, small business, and entrepreneur clientele sparked interest in new ventures. This led to a 5-fold measured increase in hardwood lumber production and a 500 percent increase in small businesses

working with this hardwood resource during the past 4 years. The project was instrumental in cutting processing costs by 40 percent and dramatically increasing production in two new enterprises. In addition, the results were directly responsible for the best practices being implemented in a hardwood processing demonstration facility. By reducing losses to manufacturing defects these recommendations are directly responsible for a savings of \$ 2 million per year in a developing industry. The workshops and technical assistance efforts consistently receive excellent reviews by participants and peers, earning a reputation for the UC Forest Products Lab as the leading source for technical information/advice in hardwood processing. The delivery of technical information to more than 200 clients was responsible for increased efficiency in the production of hardwood lumber in California and the recognition that proper practices must be followed to succeed. Training was directly responsible for reducing manufacturing waste and lowering manufacturing costs at a new hardwood business by 20 percent, a savings of \$1 million per year. As new businesses are developed, the results of this project have the potential to create hundreds of new jobs in the depressed northern California economic regions. This project is expected to lead to the development of a sustainable hardwood lumber industry in northern California that meets environmental criteria for green certification.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

2) Did the planned programs address the needs of under-served and under-represented population of the State(s)?

Listed below are examples of California's efforts to address the needs of under-served and under-represented populations in the state.

Theme: 1.32 Small Farm Viability

Title: Farm Incubator Project Humboldt in County

Description: Beginning farmers often struggle to gain access to small parcels of land to test their farming ideas. The UC Farm Incubator Project was based on the concept of incubating new businesses by offering short-term leases, support services and fellow entrepreneurs to work with. Farmland will be preserved in rural communities if it is actively producing food, and if beginning farmers have successful experiences and can grow their farm business. For five years the Humboldt County CE Office held a lease on eight acres of prime farmland owned by the US Forest Service, part of a forest tree nursery. On the farm, eight subleases were created for new growers to test their ideas for crops. Since it is very difficult to find small parcels to rent, these one-acre sites met an important need. With low rent and a cooperative water supply, the UC Farm Incubator Project provided affordable-cost support for these entrepreneurial efforts. Workshops on farm business planning were offered to the participants, and the UC CE farm advisor was available for consultation on a myriad of agricultural

topics. Crops varied from garlic to quinoa and included iris, hydrangea, vegetables, nursery crops and forest species for sale to tourists.

Impact: As a result of this project, the participants' experiences helped them gain credit and become landowners. Three businesses went on to buy their own farmland. Others benefited by testing their ideas and deciding that farming was not for them, either for personal reasons or as a result of business analysis during the project. The project ended when the Forest Service ended the lease, as they had new uses for their land. The Farm Incubator project demonstrates a program that helps beginning farmers to get started.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 2.01 Food Accessibility and Affordability

Title: Emergency Mobile Food Pantry California Food Futures and Fiber (CF3) Grant

Description: According to the 2000 Census, 13% of Calaveras County's 40,554 residents live at or below the poverty level. In addition, almost 21% of the children in Calaveras County live in poverty. Hunger is a condition of poverty. Five remote areas in Calaveras County may suffer more from the impact of poverty due to their geographic isolation. The Emergency Mobile Food Pantry's goal is to reduce this isolation and diminish the effects of poverty by providing access to food, nutrition education and resource information by bringing these services to the community. A California Food, Futures and Fiber (CF3) grant was obtained to create an Emergency Mobile Food Pantry to serve five remote areas in Calaveras County. The goal of the grant was to improve the nutritional status of the target population. This goal would be met by providing access to food, nutrition education, and resource information on a monthly basis in the individual community. Food banks and pantries have traditionally just provided food to participants. This project is striving to break the cycle of poverty by providing information to families to decrease their dependence on emergency programs and become more self-sufficient by utilizing resources available. They are utilizing FSNEP to provide the nutrition education component creating a win-win situation. Families who utilize the pantry are generally food stamp recipients or are eligible for food stamps. They are collecting data using the FSNEP forms and will assess outcomes quarterly. The CF3 funding has expired but through collaborative efforts the project is continuing.

Impact: Approximately 100 families are served each month through the pantry. These families, in addition to receiving a food box, have also been exposed to a variety of information on basic nutrition, food safety, food budgeting and meal planning, food preparation and gardening. The project provides the opportunity to try new foods (brown rice, dried cherries, couscous and tofu) and ideas and recipes for including these foods in their monthly meal planning. In addition, information on many assistance programs is offered and participants are encouraged to enroll. Follow-up is conducted at the next visit. Valuable and useable information is provided to a population that was very resistant to any additional requirement. They are asked to become engaged in learning activities

and the majority is now willing, if not eager, to do so. Another unanticipated impact is the change in the food-banks core belief of their role in the community. Prior to this project and other collaborative activities, the food bank believed their primary role was to provide food - they were concerned with quantity. Today, they are concerned with the quality of food they give families and they are thinking about the nutritional needs of their clientele.

Funding Source: Smith Lever, State and CF3 grant

Scope of Impact: State Specific

Theme: 2.06 Food Safety

Title: Food Safety Training for Extenders

Description: Food safety is a topic of much interest as foodborne illness is on the rise due to emerging microbes, food grown and shipped from further distances, and more foods prepared commercially. Health and family service professionals and consumers rely on UCCE to provide current and accurate food safety information.

Impact: One hundred percent of participants returning a 6 month follow-up survey for Make it Safe, Serve it Safe indicated they had made positive behavior changes in handling food and/or training staff in safe food handling. Changes included incorporating food safety information into college level courses, training staff and clientele, and calibrating thermometers for professional and home use. Trained food safety volunteers provided food safety information to approximately 200 consumers yearly. The safe food handling posters were shared with the Make it Safe, Serve it Safe development team, who made them available statewide to CE staff. Don't Give Kids a Tummy ache training programs were presented to preschool staff reaching 49 individuals from Head Start and private preschools.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 2.07 Food Security

Title: Food Insecurity and Overweight

Description: The number of overweight adults and children has steadily increased in the United States since 1995. In California, the largest increases have occurred in the low-income Latino population. Current research documents greater risk of overweight among low-income children and among food insecure children. Food insecurity may mean families have "limited or uncertain availability of nutritionally adequate and safe foods in socially acceptable ways." This study took place in six California counties, including San Joaquin County, in Spring 2001. Low-income Latino mothers (n=561) with one preschool age child (biological) were recruited from community-based agencies. Four types of data collection methods were used: 1) the USDA Food Security Scale; 2) a demographic record form; 3) a food inventory survey; and 4) measured heights and weights of mothers and children. Bicultural research assistants were hired and trained in each county to conduct interviews.

Impact: Overall findings from six counties: a) food insecurity related to overweight among the mothers but not children; b) significant association between greater food insecurity and lower household supplies of dairy, grains, meat, fruits and vegetables; c) lower variety of most foods in most food insecure homes, particularly fruits and vegetables, and d) mothers who experienced severe levels of food insecurity as children were somewhat more likely to now be raising children who were overweight. The study resulted in two abstracts/poster presentations, one research article, and six individual county reports, including San Joaquin County's report. Data from the study will inform further outreach efforts regarding obesity and food availability.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 2.07 Food Security

Title: The Relationship of Poverty, Food Security, and Food Assistance to Child Nutrition in Latinos

Description: In the final phase of this project, UC researchers have finished analyzing data from an exploratory study related to past food insecurity and child feeding practices. In the last report, the preliminary findings were based on data collected to date. In the full dataset (n=87), they confirmed the findings that internal consistency of their past food security instrument is very good (Cronbachs alpha=0.84). Past food insecurity, measured by this tool, was significantly correlated with lower maternal education ($r = -0.45, p < .0001$), crowding in mother's childhood household ($r = +0.30, p < .006$, and greater past food insufficiency ($r = +0.74, p < .0001$). Compared to low-income US born mothers, foreign-born Latino mothers reported significantly greater levels of past food insecurity ($p < 0.01$). These findings were summarized in a paper that was submitted to the Journal of Nutrition Education and Behavior. Based on the research in their previous years, a review article was written and published in the Topics in Clinical Nutrition (#1). In that article, they conclude that household food insecurity or insufficiency may be associated with lower dietary quality and poor cognitive development and emotional/behavioral problems in children. Food insecurity or insufficiency is not associated with risk of being overweight in childhood, but deprivation during childhood may be related to adult obesity. In a clinical setting, neither anthropometric nor income measures are sufficient to determine whether food insecurity is a problem. Over the time period of this project, they have also conducted validation work of the food security instrument in rural Mexican communities, where many of their California immigrants originate (#2). They have found that the pattern of response to the 18 food security items in the Mexican population was similar to that previously reported for their Latino immigrant population in California, but the magnitude of food insecurity was much greater in Mexico. Only 2.8% reported being food secure, whereas 44% reported mild food insecurity, 33% reported moderate hunger, and 19.7% reported severe hunger. Greater food insecurity was significantly correlated with lower total food supplies ($r = -0.27^{**}$), animal source foods ($r = -0.23^{**}$), dairy products ($r = -0.19^*$), processed foods ($r = -0.31^{**}$), and

refined sugar products ($r = -0.27^{**}$), $*p < 0.05$, $**p < 0.01$.

Impact: The 18-item food security instrument is valid in both Mexican-born and US-born Latino populations. Household food insecurity is associated with lower dietary quality and behavioral/emotional problems in children. Latino parents who experienced food insecurity during childhood (but are now food secure) may use more indulgent feeding practices with their own children, compared to parents who did not experience food insecurity in the past.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.02 Human Health

Title: Gold Coast Collaborative

Description: The Gold Coast has a diversity of interest, cultures, geographies, communities and issues which offer opportunity and challenges in building healthier communities. The Gold Coast region reflects national trends towards increased obesity, less physical activity and reduced nutrition education in schools, and competition from highly marketed, less nutritious food choices. The intent of the collaborative is to bring together community leaders and decision makers to be advocates for everyone in the Gold Coast to enjoy a community which supports healthful eating and physical activity. In reviewing national, statewide and county statistics, a collaborative group representing over a dozen organizations in the Gold Coast will promote policies that will reverse the disturbing childhood obesity trend. In times of reduced financial resources, it is better to organize actions that will prevent ill health than scramble to meet the far greater costs of treating intractable problems. In addressing the health of all Gold Coast citizens, the Collaborative has placed a special focus on the needs of children.

Impact: In less than two years, the Gold Coast Collaborative has received great press and media coverage. Their policy recommendations are intended to change the factors that contribute to children's overweight in their environment. Thus far, the Ventura and Santa Barbara School Boards have changed their vendor contracts, eliminated the sale of high sugar and high fat foods and beverages. The Forum in Ventura was attended by 250 and reported as a separate project, while the Santa Barbara Health Forum attracted 25 participants and the Youth Forum had 75 attendees. Salad bars and gardens are featured in every Ventura Unified elementary and junior high school. Children are eating crops they harvest. Each county is developing different outcome measures to determine effectiveness. School principals and food service staff see increased fruit and vegetable consumption. The Collaborative has three goals: 1) Convene a Forum of experts and stakeholders to identify strategies to address the obesity epidemic; 2) Address Children's Environments: Ensure children have healthy food options, quality physical education and facilities for active play, (eliminate marketing of high-fat and high sugar foods/beverages, discontinue exclusive soft drink and fast food contracts, promote safe routes for walking and biking to school, incorporate nutrition and physical activity education standards into core

curriculum and develop and enforce nutrition and physical activity); 3) Implement and Enforce Laws for physical activity and safe routes to school.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Parent and Household Influences on Calcium Intake among Preadolescents

Description: This project recognizes that family knowledge and expectations play a significant role in young people's choice of food. It strives to create opportunities to strengthen nutritional knowledge and family ties. California developed a set of parent/child joint food preparation activities and published them in a book, *Bone Appetite!*. The book includes food safety and nutrition pointers as well as directions for joint or individual preparation of calcium rich foods. An evaluation component is part of the product. Twenty-five teams participated with more scheduled. Response from parents and children has been very positive. This cookbook is available to other states as a thank you for completing the research instrument. It may also be used as central component of a follow up study on the effect of nutritional interventions. California also tested the parent intervention research instrument and the pilot test of the parent and child evaluation with Hispanic households.

Impact: The results of this project will be used to identify factors that influence the calcium intake of young adolescents. This information can be used in designing effective, tailored nutrition interventions for young adolescents and their parents. An improvement in calcium intake among young adolescents may reduce the future burden of osteoporosis. The book *Bone Appetite!* can be used to teach food safety and nutrition by the researchers in collaborative universities.

Funding Source: Multistate Research and State

Scope of Impact: AL, AZ, CA-D, CO, HI, IN, MI, MN, NM, OR, Utah Cooperative Extension, WA

Theme: 3.03 Human Nutrition

Title: California Cuisine: Historical Food Trends in California.

Description: Research on food patterns in Spanish, Mexican, and Gold Rush Era California has been initiated in central California archives/libraries/museums (Bancroft Library, Huntington library, Sacramento State Library, Santa Barbara Mission Archive, Sutters Fort Archive). The focus has remained on how and under what circumstances chocolate was used as both medicine and as food. Documents written by Father Junipero Serra reveal the widespread use of chocolate throughout the early California Mission Era. Diaries produced by General De Anza reveal the introduction of chocolate to California via Sonora, arriving at the San Gabriel Mission in 1776. More telling are the Gold Rush Era diaries examined that provide information on chocolate prices and use of chocolate as a common beverage of miners. Spanish and Mexican Era cookbooks housed in the Los Angeles County Library will be a focus of their efforts during the coming summer.

Impact: Understanding the historical basis of food patterns in Spanish, Mexican, and Gold Rush Era California provides insights on the current patterns of selected minority groups in California in the 21st century. The information generated from this project will be useful in developing culturally-sensitive nutrition education materials to professionals working in the US Department of Agriculture food assistance and nutrition education programs, including the federal Special Supplemental Nutrition program for Women, Infants, and Children, and the Food Stamp Nutrition Education program.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 3.03 Human Nutrition

Title: Something Fresh and Juicy

Description: Between 2001 and 2005, the percentage of overweight and obese children and adolescents in California increased by 6%. This increase in obesity is largely due to poor eating habits and inadequate physical activity. In 2005 California spent \$28 billion on obesity-related costs. Obesity and related costs could be substantially reduced by serving more healthful school lunches. School lunch programs are designed to provide a substantial portion of age-appropriate daily nutrition, but many schools still rely on packaged foods and high-fat items that are not healthful for children. Often district and food service administrators are not convinced that students will accept more healthful selections. UCCE Monterey County Nutrition Education staff initiated a foto novela project, "Fast Food High School," with high school students. The students wrote three separate nutrition-related stories. They explored critical issues and pressures of life they experience living in a "supersized" environment. They also developed learning materials to address the key pressures they identified, such as popularity, familial diabetes, and quick weight loss schemes. In the third edition, UCCE staff and the Health Academy students at Alisal High School articulated their concerns about the healthfulness of school food. These concerns attracted the attention of school district administration and the Centers for Disease Control (CDC) "Steps for a Healthier Salinas School Health" consultant.

Impact: The school district was already discussing the feasibility of offering salad bars at three selected schools in the fall 2006 semester. Concurrently, but separately, Alisal High School (AHS) students began to develop their foto novela, voicing their concerns about the lack of healthful food choices. The project led to collaboration among UCCE staff, the AHS Health Academy educator, the Food Service Director, the CDC grant subcontractor and high school administrators to build a salad bar in advance of the original plans. Students and farmers from the Agricultural Land-Based Training Program donated fresh produce. The joint effort resulted in students literally enjoying the fruits (and vegetables) of their labors. The decision to extend the fresh salad bars to all district high schools makes them available to 14,252 students, exceeding the original goals of all participants.

Funding Source: Smith-Lever and State

Scope of Impact: State Specific

Theme: 5.01 Aging

Title: Seniors Get Education Tailored To Their Own Health Concerns

Description: More than 33 million Americans are age 65 or older, and the number of seniors in the United States is expected to double over the next 30 years. In Sacramento County, 15 percent of the population is over 60. An increase in age over 65 may increase the risk of developing chronic diseases such as diabetes, heart disease, cancer and arthritis. Eighty percent of seniors have at least one chronic health condition and 50 percent have at least two. Heredity and lifestyle are two factors that affect the aging process. An associate professor of family and community medicine at UC Davis Medical Center, said healthy aging is 30 percent genetic and 70 percent behavioural. "Over two-thirds of the things that you need to do to age healthfully are within your control," he said. Focus groups were conducted with 57 seniors from two Sacramento County housing facilities. The participants were asked: What are your major health concerns and what would you like to know more about? Diabetes, heart disease, arthritis and high blood pressure were the most commonly noted major health concerns. The focus group responses were used to create an educational program for senior consumers, which was subsequently presented in English and Russian at the two senior housing facilities. The program increased awareness among seniors of the importance of exercise, nutrition and regular doctor visits. At the end, they were able to identify major health concerns, list steps toward healthy aging, recognize personal areas to change for healthy aging, and discuss risk factors associated with breast cancer, heart disease, diabetes and osteoporosis.

Impact: Senior consumers are concerned about their health. Many of them experience symptoms that may be signs of chronic disease. These seniors are interested in knowing how to prevent chronic disease and to make changes in their behavior to promote healthy aging. Healthy seniors can remain in their homes with little assistance. As health care costs continue to rise, it is imperative for seniors to learn how to promote healthy aging. Comments from senior consumers following the education program: "I will exercise and try to stay on my diet. Also, I'm going to see a doctor regularly." "Exercise, watch my diet, and increase social communication."

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.02 Agricultural Financial Management

Title: DIRECTING FARMERS TO SUCCESS

Description: Knowledge of farming is an obvious prerequisite for business success. However, just as important are knowing regulatory requirements, having a market for one's crops, securing financial resources and advice, and staying up to date on all the latest farming and pest management practices. Knowing who to call for information or how to find help can be daunting tasks for any farmer, and more so for a new-entry farmer or one with limited English skills. To help farmers, especially those with small operations, limited resources and limited English skills, a unique directory was compiled by UC Cooperative

Extension advisors in the Central Coast. To help steer the farmer to the right help, the directory lists agriculture-related agencies and organizations by tasks a farmer might perform, or by topic groupings. There is also a cross-referenced alphabetical listing for all entries. Samples of the twenty-five headings are "Air Quality and Fire Protection", "Education", "Financial Management", "Marketing and Promotion", "Produce Inspection and Certification", "Wetlands and Water Bodies". The directory is in English and Spanish. This is the second edition of the directory which was originally printed in 1996.

Impact: Farmers and others in agriculture-serving industries and agencies now have ready access to information and contacts for a broad cross-section of research, education support, and regulatory bodies. Given the myriad aspects of farming today, the directory serves as a valuable one-stop resource. Five hundred of the directories have been distributed among Monterey, Santa Cruz, and San Benito County farmers and farmer-serving agencies. Word of mouth had led to more requests for the book, indicating its popularity and usefulness

Funding Source: Smith Lever and State

Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H

Title: PROJECT LEARNING TREE, PROJECT WILD, AND PROJECT WET

Description: The "Projects" (Learning Tree, WILD and WET) are interdisciplinary, supplementary conservation and environmental education curriculums for educators. The concepts in the Project curriculums provide learners with opportunities to engage in hands-on learning experiences that demonstrate the direct relationship to assessing environmental health through the study of forests, terrestrial and aquatic wildlife and water.

Impact: The city of Marina California is approximately three miles from the shore of the Pacific Ocean, and is statistically recorded in the Cal 4-H enrollment system as a suburb. Educators indicate that the 77% non-Caucasian student enrollment at the site rarely take advantage or has the opportunity to take advantage of the natural environment at their doorstep. Through the implementation of the Project WILD program, students have utilized their own community as a living laboratory to gain an awareness and understanding of their natural environment and to actively participate in the discovery of new ecosystems and environments. To date 2 sites have been trained on the "Projects." In total, 7 adults have provided over 95 children with hands-on experiences to assess environmental health through the study of forests, terrestrial and aquatic wildlife and water.

Funding Source: Smith Lever and State

Scope of Impact: State Specific

(3) Did the planned programs describe the expected outcomes and impacts?

The planned programs described achieved many of the expected outcomes as described by the case study examples in Section A.

(4) Did the planned programs result in improved program effectiveness and/or efficiency?

Collaboration with colleagues in other agencies, institutions and other states resulted in improved program effectiveness by maximizing the use of available expertise. With declining numbers of academics to do research and conduct extension programs, it has become even more critical to be able to focus on the highest priority needs of the citizens of California.

Theme: 1.28 Plant Production Efficiency

Title: Crop Physiology of California Tree Crops

Description: UC researchers continued collaboration with a modeling group in Canada to develop a functional-structural simulation model to simultaneously simulate dry matter partitioning and structural development of fruit trees. This work has resulted in a completely new approach for simultaneously modeling tree architectural growth, source-sink interactions and carbon partitioning in trees. The original version of this model was largely a "proof of concept", using abstract units to test the feasibility of the approach for modeling source-sink interactions and carbon partitioning in trees. Having "proved the concept" they are now improving the model and using experimentally derived data to quantitatively test its validity for simulating actual tree growth and architectural development. The evaluation and characterization of size controlling rootstocks for peach and nectarine has also continued. The role of plant water relations in determining the size controlling behavior of experimental rootstocks has been confirmed with controlled laboratory experiments. Additional physiological characteristics that may be involved in the size-controlling behavior have also been investigated but so far all results point to root hydraulic conductance as being the operative mechanism. Studies of the behavior and control of vegetative shoot growth and its interaction with reproductive growth have continued in pistachio and almond. Data from both projects are currently being prepared for publication.

Impact: The modeling project has provided a working model for studying and describing source-sink interactions at the whole plant level and identified key factors controlling fruit tree growth, fruit yield and fruit quality. The concepts imbedded in the PEACH model have been used to evaluate the impact of weather within thirty days after bloom on fruit maturity date and crop yield in peaches. The rootstock research has generated significant grower interest and two rootstocks have been released for commercial use to the California industry. Information on the mechanism of dwarfing has been made available to assist growers in understanding the physiological limitations of these rootstocks.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.01 Food Accessibility and Affordability

Title: Sustaining Local Food Systems in a Globalizing Environment: Forces,

Responses, Impacts

Description: In 2004/2005, researchers conducted a study of the regional agricultural marketing programs throughout California. The study was initiated to provide background information for the Yolo County Agricultural Commissioner and an advisory committee, formed to explore the development of a Yolo County organic label. The UC Sustainable Agriculture Research and Education Program (SAREP) agreed to gather and analyze data about the regional agricultural marketing programs emerging throughout the state (including those that focus on organic marketing), to determine the feasibility of creating a local and/or organic label and marketing effort in Yolo County. In the winter of 2005 more than 25 individuals associated with regional agricultural marketing programs, statewide commodity boards, and the statewide Buy California Initiative were interviewed. Information from twelve existing programs and three which no longer exist were summarized. The study describes the efforts of a dozen regional agricultural marketing programs that have formed to date, the challenges they have faced, the costs they have incurred, the economic contributions they have made to their counties, and the opportunities they have created in their communities. In particular, they were interested in describing a cost/benefit analysis for farmers and communities in other regions of the state who are interested in potentially starting a similar program in their counties. The study has been completed and shared with agricultural marketing experts representing many of these marketing programs and will soon appear on SAREP's website. Two presentations about the study results were also given in November 2005-- at the California Small Farm Conference and at a Marketing Learning Community meeting organized by the Community Alliance with Family Farmers. Yolo Local/Organic Label Survey During the summer of 2005, a short telephone survey of Yolo County and Bay area producers, agricultural businesses, processors and retail buyers was conducted as a supplement to the Agricultural Marketing Study. Participants were queried about their interest in a local and/or organic label and their willingness to pay for the creation of a local marketing program. The results of this survey are currently being analyzed and will be made available on SAREP's website in the spring of 2006. Mandarin Marketing Study They completed a final revision of the Mandarin Marketing study they conducted for Placer County mandarin growers last year. They are printing hard copies of the study for distribution to policymakers (Board of Supervisors, Ag Commissioner and others) in Placer County as well as study participants. The study will also appear on SAREP's website.

Impact: The Placer County Agricultural Marketing Director plans to distribute the Mandarin Marketing report widely. First and foremost, the report will provide needed information to Placer County mandarin growers who are searching for new marketing venues for recent bumper crops of mandarins. In addition to local farmers, it will be shared with Placer County policymakers with the intent of convincing them of the importance of supporting regional agriculture and marketing efforts. The Placer County Marketing Director hopes to use this report in a larger effort to limit urban development in the Placer County foothills and preserve more land for agriculture. The Regional Agriculture Marketing Program

study is already being read and used by new, emerging agricultural marketing groups to assess what it takes to initiate and sustain such a program. In particular, it is being studied by the Yolo County Agricultural Commissioner as the county decides if and how it might create a local/organic label. The telephone survey conducted with regional stakeholders will provide insights for the Yolo County Agricultural Commissioner and other decision-makers as they decide how much demand there is for a local/organic label in Yolo County and whether businesses are willing to pay for it. The data gathered in this survey could help in future organizing, fundraising and outreach.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, KS, ME, MA, MI, MN, MO, NH, NJ, NYC, OR, PA, PR, VT, WA, WVA, WI

Theme: 2.05 Food Resource Management

Title: California Food Industry Referral Guides

Description: Many of the services sought by existing small and large food processors, and entrepreneurs thinking about getting into production of a food product, are common. Supplying the information on an individual basis is time-consuming. A UC CE specialist created a database of companies that provide goods, services and consulting to the California and US food industry. Based on the information and services most commonly sought, she developed 16 searchable categories, calling them Food Industry Referral Guides. A food safety microbiologist assisted the UC CE specialist with the referral guides. Initially, guides were distributed as hard copies. In 2000, databases were installed on the Web (<http://fruitandvegetable.ucdavis.edu>), providing the California food industry instant access to the most current information available. The referral guides, which are updated as new information becomes available, cover the following topics: Aseptic Processing, Cold Storage, Consultants, Co-Packers, Dehydrators, HACCP, Ingredients, Lab Analysis, Lab Equipment, Nutritional Labeling, Packaging Containers, Packaging Equipment, Processing Equipment, Product Development/Sensory, Sanitation and Training/Continuing Education.

Impact: Food industry clientele find the guides an easy means of identifying local resources. Instead of spending an hour researching companies that perform laboratory analysis for a particular food industry client, the client is directed to the Food Industry Referral Guides on the Web and can search directly. This is a tremendous time-saver for clients. In 2001, tracking visitors to the Web site began. The website also includes information on extension short courses and an applied research program. By announcing the existence of the site to callers and conference attendees, site traffic increased to about 2,000 visitors annually. Sixty-four percent of hits came from North America; 11.5 percent from Asia; and 11 percent from Europe. Of the North America clientele, 61 percent came from the US. The international food science community utilizes the referral guides; consequently, there is more awareness of the expertise available through the University of California.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 2.06 Food Safety

Title: Assuring Fruit and Vegetable Product Quality and Safety Through the Handling and Marketing Chain

Description: UC researchers have developed a real-time polymerase chain reaction (PCR) assay and instrument for the detection of *Salmonella enterica*. The instrument is compatible with pumps and valves for automatically loading a sample and cleaning the reaction chamber once the reaction is complete. Silicone tubing for fluid transfer was attached to a round glass tube reaction chamber. By sealing the reaction chamber with pinch valves directly on a thermoelectric module for heating and cooling, it was possible to make copies of the intended DNA target, a segment of the *invA* gene. A two-step PCR was used, cycling temperatures between 94 and 62 deg. C for 30 and 60 seconds respectively, for a total of 35 cycles. AmpliTaq Gold polymerase concentrations were increased to 6.25U per 50 ul reaction and bovine serum albumin (BSA) was also added to each reaction to a final concentration of 0.25 mg/ml. The increase in BSA and polymerase concentrations helped to increase the rate of the reaction. The signal to noise ratio of the fluorescence detection system was greatly improved by using an interference filter and making changes to the design of the signal conditioning circuitry. A low input bias current operational amplifier amplified the signal from the photodiode while fluorescence was generated. A conductive guard around the inputs to the op amp was connected to the common of the circuit and the case of the op amp package, reducing noise and allowing the gain of the circuit to be increased. Following a reaction, it was possible to verify results by examining amplification and dissociation data stored in the memory of the embedded controller that controlled the system. The PCR mixture was removed from the automated system, and the sample was placed into a commercial instrument where a dissociation analysis was run for comparison with the automated system. Additionally, agarose gels were run to verify that the correct size fragment was formed. They were able to detect *Salmonella enterica* serovar Newport over a range of 500 ng to 50 pg of extracted DNA per 50 ul reaction. This detection range corresponds to approximately 108 to 104 colony forming units of *Salmonella* per 50 ul reaction. These tests were run by using new silicone and glass tubes. Preliminary tests with pumping PCR mix into the reaction chamber with 5 ng of extracted DNA show that there is no difference in threshold cycle value or product melting temperature between the samples that were pipetted into the reaction chamber and those that were pumped in. They are now testing the reusability of the reaction chamber by cleaning with DNAZap and buffers, and using uracil DNA glycosylase prior to the reaction to remove any additional DNA carry-over contamination.

Impact: The process of growing sprouts, such as alfalfa and bean sprouts, can permit the growth of bacteria due to warm and moist conditions found in many sprouting operations. Several outbreaks of hazardous bacteria have been traced to sprouts. As a result, sprout growers are required to test sprout water samples for *Salmonella* and *E. coli* O157:H7. Testing may be done by shipping samples

off site to a fully equipped microbiology laboratory for analysis of sprout water. However, shipping water samples off site is a time consuming process. Testing water samples on site with an automated sensor would let sprout growers know immediately if their product was safe to ship or not. While a wide variety of commercially available real-time PCR instruments exist, they are typically large and require skilled labor to operate and extensive equipment for liquid handling. Screening samples for the same bacteria from the same media (sprout water) is a repetitive task that is well suited to automation. An automated PCR sensor that requires minimal user input to detect pathogens such as Salmonella and E. coli O157:H7 would ensure that sprout growers are producing foods that are safe for consumption.

Funding Source: Multistate Research and State

Scope of Impact: CA-D, GA, HI, IN, ME, MD, MI, NYG, NYC, NC, PA, WA

Theme: 5.25 Tourism

Title: AGRITOURISM MANUAL HELPS CALIFORNIA FARMERS GROW ECONOMICALLY

Description: A 1999 survey of California farm operators revealed a growing need for materials on two increasingly profitable industries: agritourism and nature tourism. Farmers and ranchers have heretofore lacked a centralized resource for obtaining such materials, in a time when opportunities abound for tourist ventures to take root. The UC Agriculture and Nature Tourism Workgroup had a goal: to produce a comprehensive manual, providing information on starting, maintaining and expanding an agritourism or nature-tourism venture. The result is a 250-page manual covering such myriad topics as assessing one's business, marketing and promotion, employee management and relations, regulatory compliance, and business-plan development. Widely considered the definitive guide for California agritourism and nature tourism, the manual is currently being used by several organizations involved with economic development in the state's rural and agriculturally depressed regions. Completed in 2002, the UC manual sold out in only six months. However, an updated, fall 2005 edition is currently available, published by ANR.

Impact: The UC Workgroup has trained over 900 farm operators across California in diversifying their businesses with tourism. Using the UC manual as a guiding tool, ranchers and farmers in diverse communities are taking preliminary steps toward embarking on new tourist ventures. Workshop attendees rave about the UC manual as a resource for tourist business planning. One participant from a 2004 workshop in Paso Robles says, "Chapter Two on 'Assessing Your Potential' really helped my husband and me refine their vision and get started. It made us aware of ALL the components that must be addressed." Another participant from a 2003 workshop in Reedley says, "I used the information in the manual to prepare my expansion and my plan to meet with county staff, before I submit an application."

Funding Source: Smith Lever and State

Scope of Impact: State Specific

SECTION E. MULTISTATE EXTENSION ACTIVITIES

(1) *Did the planned programs address critical issues of strategic importance, including those identified by stakeholders?* The programs described below were initiated in response to the critical needs of stakeholders.

Theme: 5.28 Youth Development/4-H

Title: 4-H After-school

Cooperating States: California, Ohio, Kansas, Oklahoma, Nevada, Arizona, Massachusetts, Mississippi, Michigan, Washington D.C., and New Mexico

With nearly 40 million children between the ages of 5-14, the United States is experiencing a burgeoning need for out-of-school programs. The need to care for school-age children is a concern for millions of American families, particularly those with a single parent or both parents employed. This collaborative multistate effort works to improve the quantity and quality of afterschool programming. As a result, over this past year, 404,917 youth participated in 4-H afterschool programs, 2,249 afterschool staff, 8,957 4-H volunteers, and 3,445 Extension staff were trained in 4-H Afterschool programming, and 3,293 4-H Afterschool Programs nation-wide. For over two decades, 4-H Afterschool programming has been a national focus for 4-H. A California advisor is part of the current leadership, the National 4-H Afterschool Leadership Team. She was involved in providing academic leadership, programmatic direction, and evaluation/research expertise to set a national agenda.

She worked with colleagues from many other states to develop curricula and other educational materials, as well as secure additional funding. She assisted in the development of four national manuals: *Starting 4-H Clubs in Afterschool Settings*; *A Sampler of 4-H; Afterschool Activities*; *4-H Afterschool Resource Guide...Guiding Growth*; and *Teens as Volunteer Leaders...Recruiting and Training Teens to Work with Younger Youth*. In addition, she provided project assistance to the ten funded states and assisted with contract monitoring, as well as visited the Pennsylvania project in March. She also assisted in the organization of the three-day training held in June in Dallas, TX that was attended by the ten funded states (teens, volunteers, and CE staff) that are implementing the Workforce Preparedness Project. She taught on the content of the *Teens as Volunteer Leaders* manual. Lastly, with funding from JC Penney Afterschool Fund, the 4-H Afterschool Leadership Team provided vision, planning, training, material development, grant writing, marketing, and a variety of consultation.

Theme: 1.30 Rangeland/Pasture Management

Title: California Browsing Academy

Cooperating States: California and Tennessee

The purpose of the California Browsing Academy is to teach, demonstrate and provide practical experience in using goats to reduce fuel loads and control invasive plants. A California advisor worked with colleagues from the University

of Tennessee Cooperative Extension and Tennessee State University on the three day course, which emphasized the practical application of research-based grazing and browsing principles using goats. The target audience was ranchers, land managers, and agency personnel, those who manage livestock on privately owned or public pasture and rangeland. The participants learned through the hands-on application of grazing and browsing principles in real brushy areas with live goats.

Theme: 1.01 Adding Value to New and Old Agricultural Products

Title: Carrot breeding and evaluation

Cooperating States: California and Wisconsin

A California advisor worked with the USDA Carrot Breeding and Evaluation program that is headquartered at the University of Wisconsin. He planted many of the carrot varieties produced by that program in research plots in Kern County. He also served as the caretaker of the USDA Carrot Winter Nursery at the Desert Research and Extension Center (DREC). He maintained the accounts to pay for the costs of the winter nursery at DREC and make sure the plot is readied for planting and harvesting. He helped in the harvest of the plot in setting up the field day at DREC. The program benefits the California carrot industry by releasing new carrot breeding lines to commercial breeders to improve the commercial carrot varieties that are grown.

Theme: 1.23 Organic Agriculture

Title: Determining environmental viability of organic vegetable varieties

Cooperating States: California and New York

Depending on the commodity, planting season, and cropping system, tillage management typically constitutes up to 20% of the budget for annual crops produced in California. Tillage systems in the Central, Desert and Coastal Valleys were developed more than six decades ago and have changed very little since then. Producers continue to express interest in the viability of organic vegetable production in the desert. In order to be a viable competitor in an organic vegetable industry, growers need to adopt management strategies that integrate proven production methods that improve efficiency and provide sustainability of resources. To remain a competitive, viable and sustainable industry, producers, PCA's and other industry representatives must capitalize on adopting new technologies and organic production methods that improve efficiencies, reduce inputs, encourage diversity while adapting to regulatory and environmental constraints. A California advisor worked with a colleague from Cornell University to evaluate plant management systems and new technologies to improve vegetable production efficiency, reduce inputs, improve environmental, and production resources. Collaboratively, they developed and screened sustainable approaches to organic vegetable production.

Theme: 1.07 Apiculture

Title: Evaluate pollen flow under honey bee pollination systems

Cooperating States: California and Arizona

The purpose of this project is to determine the distance honey bees will carry alfalfa pollen from one field to another. With the introduction of genetically modified crops, growers and seed companies are concerned about contamination of conventional crops with GMOs. Once the distance is identified, isolation standards can be adjusted to maintain the purity and the quality of seed stock. A California advisor worked with a group from the USDA Agricultural Research Service in Arizona and the Tucson Bee Lab. They harvest samples, using UC equipment and UC personnel, to correlate what they find with their bee sweeps. They got a grant from USDA CSREES.

Theme: 1.02 Agricultural Competitiveness

Title: High Density Pear Production Systems Project

Cooperating States: California, Oregon, Washington

The pear industries in California, Oregon, and Washington have decided to pursue new orchard systems in order to remain globally competitive. This project's goal is to foster efficient orchards that produce high quality fruit. A California advisor worked with colleagues from both Oregon and Washington State Universities to combine high density training systems, alternative varieties, size-controlling rootstocks, and mechanically-assisted pruning and harvest aids. The project helps assure a competitive pear industry on the West Coast. Growers on small acreages looking for alternative high value crops will also benefit from this research.

Theme: 5.28 Youth Development/4-H

Title: Youth Leadership National Trainings Design Team

Cooperating States: California, Arizona, Texas, Nebraska, Mississippi

A California advisor was a member of a multistate design team that provided technical assistance and follow-up for two national 4-H trainings. The John Deere Leaders Academy was three-day training delivered in early October 2005 in Chevy Chase, Maryland to teams comprised of one state level staff person and one youth from throughout the United States. The goal was to impart or enhance their leadership skills so they would be more effective in their state roles and would extend the skills to 4-H members in their state. The topics included youth adult partnerships, diversity, forum moderation, decision making models, action planning, and other related topics. The EYSC4 was a four-day training, held in Chevy Chase, Maryland in early February 2006. The goal was to train and empower teams comprised of two youth and two adults from rural counties in the activities and curriculum we devised and presented at our two Rural Youth in Governance pilots. The fifteen participating teams were selected through a competitive peer-review process and include one California team of two adults and two youth.

Theme: 1.30 Rangeland/Pasture Management

Title: Prescribed Grazing Mendusahead/goatgrass Control Project

Cooperating States: California & Oregon

Medusahead is an aggressive and invasive non-native annual grass causing severe undesirable effects on western rangelands. Medusahead grows on more than a million acres of grassland, oak woodland and chaparral scrubland in California. The presence of Medusahead can reduce the land's livestock carrying capacity by as much as 75 percent. Medusahead control has been explored since the 1950s, but with limited success. Burning is an effective method, but it is not widely used because of air quality and liability issues. Herbicides are not practical in rough terrain and selective herbicides targeting Medusahead are not available. The main goal of this project is to control rangeland weeds by adding integrated precision grazing to the toolbox of ranchers and land managers, and by promoting adoption of sustained, long-term grazing plans to battle weeds. The project has three fronts: comparison and demonstration of methods at research centers, implementation of "seed" demonstration areas in private ranches, and education and dissemination of knowledge. A California advisor worked with an Extension agent from Oregon State University to discuss and plan grazing treatments. Each collaborator set up cooperator ranches in their respective counties that they visit from the early boot stage of the Medusahead or Goatgrass (generally spring through June in Mendocino & Lake Counties) and take plant samples. Along with his colleagues, the California advisor made these collections weekly. The sample sites are GPS'ed and other data is noted (e.g. elevation, slope, aspect, etc.). Close-up and landscape pictures are also taken. Samples are submitted to a lab where the plants are identified to phenological stage of growth. This data is classified by location, precipitation, temperature and other variables for the purpose of creating a model that will enable the investigators to predict when the invasive species is most vulnerable to grazing as a means to control it.

Theme: 4.23 Water Quality

Title: Goose Lake Fishes Workgroup

Cooperating States: California and Oregon

A California advisor continued his ongoing work with a colleague from Oregon State University Cooperative Extension monitoring the water quality in the Goose Lake Basin of California and Oregon. This bi-state working group was formed after the basin went dry in 1992, threatening fish habitat. Their goal is to protect and reestablish native fishes in the basin.

Theme: 1.11 Biotechnology

Title: RiceCAP Project

Cooperating States: California, Arkansas, Florida, Missouri, Wisconsin, Louisiana, Texas, Mississippi

The genome, or DNA genetic code of rice is composed of approximately 50,000 "pieces" of DNA, called genes, which control all plant traits including yield and pest resistance. The sequence information is now publicly available to rice researchers worldwide. For the rice industry to effectively utilize this valuable resource, rice researchers need to begin to understand the function of these genes and how they impart economically valuable attributes to commercial rice.

A better understanding of these genes will enable researchers to develop a hardier and more productive rice crop. Two attributes that have been difficult to improve through traditional plant breeding efforts are milling yield and disease resistance to sheath blight disease, one of the most pervasive and destructive diseases of rice worldwide.

The California advisor worked with colleagues from many other states on the RiceCAP project. The RiceCAP project is supported by the USDA National Research Initiative Competitive Grants Program. Program funding is from the USDA, Cooperative State Research, Education, and Extension Service (CSREES) in the area of Applied Plant Genomics Coordinated Agricultural Program (APG-CAP). RiceCAP is an ongoing project that aims to develop a set of biotechnology-based tools to improve these two attributes in U. S. rice varieties. The tools being developed will help rice researchers identify genes which control these important agronomic traits as well as determine their function in the rice plant. This biotechnology toolbox will allow traditional rice breeders to address problems which they have been unable to adequately address in the past. The RiceCAP project is a multi-institution and multi-state program with a strong research component as well as teaching and extension efforts to fully engage the rice community on the potential benefits of the overall effort. The project will advance the utility of the biotechnology information available for rice, train traditional rice breeders in the usefulness of biotechnology based tools, and educate a broader audience on the merits of such an approach to improve rice cultivars. The management of this project will receive significant input from scientific and stakeholder advisory boards, with the stakeholder advisory board composed of industry representatives from the rice community. The RiceCAP project is entitled "A coordinated research, education, and extension project for the application of genomics discoveries to improve rice in the United States." The advisor was involved in the education and outreach component of this project. He is a member of the outreach team, consisting of cooperating scientists and extension specialists from several of the institutions participating in the project. The overall objective of the outreach component of the RiceCAP project is "to effectively communicate the science and potential of rice plant genomics, including progress and description of the RiceCAP to the US rice industry."

Theme: 4.14 Natural Resource Management

Title: Sage grouse conservation planning

Cooperating States: California and Nevada

A Northern California advisor continued to work with a colleague from the University of Nevada Cooperative Extension. He assisted with developing sage grouse conservation plans for northeastern California and northwestern Nevada. The goal is to develop conservation plans for the three population management units that cross the California/ Nevada line. The aim is to prevent the need for threatened or endangered species designation for the sage grouse. Stakeholders include the Governor of Nevada, The Nevada Department of Wildlife, the California Department of Fish and Game, ranchers and sportsmen.

Theme: 4.14 Natural Resource Management

Title: NECC-1009

Cooperating States: California, Arkansas, Indiana, Maine, New Jersey, New York, Oregon, Pennsylvania, Ohio, Michigan, and Massachusetts

New tree fruit cultivars are continuously being developed around the world. However, most land grant universities no longer have a critical mass of researchers addressing the regional and national needs for evaluating fruit cultivars. The fruit industry and scientists working in tree fruit research would benefit from a unified system of evaluation and a repository for information about new cultivars. A California advisor is part of a coordinating committee that aims to: 1) provide a means for scientists in diverse fields to gather and discuss the merits and liabilities of new tree fruit cultivars, including information on growth, yield, geographical adaptability, fruit quality, disease susceptibility and insect preference of new cultivars of such fruit as apples, peaches, plums, cherries and other tree fruit; and 2) function as a repository and gathering group for new information and publications about tree fruit cultivars. The information would be located on the web and provide easy access to both industry and the university community. She met with this multidisciplinary group to discuss the merits and liabilities of new tree fruit cultivars. They meet annually to review information and data developed by the cooperators pertaining to the evaluation of tree fruit cultivars. There outcomes are: 1) the coordination of evaluation procedures for apple and other deciduous tree fruit cultivars; 2) the exchange of information on the performance of different fruit cultivars in multiple regions of the country; and 3) the increased knowledge of tree fruit cultivars.

Theme: 1.28 Plant Production Efficiency

Title: Southwestern Regional Potato Project

Cooperating States: California, Texas, Colorado

California is a major producer of fresh market potatoes in the United States. All types of fresh market potatoes (including russets, whites, reds, yellow-fleshed, and specialty) are grown in the potato production regions of California. The growing conditions for these potatoes are significantly different in California, particularly in Kern County and other Southern California locations, as compared to other potato growing areas in the United States. Most potato breeding programs are located in the Northern half of the US and are adapted for cooler climates. The Southwest is a warmer, drier region and require potato varieties developed for those conditions. California does not have a breeding program; therefore, it relies on breeding programs from other areas. A California advisor continues his work on the Southwestern Regional Potato Project. He collaborated with researchers from Texas A & M University and Colorado State University. The goal of the project is to develop new potato varieties that fit the needs of the potato growers in the southwest US. Along with his colleagues in the other states, he evaluates the new potato varieties that are breed in Texas and Colorado.

Theme: 1.27 Plant Health

Title: Spinach downy mildew management

Cooperating States: California and Arkansas

During recent years, consumers in California and throughout the country have greatly increased their consumption of spinach. As a result, the state's growers are producing more spinach than ever before. Monterey County alone grows over 16,000 acres, about 60% of the state's spinach crop. Spinach has an extremely high vitamin and nutrient content, and contains high levels of beneficial carotenoids such as the antioxidant lutein. Being a leafy vegetable, spinach is susceptible to damaging leaf diseases that reduce the yield and quality of the harvested crop. Coincidentally, several new spinach disease problems have developed while acreage has expanded, increasing the potential for significant losses. These diseases must be managed effectively so that the spinach industry can meet increasing market demands for fresh, high quality spinach. A California advisor continued his collaboration with his colleague at the University of Arkansas to identify, characterize, and manage the new races of spinach downy mildew that are occurring in California. This collaborative program has helped develop fungicides that protect the state's spinach crop. Also, in conjunction with industry groups, varieties have been released that resist the new downy mildew races. The planting of this resistant stock has helped reduce the amount of chemicals applied to spinach. As a result of this work, the spinach industry is better able to deal with this damaging problem.

Theme: 5.28 Youth Development/4-H

Title: 4-H mentoring

Cooperating States: California, Arizona, Oregon, West Virginia

A California advisor collaborated with colleagues in Arizona, Oregon, and West Virginia to study and compare formal and informal mentoring programs for new 4-H staff. The California advisor met with the Mentoring Group, a sub-workgroup of the Professional Development Committee at the National Association of 4-H Extension Agents Conference in Milwaukee, Wisconsin, October 2006. This is an ongoing multistate effort to assess the 4-H mentoring programs.

Theme: 5.28 Youth Development/4-H

Title: Engaging Youth Serving Community IV

Cooperating States: California, Arizona, Arkansas, Delaware, Florida, Idaho, Kentucky, Mississippi, Montana, Nebraska, Oklahoma, Texas, and South Carolina

A California advisor worked on the National 4-H Initiative called Engaging Youth Serving Community IV. She was a member of a team of trainers from California invited to conduct sessions at a national 3-day workshop for teams of teens and adults representing 15 states. Her role was to teach how to conduct public forums and how to assess where a local issue is appropriate to frame for local discussions. In addition, she helped write the curriculum and participated in the development of the evaluation instrument.

Theme: 1.16 Grazing

Title: Goat and sheep grazing

Cooperating States: California and Tennessee

A California advisor worked with colleagues in Tennessee on the Tennessee Small Ruminant College held at the University of Tennessee Research and Education Center in Spring Hill, Tennessee. He presented grazing principles and niche marketing of sheep. The purpose of the college was to expose Tennessee producers to opportunities with goat browsing and sheep grazing.

Theme: 4.12 Integrated Pest Management

Title: Testing new pheromone application techniques

Cooperating States: California and Washington

A California advisor worked with a colleague from Washington State University on testing new pheromone application techniques. She field tested both an ultra low volume application of pheromone for the Oriental Fruit Moth and a new Oriental Fruit Moth bait lure. She also conducted field testing on the microflake applications of pheromone for codling moth control, a unique application technology.

Theme: 1.02 Agricultural Competitiveness

Title: NC-140

Cooperating States: California and Washington

The pear industry is facing nearly insurmountable world competition, and this research may help identify dwarfing rootstocks that allow growers to plant higher density orchards that are more productive with less labor. The NC-140 project is a national cooperator project in which many researchers are evaluating pear rootstocks. A California advisor worked with colleagues from Washington State University to find rootstocks that impart reduced vigor to the trees and that produce early and heavy yields. On the 80 Bartlett pear trees that were planted in Sacramento County (10 replicate trees of 8 different rootstocks) in 2005, they took growth measurements, including trunk circumference, tree height and spread, and overall vigor. Fruit measurements will be taken later when bearing starts.

Theme: 1.27 Plant Health

Title: Walnut codling moth behavior

Cooperating States: California and Michigan

A California advisor continued to work with a Michigan State colleague to determine if codling moths in California walnuts have the same mating behavior cues as codling moths in other states and crops. She tested walnut California Codling moth behavior in the Michigan State University wind tunnel to see if its behavior is different in mating disruption situations. The goal is to get better adoption of mating disruption in walnuts and decrease the use of broad spectrum pesticides, particularly those found in water.

Theme: 4.12 Integrated Pest Management

Title: Lygus management in the landscape

Cooperating States: California, Texas, Arizona, and New Mexico

A California advisor worked with colleagues from Southwestern states on the preparation of a USDA-RAMP grant for California, Texas, New Mexico, and Arizona to manage Lygus in landscape. Lygus bugs are indigenous insect pests in the order Hemiptera. They feed on floral and seed parts. Depending on the host, Lygus can cause loss of quantity (yield) as well as quality (surface scarring or pitting). Crops on which Lygus is problematic include cotton, black-eyed beans, lima beans, seed alfalfa, lettuce, tomato, pome fruits, and seed crops. Other crops that act as habitat are safflower, sugar beets, alfalfa forage, and almost any weedy field of tomatoes, garlic or onion. Range land and disturbed fallow ground can develop weed hosts, in which Lygus will build and from which populations will migrate. In field and row crops, Lygus migrates from other sources. In cotton for example, a field might be under complete biological control until Lygus migrate and if the population exceed action thresholds, insecticides are required to reduce their numbers. A major problem in Lygus management is the lack of selective, environmentally soft insecticides; thus secondary pest outbreaks often follow Lygus migration. The complexity of managing this polyphagous pest across large areas is immense. Ecological and biological knowledge are essential to develop large-scale (landscape level) management approaches. Development and delivery of alternative management approaches and IPM strategies are required.

Theme: 1.14 Emerging Infectious Diseases

Title: Citrus greening

Cooperating States: California and Arizona

Citrus greening or Huanglongbing (HLB), probably the most devastating disease of citrus, has entered United States. The pathogenic bacteria and the psyllid vectors have not yet been identified in California. Early detection and eradication of HLB infected trees and a survey for the presence of the psyllid vectors is going to be crucial for the protection of the California citrus industry from economic losses and restrictions in citrus cultivation. A California advisor worked with colleagues from the University of Arizona on research to lead to further characterization of the HLB invading bacteria species and the possible identification of endemic biocontrol agents for the vectors. Nurseries, citrus groves, and residences that have acquired citrus material from HLB infested areas will be priority targets for the vector and citrus survey. Citrus trees will be tested both biologically and molecularly for HLB disease. The fundamental information generated will be instrumental for the design of any future prevention or control strategies for HLB in California. Stakeholders are citrus growers in California and Arizona. The impacts, if HLB is found, are the detection of HLB and eradication of HLB by the State of California and Arizona.

Theme: 1.30 Rangeland/Pasture Management

Title: BEHAVE Workshop

Cooperating States: California and Utah

A California advisor worked with a colleague from Utah State University to develop and present workshops on Behavioral Education for Human, Animal, Vegetation, and Ecosystem Management (BEHAVE). BEHAVE workshops aim to help producers and managers increase their ability to better reconcile ecological, economic, and social facets of management. They cover the following principals: improve economic viability and ecological integrity of pasture and range-based enterprises; enhance and maintain biodiversity of rangeland; restore pastures and rangelands dominated by weeds; optimize wildlife benefits to landowners, managers, and users; mitigate livestock abuse of riparian areas; and improve ability to manage complex adaptive systems. The behavioral principals and practices provide an array of solutions to the problems people face in managing to improve the integrity of the land and to make a living from the land. Unlike the infrastructure of a ranch such as corrals, fences and water development, behavioral solutions costs very little to implement and they are easily transferred from one situation to the next. He gave a BEHAVE workshop on Nov 10, 2005 in San Luis Obispo. He also went to Utah for a BEHAVE workshop.

Theme: 5.25 Tourism

Title: National Extension Tourism Design Team

Cooperating States: California, Utah, New York, Texas, Vermont, Wisconsin, and Iowa

Two California advisors worked on multistate collaborations to promote agritourism. One California advisor served on the National Extension Tourism Design Team with extension colleagues from several other states. They conference called monthly, sharing resources and information nationally. Many agriculture producers and rural families are interested in tourism as a means to increase their profitability. Recent economic impact studies conducted in New York and Hawaii indicate that this is a growing activity among small farms, that the net value has increased, and that individual operators have increased their profitability.

Theme: 1.03 Agricultural Profitability

Title: Flume installation

Cooperating States: California and Arizona

A California advisor worked with colleagues in Arizona and the US Bureau of Reclamation's Yuma Regional Office on installing flumes, water measuring devices, on a commercial farm in the Imperial Valley. In addition, he developed two irrigation slide charts in English and Spanish. They had help with the Spanish translation from a scientist at the USDA Agricultural Research Service Water Lab in Phoenix.

Theme: 4.14 Natural Resource Management

Title: Science Review Panel

Cooperating States: California and Texas

A California advisor continued to serve on the Science Review Panel through Texas State University/San Marcos (River System Institute). He helped review a

potential water transfer project between the Lower Colorado River Water Authority and the San Antonio Water System.

(2) Did the planned programs address the needs of under-served and under-represented population? The programs described below involved underserved/under represented stakeholders with specific needs.

Theme: 5.01 Aging

Title: Disaster preparation and recovery programs for elderly

Cooperating States: California, Florida, Oregon, North Carolina, Texas, Louisiana, and Alabama

The purpose of this project is two-fold: 1) to develop a set of disaster preparation and recovery material written specifically for older adult audiences; and 2) conduct web-based trainings to market those materials throughout the Southern region and beyond. A California advisor is collaborating with colleagues from other states to: 1) heighten awareness of the special needs of older adults during time of disaster; 2) increase the frequency with which older adults turn to Extension for timely, research based information regarding disasters; and 3) provide older adults with the information they need well in advance of disaster, enabling them to make informed, timely decisions and plans regarding potential evacuation and recovery.

Theme: 1.02 Agricultural Competitiveness

Title: National Sweetpotato Collaborators

Cooperating States: California, North Carolina, South Carolina, and Louisiana

California has a small sweet potato industry; thus, there is no sweetpotato breeder in the state. As a result, the industry here is dependent on the breeding efforts in southern states for new and improved varieties. The situation is similar in many states, and therefore a collaborative, multi-state variety trial is conducted every year. The objectives of this trial are to evaluate new breeding lines of sweetpotatoes for their quality and yield in central California. A replicated, randomized plot layout was established in a grower's field using cuttings from the roots of different varieties. Evaluations were made of their production in the hot beds, transplant survival and field growing characteristics, yield and root quality, and post harvest storability. Plots were planted with the cooperator's equipment and grown using standard practices. The results were presented at the winter sweetpotato meeting and in newsletters and progress reports. Root samples were shown at these meetings. Results were also published in the annual National Collaborators meeting handbook. This trial has a large impact on the sweetpotato industry because it allows the growers to view new material as it develops. Many Asian and Latino growers, and all growers regardless of race, benefit from the availability of new varieties that the growers may not be able to test or acquire on their own. In addition, most new varieties are especially appreciated by the organic growers because of their improved disease

resistance. The continual testing of new varieties keeps California on the forefront of changes in the industry to help maintain its competitive edge. Two California advisors worked with colleagues from North Carolina State University and Louisiana State University. One California advisor was the principal contact and organizer for the trial. He arranged to have the roots (seed) shipped to our office and design the trial, made evaluations, summarized and reported results. The other California advisor is the Chair of the National Sweet Potato Collaborators Group. He worked on organizing the annual meeting.

Theme: 1.03 Agricultural Profitability

Title: Acta Horticulturae volume

Cooperating States: California, Texas & Arizona

The Fourth International Symposium on Rose Research and Cultivation was held in September, 2005, in Santa Barbara, CA. This meeting is held every five years, and was held for the first time in the US. Per symposia sponsored by the International Society for Horticultural Science (ISHS), a volume of Acta Horticulturae is produced, which contains the papers presented at the symposium. A California advisor worked with colleagues from the University of Arizona and Texas A&M University to assist in the compilation. The goal is to capture and preserve the research-based knowledge presented at the symposium. This extension effort serves underrepresented populations because many of the middle management and labor force associated with rose plant production is from such populations.

Theme: 5.28 Youth Development/4-H

Title: 2006 4-H curriculum design team

Cooperating States: California, Arizona, Montana, Colorado, Tennessee, Pennsylvania, Maine, Idaho, Kansas, Washington

A California advisor was on the design team for the 2006 publication *Destination Success; Helping Youth Groups Succeed*. This is an interactive curriculum for youth workers as they work with youth in grades 2-6. She authored four activities. The design team represents 12 states. The curriculum is to be piloted in 2006-2007. It is anticipated that many youth groups including underserved populations will be served by this activity.

Theme: 4.23 Water Quality

Title: Agua Pura/WELLS Project

Cooperating States: California and Wisconsin

A California advisor worked with a colleague from the University of Wisconsin's Extension Environmental Resources Program to continue developing the best education practices for watershed education programs. The focus was on developing effective models for reaching underserved populations. The program is expected to provide resource materials for watershed education programs throughout the US and in Mexico.

Theme: 4.04 Biological Control

Title: Control of lettuce drop with biological control and altered fungicide programs

Cooperating States: California and Arizona

A California advisor continued working with growers and consultants in the low desert production to research lettuce drop in Imperial Valley. It is particularly a problem in the eastern portion of Imperial County where lettuce production is more intense. The objective is to extend lettuce drop control information to producers and consultants who work in conditions similar to those of Imperial County, California, where the study is being conducted. In the southwestern portion of Arizona, lettuce drop is present and is more damaging than it currently is in Imperial County, California, due to more intensive lettuce cropping systems in that production area. A field research experiment on the biological control of lettuce drop was conducted in cooperation with a colleague from the University of Arizona, Tucson. They tested the performance of registered fungicides at novel application timings for control of lettuce drop. The project provides producers in California and Arizona with improved techniques for managing this damaging disease under low desert conditions. Many of the Pest Control Advisors who must address this problem are Hispanic.

Theme: 3.03 Human Nutrition

Title: Healthy Families Eating Smart and Being Active Curriculum

Cooperating States: California, Iowa, South Carolina, Colorado, Nevada, Montana, Missouri, Indiana, and Florida

Three California advisors worked with State University Extension agents from many states, to standardize the UCCE Learner Centered EFNEP Curriculum, which was identified as the model. The goal was to provide guidance for the development, training, implementation, and evaluation of the EFNEP curriculum, reflecting the new My Pyramid, the new Dietary Guidelines, and the experiential learning model. Colorado adapted and developed the curriculum, now called *Healthy Families, Eating Smart and Being Active*. Florida, California and Iowa will be piloting the curriculum. Missouri and Montana will be peer reviewing the curriculum. This standardized curriculum will assist in the delivery of consistent messages to low-income families with children. The stakeholders are low-income families at high risk of developing obesity and nutrition-related chronic disease. The potential impact is increasing the number of EFNEP and FSNEP clientele that adopt healthier lifestyle behaviors.

Theme: 3.03 Human Nutrition

Title: Poverty and Obesity; Energy Density Food Cost Study

Cooperating States: California and Washington

One hundred years ago in the United States obesity was a sign of plenty and leisure. People who could afford to eat what they wanted and to pay others to work for them were the ones that put on the extra pounds. The economics of obesity have changed dramatically since then, with the burden of overweight and obesity falling disproportionately on the poor. Unsafe neighborhoods, lack of convenient grocery stores, less leisure time and tight food budgets may all

contribute to obesity and accompanying diseases such as diabetes among the poor. This is a rigorous research project that was conceived in 2003 and should be completed by October 2007. The goal is to compare two socio-economic groups looking at the cost of food and types of food purchased. Food stamp eligible females will be recruited in from the following CA counties: Calaveras, San Joaquin, Solano, Tulare and Yolo. A similar group of higher income women will be recruited in Seattle, Washington. Two California advisors are working on this study, which is under the overall direction of University of Washington, with UC Davis and the Western Center for Human Nutrition Research serving as co-project directors.

During 2005, a component of the study was evaluated to identify indicators at the local level that are outside the individual's control and may vary by location and by economic cycling. Although households control many food purchase decisions, our objective was to identify non-volitional external indicators that predict local ability to support compliance with the Thrifty Food Plan (TFP) recommendations in four California counties. Links between poverty and obesity may be mediated by food purchase decisions based these indicators. The USDA food stamp allotments are connected to the TFP, which supports access to a nutritious diet on a limited budget. A shopping list is provided with the TFP menu to assist in obtaining all the items needed for that week. Food Stamp Program participants have indicated that although the TFP worked with a limited budget, in the long-run there were problems. In 2006, the second phase of this study was underway in San Joaquin, Amador, Calaveras, Solano, Tulare, and Tuolumne Counties. County level survey workers collected data from 30 women in each county using the instruments developed in 2004/2005. In 2006/2007 the data collected in this study will be analyzed and the results disseminated through professional journals and conferences. The stakeholders in this study are low-income food stamp recipients and their families. This study indicates that food stamp cuts, food price and food availability all may serve as external indicators predicting food stamp recipient's vulnerability to economic cycling and less nutritious food selections. Further research is needed to determine if this economic cycling leads to poor food choices and/or is contributing to the higher rates of overweight and obesity in low-income, food stamp eligible populations.

Theme: 5.05 Children, Youth, and Families at Risk

Title: Latina/o Adolescent Pregnancy Prevention

Cooperating States: California and Arizona

California has one of the highest teen pregnancy rates in the nation. Although the teen birth rate is declining, the teen birth rates for Latinas are nearly four times the birth of white teens in California. A California advisor worked with colleagues from the University of Arizona on conducting research for the Best Practices in Teen Pregnancy Prevention, Practitioner Handbook. They discovered that limited formal research had been conducted on culturally relevant practices for Latina pregnancy prevention. In response, they worked on an applied research project and identified best practices in working with this population. The collaboration

has published two handbooks for practitioners, and several journal articles that describe the results of our research. They plan to publish additional articles that will inform educators, policy makers, and practitioners.

Theme: 5.05 Children, Youth, and Families at Risk

Title: Myers-Briggs type indicator curricula development

Cooperating States: California and North Carolina

A California advisor engaged in consultations with North Carolina State University's Personal and Organizational Development (POD) staff to develop and refine Myers-Briggs type indicator (MBTI) presentations for UC staff and external clientele. The objective was to develop high-quality presentations, in consultation with experts in this field. The impacts are more effective presentations and, ultimately, greater adoption of MBTI principles. This program addresses at-risk youth populations, as well as UCCE staff.

Theme: 1.03 Agricultural Profitability

Title: Three-cornered alfalfa hopper control and economic thresholds

Cooperating States: California and Arizona

Three-cornered alfalfa hopper was documented to be at very high levels in 2005 fall alfalfa, with visible damage to alfalfa hay and quality. Previous research has targeted adults in the fall, but treating for adults in mid-summer prior to oviposition is expected to result in increased hay yields and quality. A California advisor worked with a colleague from the University of Arizona on research aimed at controlling three-cornered alfalfa hopper with the intent of establishing economic thresholds. The stakeholders are alfalfa growers in the low deserts of Arizona and California. In addition, research reports will be distributed via web and University of Arizona Forage and Grain Report and will reach Native American growers, Hispanic growers and others interested.

Theme: 1.28 Plant Production Efficiency

Title: Wild Rice Agronomy Project

Cooperating States: California and Minnesota

A California advisor worked with a colleague from the University of Minnesota, Grand Rapids on a collaborative wild rice agronomy project. The objective of this project is to coordinate wild rice research between Minnesota and California. Research includes depth and time of seeding. This work targets wild rice growers in both states and Native Americans in Minnesota.

Theme: 5.28 Youth Development/ 4-H

Title: Youth in Governance Research & Evaluation Team

Cooperating States: California, Wisconsin, and Ohio

A California advisor worked on the National Youth in Governance Initiative with colleagues from the University of Wisconsin, the Ohio University, and the National 4-H Council. The Initiative supports the preparation for, and practice of, youth participation in governance roles and targets both youth and adults supporting each in developing the skills and knowledge needed to be effective in

youth in governance. The Initiative is focused on a multi-strategy approach that builds toward both program and system change and includes five pathways. One of these pathways, Research and Evaluation, focuses on two principle questions: 1) what does the research tell us about best practices of youth and governance and how do we apply that to the work we do within 4-H Youth Development?; and 2) where are the leverage points for organizational change and how and where can youth development organizations make changes that will enable them to operate within a youth in governance approach? The goals are to answer these questions and thus create mechanisms for change. The California advisor trained multi-state audiences and worked with collaborators prepping for training site. She also worked writing curriculum for the training.

Theme: 1.23 Organic Agriculture

Title: Soil biofumigation and solarization for weed management

Cooperating State: California and Idaho

There is a continued demand for organic produce by consumers. This heightens the need for growers to use effective, sustainable agriculture or organic production methods. A California advisor continued to work with Idaho colleagues to reduce growers' dependence on synthetic pesticides. Their goal is to provide the growers with guidelines for using allium biofumigation and/or solarization in lieu of soil fumigation to provide weed control. They are also researching how to improve field worker safety. Many of the smaller scale specialty crop farms in the Central Valley that will implement these techniques are operated by ethnic growers.

Theme: 1.02 Agricultural Competitiveness

Title: Evaluation of lemon varieties for the desert

Cooperating States: California and Arizona

A California advisor worked with a colleague from the University of Arizona to evaluate selected cultivars of lemon for suitability in the California and Arizona desert production areas. The stakeholders are citrus producers and nurseries in these desert areas, including women, minority and small-scale growers. The impact of early and late season varieties will help sustain higher production levels for the desert region.

Theme: 1.27 Plant Health

Title: Research on strawberry viruses

Cooperating States: California and Oregon

Strawberry viruses are transmitted by whitefly and aphid. Two California advisors worked on strawberry viruses in collaboration with Extension and USDA ARS colleagues in Oregon. One California advisor continued to work on research to identify what viruses and what insect vectors are most important. Small scale growers (less than 30 acres), who constitute at least 30% of the industry, are served well by these efforts to produce a better quality plant. In addition, strawberry nurseries need to know if their virus-free meristem programs are, in fact, keeping the industry virus free. Another California advisor worked on

Strawberry Virus Testing evaluating nurseries. He worked closely with a Native American nursery manager, who is a cooperator on the project.

Theme: 5.07 Community Development

Title: Tri-state area economic mapping

Cooperating States: California and Nevada

A California advisor worked on an economic mapping study of the Laughlin, Bullhead City, Needles area of Nevada, which was headed by a Nevada Extension colleague. He conducted research on US Census information.

Theme: 1.17 Home Lawn and Gardening

Title: Master Gardener Training

Cooperating State: California and Nevada

A California advisor continued his work with his Nevada colleague. He conducted two training activities for Master Gardeners and Cooperative Extension volunteers. Many of the participants were senior citizens and area gardeners. There is a large demand for knowledge about producing fruits and nuts in the home garden. Home horticulture increases personal well-being and consumption of fruits and vegetables. The targeted population will have improved life style and improved nutrition.

(3) Did the planned programs result in improved program effectiveness and/or efficiency? Collaboration with colleagues in other states results in improved program effectiveness by maximizing the use of available expertise. All states have faced budget reductions and need to use the remaining resources in the most effective manner. With declining numbers of academics to do research and conduct extension programs, it has become even more critical to share expertise across state borders.

Theme: 5.28 Youth Development/4-H

Title: National Partnership for After School Science

Cooperating States: California, New Hampshire, and Minnesota

A California advisor worked with a 4-H Youth Specialist from New Hampshire and an Extension Educator from the University of Minnesota, as well as other colleagues nationwide, on a national initiative called the National Partnership for After School Science (N-PASS). The goal is to promote a model for long term professional development for after school program providers to help community based organizations (CBO's) implement high quality, hands-on science and engineering projects with their children. Taking a cue from research in formal education, which indicates that occasional or one-shot training has little impact on the way teachers present science material to their students, N-PASS focuses on long term training and support of afterschool agencies in order to ensure a lasting impact on the way these institutions contribute to the science education of the children they serve.

Theme: 4.12 Integrated Pest Management

Title: National Integrated Pest Management Symposium

Cooperating States: California, Illinois, Michigan, Oklahoma, Washington, Maryland, Montana, Texas, Arizona, Georgia, Kentucky, Florida, New York

A California advisor served on the national organizing committee for the 2006 National IPM Symposium, "Delivering on a Promise," which was held in St. Louis, Missouri, April, 2006. The symposium addressed strategies and technologies to solve pest problems in agricultural, recreational, natural and community settings. The conference was attended by more than 650 people from 23 countries.

Theme: 1.28 Plant Production Efficiency

Title: Vegetable crop production/pest management

Cooperating States: California and Arizona

Three California advisors worked with colleagues from the University of Arizona Cooperative Extension on research that benefits growers and pest control advisors in both California and Arizona, who have an interest in aspects of vegetable crop production. They helped organize the annual meeting, the 16th Desert Crops Workshop, held in California, December, 2005. The objective is to share latest research and information available on applicable vegetable crop production for the low desert. One of the advisors was a moderator. Another advisor gave a presentation entitled "Research Update on Melons and Ground Beetles." The immediate usage of information presented would allow for greater/more efficient production and, if markets allow, more economic return to growers.

Theme: 1.28 Plant Production Efficiency

Title: Glassy-winged sharpshooter feeding on citrus

Cooperating States: California and Wyoming

A California advisor worked with a colleague from the University of Wyoming on a study to evaluate glassy-winged sharpshooter feeding on citrus. The glassy-winged sharpshooter is an insect that can feed heavily on citrus and has the potential to spread disease in grapes. Areas surrounding citrus might be treated with an amino acid to act to attract the insects away from citrus. In this way, citrus may not need to be sprayed for these insects. This would reduce pesticide use and reduce the disturbance on natural enemies of other pests in the trees. This potentially could be used for all crops that are affected by glassy-winged sharpshooter.

Theme: 1.24 Ornamental/Green Agriculture

Title: APHIS SOD Science Panel

Cooperating States: California, Georgia, and South Carolina

A California advisor worked on follow-up from the 2004 APHIS SOD Science Panel, which reviewed and evaluated scientific information on the biology of *Phytophthora ramorum*. The objective of the panel was to provide the best possible science-based rationale for regulatory management of the nursery industry. He worked on Sudden Oak Death with colleagues from the University of

Georgia and Clemson University. They are working to develop a practical science-based approach to regulation of the nursery industry.

Theme: 1.06 Animal Production Efficiency

Title: California, Oregon, Idaho and Nevada Working Group (C.O.I.N.)

Cooperating States: California, Oregon, Idaho, and Nevada

With decreasing staffing in livestock extension positions in all western states, this activity has provided a critical mass to address the livestock industry's education and applied research needs. Two California advisors collaborated with Extension livestock advisors and specialists from other western states on projects under the overarching theme of Livestock Systems Management. The goal is to help further the knowledge of their individual clientele at the local level. They used the email list-serve to post questions and obtain educational and research information from the four western states. The impact is quicker problem solving and has allowed members to be able to access a larger network of expertise in responding to clientele questions.

Theme: 4.23 Water Quality

Title: Horticultural best management practices for storm water regulations

Cooperating States: California and Hawaii

A California advisor worked with a colleague in Hawaii on the development of horticultural best management practices (BMPs) for storm water regulations. The extension objective of this program is to provide other states with information on the handling of regulatory requirements that may not have been established in their areas yet, but are certainly on the horizon. Growers in Hawaii have similar concerns regarding water quality regulations, but have not yet developed a program.

Theme: 1.27 Plant Health

Title: Garlic study

Cooperating States: California, Oregon, Australia & New Zealand

White rot is devastating to garlic and onion production throughout the world. Host plant resistance is not available. Once a field is infected, it can limit allium production for over 20 years. The garlic study involves Oregon State University and researchers in Australia and New Zealand. Together they are evaluating fungicides, application methods, and use of biostimulants in a multi-layered approach to white rot management in alliums. They are trying to identify effective fungicides and application strategies to minimize the impact of the disease, as well as incorporate the use of biostimulants in years when a non-host crop is being grown. The California advisor worked conducting cooperative trials. She visited trials in Oregon and communicated frequently with her colleagues.

Theme: 5.09 Consumer Management

Title: Journal of NEAFCS Editorial Subcommittee

Cooperating States: California, Missouri, Idaho, Virginia, Louisiana, Utah, Ohio, and Arizona

A California advisor was on the Editorial Subcommittee for the Journal of National Extension Association of Family and Consumer Sciences (NEAFCS), along with Extension colleagues from Missouri, Idaho, Virginia, Louisiana, Utah, Ohio, and Arizona. The goal is to publish applied research articles and successful programs in the official peer reviewed journal for NEAFCS. This is a means for family and consumer science educators to share their ideas and the results of their programs. The Journal is published annually and serves all family and consumer science professionals nationwide.

Theme: 1.28 Plant Production Efficiency

Title: Nordmann and Turkish Fir Progeny Project

Cooperating States: California, Washington and Oregon

A California advisor worked on the Nordmann and Turkish Fir Progeny Project with Extension colleagues from Washington and Oregon. The objectives of this study are to determine if specific Nordmann and Turkish progeny lines have resistance to naturally infested P.c. soils, and to measure their growth characteristics at several local elevations and climates. Plantings of the same progeny lines will occur in the Pacific Northwest. The potential impact is to increase the local Christmas tree production area and market.

Theme: 1.19 Invasive Species

Title: Precision cultivation of weeds

Cooperating States: California and Arizona

The Eco-Dan® guidance system is new technology that has an electronic eye that can lock onto a seedline and process the image with a computer to accurately guide a cultivation rig down the row. A California advisor is a co-principal investigator working with an Extension Farm Advisor from the University of Arizona on the technology's potential to cultivate close to the seedline to remove more weeds mechanically. They received CSREES grant to evaluate this cultivation system and evaluate its impact on reducing herbicide applications. He invited a representative from the Eco-Dan Corp to give an over view of the technology for the 2005 Salinas Valley Weed School. He presented the findings from their 2005 evaluations of close cultivation. They examined narrower cultivation bands (i.e. 2 and 3 inches) vs. the normal 4 inch wide band in Monterey County and in Yuma, Arizona. He counted the weeds prior to cultivation and post cultivation at the different widths to determine the percent of weed control. Following cultivation, hand weeding of the plots was timed to determine the impact on the time-to-weed per acre. Stand of the crop and yields are also evaluated to determine the impact of close cultivation on yield. The results were a reduced number of weeds and weeding time with the 2 inch wide cultivation band. There was not a reduction in the stand or yield at the narrower cultivation widths. The potential impact is that the Eco-Dan® cultivator is utilized by growers in the Salinas Valley, to cultivate closer and reduce herbicide use, not just to use this technology to increase the speed of cultivation.

Theme: 1.28 Plant Production Efficiency

Title: Product evaluations to offset low desert cotton stress

Cooperating States: California and Arizona

Heat stress is thought to reduce cotton yields by 1-2 bales per acre in the low desert. Several products have the potential to help offset this stress and result in increase yields and quality of low desert cotton. A California advisor worked with a colleague from the University of Arizona to evaluate products for their ability to economically increase cotton returns via increased yields/quality. Publication of results will occur in the University of Arizona College of Agriculture and Life Sciences Cotton Report. The potential impacts of increased cotton yields of 0.5 bales/acre and associated quality increases are expected. This could be as much as \$250/acre. Impacts will be determined in most part by economics of cotton production. Results will have applicability for cotton growers low desert (both Arizona and California), and maybe also for cotton growers in the Central Valley of California.

Theme: 1.03 Agricultural Profitability

Title: Tree Fruit Technology Roadmap Initiative and Competitive Orchard Systems

Cooperating States: California and Oregon

A California advisor worked with a colleague from Oregon State University on the Tree Fruit Technology Roadmap Initiative and Competitive Orchard Systems. This is a set of initiatives being promoted by the Washington Tree Fruit Research Commission to ensure the US industry remains economically viable by reducing production costs and delivering premium quality products to the consumer. It includes: automated orchard and fruit handling operations; optimizing fruit quality, nutritional value and safety; and delivering digital rural information technologies.

Theme: 4.17 Pesticide Application

Title: UC ANR Spray Application Technology Work Group

Cooperating States: California and Oregon

A California advisor worked with a colleague from Oregon State University on the UC ANR Spray Application Technology Work Group. The objective is to establish a means of rapid communication and problem solving among work group members (ultimately benefiting their clientele) via email list-serve, annual meetings, and in-service trainings. Additional objectives include exchange of research results and protocols to improve efficiency of spray delivery and reduce the off-farm movement of pesticides and other agricultural chemicals.

Theme: 4.26 Wildfire Science and Management

Title: Wildfire education

Cooperating States: California, Idaho, Nevada, and Oregon

A California advisor worked with colleagues from the University of Nevada, University of Idaho, and Oregon State University to identify appropriate Cooperative Extension outreach materials and programs to deal with wildfires. They shared a website and other information, adapting it to specific issues in their respective states.

Theme: 1.03 Agricultural Profitability

Title: Cotton entomology

Cooperating State: California, Arizona, Texas, New Mexico, North Carolina State, Arkansas, Tennessee, Louisiana, Mississippi and Florida

Cotton producers in California are faced with economic limitations in managing pests. A California advisor met with cotton entomologists from many states to discuss current pest management issues, review research and extension developments and compile insect loss statistics. During group meetings, growers and pest control advisers have provided important input on the direction of IPM in cotton. These meetings have established important contacts between growers, elevated research and extension activities, created grants, and increased organic production practices. Their collaborative findings are published annually as part of the Proceedings of the Beltwide Cotton Conferences.

Theme: 1.11 Biotechnology

Title: American Society of Agricultural and Biological Engineers Annual International Conference

Cooperating States: Nationwide scope

A California advisor presented her research entitled *The Aprak: California Dairy Manure Management Tool* at the annual international American Society of Agricultural and Biological Engineers conference in Portland, Oregon, July 2006. This presentation covered manure management recordkeeping and application planning software program that we developed in California but that has applicability to other regions of the US. The American Society of Agricultural and Biological Engineers (ASABE) is an educational and scientific organization that works to advance engineering that is applicable to agricultural, food, and biological systems. The organization develops efficient and environmentally sensitive methods of producing food, fiber, timber, and renewable energy sources for an ever-increasing world population. It has 9,000 members in more than 100 countries. The organization's meetings facilitate the exchange of technical information and promotes the science and art of engineering in agricultural, food, and biological systems.

Theme: 4.21 Soil Quality

Title: Soil Fungus Conference

Cooperating States: California and Idaho

A California advisor worked with a colleague from the University of Idaho to help organize the Soil Fungus Conference. This is an annual meeting that brings together soil plant pathologists to present ideas and research in an effort to educate and inform each other what is happening in the Western United States in the area of soil borne pathogens.

Theme: 1.02 Agricultural Competitiveness

Title: Western and National Forage Conference

Cooperating States: California, New Mexico, Utah, Washington, Arizona, Oregon, and Nevada

Forages, taken as a group, are California's largest acreage crop, over 20% of irrigated farm acres. This includes 1.1 million acres of alfalfa and an additional over 1 million acres of other forages (corn silage, sudangrass hay, small grain forages, misc. forage crops). The California Alfalfa Workgroup is the key University of California contact point for alfalfa and forage crops. The workgroup has sponsored the Western and National Forage Conferences. Two California advisors worked with colleagues from Southwestern and Northwestern states to help plan and organize the Western Alfalfa and Forage Conference. It encompassed such topics as industry trends, economics, water politics, pest control, varieties, irrigation, big bales, alfalfa marketing, and forage testing and quality. Water issues, water quality issues, economics, and pest management issues were addressed by experts from California and neighboring states. Growers, PCAs, educators, and industry members attended. The conference was widely appreciated by attendees.

Theme: 1.06 Animal Production Efficiency

Title: Western Beef Resource Committee

Cooperating States: California, Arizona, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming

Two California advisors worked on projects of the Western Beef Resource Committee. The Western Beef Resource Committee is composed primarily of Extension beef specialists for the western states. The committee produces a comprehensive collection of hundreds of articles on beef production written for the cattle producers. The advisors collaborated on developing publications addressing beef production in the Western region of the US.

Theme: 4.23 Water Quality

Title: International Conference on the Future of Agriculture: Science, Stewardship, and Sustainability

Cooperating States: California and Kansas

A California advisor collaborated with colleagues from Kansas State University on the International Conference on the Future of Agriculture, which was held in Sacramento, August 2006. She gave a presentation, based on her research from over the past ten years, on the impact of improved nutrient practices on shallow groundwater quality control under dairies. The conference's focus is "integrating science technology and policy to address the environmental challenges in an agricultural setting."

Theme: 1.27 Plant Health

Title: Plant Doctor Workshop

Cooperating States: California, Minnesota, Texas, Nebraska, Georgia, Kansas, Florida, Hawaii, Iowa, New York, Montana, Michigan, and Washington

A California advisor continued to be a member of the Extension Committee for the American Phytopathological Society (APS). The committee consists of 12 people from land-grant institutions and cooperative extension offices representing 12 states. He helped plan for the Plant Doctor Workshop at the American Phytopathological Annual Meeting in San Diego. This meeting focuses on discussing “the most recent advances in the science and practice of plant pathology.”

Theme: 1.27 Plant Health

**Title: Agronomy/Pest Management Professional Improvement Conference
Cooperating States: California, Georgia, North Dakota, and New Jersey**

A California advisor worked with colleagues from Georgia, North Dakota, and New Jersey to organize the Agronomy/Pest Management Professional Improvement Conference section for the National Association of County Agricultural Agents annual meeting. The conference provided educational opportunities in agronomy/pest management for others in Cooperative Extension nation-wide. Agronomy/Pest Management was a major programming/issue thrust of many attendees at the National Association of County Agricultural Agents annual meeting. The participants exchanged ideas, increased knowledge, and improved applicability.

SECTION F. INTEGRATED RESEARCH AND EXTENSION ACTIVITIES

Cooperative Extension (CE) and the Agricultural Experiment Station (AES) in California are administered by a single authority, the Vice President for Agriculture and Natural Resources, University of California. In his dual role as CE Director and AES Director, the Vice President ensured integration of *all* research and extension activities, including all activities supported by Hatch and Smith-Lever 3(b)(1) and (c) funds.

California AES and CE programs were planned and conducted so as to form a seamless continuum from creation and development of new knowledge to the dissemination and application of that new knowledge. Research and extension programs were coordinated at a statewide level by four Program Leaders - Agricultural Policy and Pest Management, Agricultural Productivity, Human Resources, and Natural Resources - who promoted the integration of research and extension goals and activities across and within AES and CE.

The Program Leaders had oversight of a network of "workgroups," each of which brought together AES and CE personnel collaboratively as they planned and coordinated research and extension programs in a particular high priority program area. Workgroups also included clientele and other external stakeholders as appropriate. Through the workgroups, research goals were developed that addressed practical information needs and mesh with outreach and educational capabilities. Likewise, extension goals were defined in keeping with the available and anticipated stream of research findings. Last year, at a meeting of all Workgroup chairs and Statewide Program Directors, both groups were encouraged to provide input on program priorities and programmatic gaps in positions, both research and extension. This additional role for the workgroups increases the grass roots input into Divisionwide program planning and identification of priority AES and CE positions to be filled.

Many campus-based faculty held joint appointments in CE and AES, thus fully integrating the research and extension functions. The growing number of these appointments ensures that the research generated on campuses has the natural conduit to the CE counterparts in the counties and most importantly, to the end user clientele. In addition, the CE specialists are academic members of appropriate campus departments, facilitating their role as the link to the CE county advisors' programs.

The complete integration of strong AES and CE programs in the University of California ensures that stakeholder needs are identified at the local and statewide level and are brought to the campus researchers' attention. Working closely with their CE counterparts, CE Specialists and county advisors, the AES scientists can then design research projects that will address the stakeholder issues. Results of the research are then applied and disseminated through the CE county programs.

The ANR Biological Control Workgroup, through the California Conference on Biological Control (CCBC), Western Regional 1185 Conference, and the creation of the Center for Biological Control and Western Regional 1185 websites, is an excellent example of the integration of ANR's research and extension academics. The workgroup has addressed all of the key issues pertaining to improved communication and collaboration, providing a forum for biological control practitioners to discuss and work together on issue-related topics. Specifically, CCBC addresses specific high priority issues or concerns affecting clientele by selecting topics that are of immediate concern to land-based agriculture and preservation of natural areas (terrestrial and aquatic). Members of the ANR Biological Control Workgroup decide the Conference Program, which focuses on biological control of arthropod and weed pests and addresses priority issues outlined in the ANR Strategic Plan. At CCBC III, the role of genetic tools and biological control was a Conference theme because of the emerging critical role of genetic tools in biological control - from GMOs, to marking and releasing natural enemies, to determining the origin of new pests in order to better determine where natural enemies for use in classical biological control programs should be collected from.

At CCBC IV, the role of biological control in sustainable farming programs was the key topic. CCBC IV was also co-sponsored by the ANR Organic Farming Workgroup, which held their meeting on day 3 of the Conference. The CCBC V conference will cover citrus biological control, a crop with major historical roots for the discipline, but which has been experiencing rapid changes with control techniques. Additionally, urban biological control will be addressed, and has significance for a state that is becoming increasingly "urban". Invasive weeds have risen to a high priority status throughout the world, and California is no exception. CCBC V will devote a session to weed biocontrol projects. The detailed coverage of these topics, specifically, the benefits biological control practitioners provide end users in California.

One of the landmark accomplishments of all the CCBC conferences has been a Conference Proceedings of approximately 200 pages. The proceeding has articles contributed by each of the invited session speakers on their area. The proceedings are produced in advance of the meeting and presented as part of the registration package. Excess copies are produced for each meeting, and these are donated to selected UC libraries, and then global advertisements for sale of the proceedings are made using internet news groups. Consequently, CCBC proceedings have been sold to biological control practitioners throughout the Americas, Asia, New Zealand, Australia, Europe and even eastern Europe (e.g., Slovakia).

Proceedings from the day 3 ANR Organic Farming Workgroup symposium were published separately by UC-SAREP and also made available in PDF format for

the web. The conference proceedings for the upcoming CCBC V will be available in hardcopy, electronically, and downloadable from the web.

Perhaps one of the most obvious features of the CCBC and W-1185 Conferences is that it builds linkages with non-ANR cooperators to improve coordination and impact and/or leverage resources. Currently, scientists from the UC, CDFA, USDA, CA-DPR, California State Universities, non-CA Universities, and County-level pest managers work on aspects of biological control of insect and mite pests in California. Consequently, there is a great diversity of work conducted by many people on and off UC campuses that focuses on biological control or improved understanding of the ecological principles (e.g., predator-prey dynamics) that govern biological control. The ANR Biological Control Workgroup members include AES and CE faculty at UC Berkeley, UC Davis, UC Riverside and county-based UCCE advisors. The Workgroup has also encouraged statewide cooperation between UC, USDA, CDFA and other agencies in the development of collaborative programs and, for this reason, includes members from state and federal agencies. Lines of communication between primary biological control researchers and University, state, federal and private organizations have been strengthened through joint CCBC program design and participation. The outcome has been communication and collaboration by a number of scientists, resulting in improved practice, regulation, and extension of biological control technology in California.

Because ANR Biological Control Workgroup members are involved with planning decisions and program development, there is naturally a collective decision making process to identify and prioritize issues, goals, and activities to be pursued by the workgroup. The ANR Biological Control Workgroup, through the California Conference on Biological Control has addressed all of the key issues pertaining to improved communication and collaboration providing a forum for biological control practitioners to discuss and work together on issue-related topics. To direct positive changes on both of these issues, members of the ANR Biological Control Workgroup are developing a longer-term plan to foster leadership and innovation in biological control by facilitating intellectual exchange and the development of new opportunities for research and outreach, thereby solidifying a statewide and arguably a global leadership role in biological control for the University of California.