UNIVERSITY OF CALIFORNIA
DIVISION OF AGRICULTURE AND NATURAL RESOURCES

FY 2003
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" (Lincoln's words) with Experiment Stations established to develop "useful and practical information...and to promote scientific investigations and experiments," and a Cooperative Extension program to "aid in diffusing...useful and practical information."

UC-ANR is 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 23 statewide special programs and projects, and supported by 9 Research and Extension Centers and 34 sites of the Natural Reserve System.

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 150 specialists and 260 advisors.

UC-ANR's mission, "... is to serve California through the creation, development and application of knowledge in agricultural, natural and human resources."

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

NATIONAL GOAL 1

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

Globalization of the supply of food, fiber, and ornamentals has placed California's farmers under unprecedented pressure. Import competition from low cost producers throughout the world have combined with the power of the large supermarket chains to squeeze prices of even our specialty crops, so that for many farmers the returns on their crops and products do not cover the cost of production. Production costs continue to increase as farmers respond to societal demands for reduced environmental impact, and as the cost of inputs (energy, water, agrichemicals and labor) continue to rise. California's AES scientists and CE academics resonate to the National Goal 1 of empowering our agricultural system with knowledge that will improve competitiveness in domestic production, processing, and marketing. Our work is, for example, examining the economic forces driving prices, introducing 'new' crops (blueberries and pomegranates are just two examples), developing cost-effective techniques for reducing environmental contamination, improving postharvest quality, and exploring tools to permit organic production of vegetables and fruits.

Last year, 499 local extension programs were delivered in this program area. In addition, 46 statewide collaborative workgroups composed of both AES and CE academics planned and conducted research and extension projects. In addition, UC ANR has 6 Statewide Special Programs that bring together AES and CE resources and personnel that addressed critical issues in the state that are included within National Goal 1. California academics received 23 patents, and published 1001 peer-reviewed articles and 62 extension publications that addressed Goal 1.

FY 2002-2003 Allocated Resources

Extension Federal Funds (Smith Lever	Extension State Match	Research Federal Funds	Research State Match
$3,228,529	$26,099,155 [177.65 FTE]	$2,807,546	$56,642,061 [230.33 FTE]

Overproduction, global oversupply, invasive species, competition for water and labor, and the pressure for urbanization of prime agricultural areas threaten the future profitability of the nation's most productive agriculture. Responding to these threats requires the development of innovative marketing strategies, new crops and products, and new ways to produce them. In the future we may expect a challenging paradigm shift in which the agricultural 'commons' is no longer exploited in the interest of maximizing production, but is licensed so as to balance supply and demand, to maintain prices at a level adequate to ensure profitability and sustainability for California's farmers, and thus maintain the rural amenities that agriculture provides. In a global marketplace, this strategy will only be successful if California's agricultural products are clearly differentiated from those of other producers. Our advisors, specialists, and faculty need to provide research-based information to support the development of premium-quality grade standards, speed the transition to organic agriculture, develop new techniques of processing and packaging familiar products, and exploit the potential of a wide range of 'new' products and crops. Strategic enhancement of breeding programs for high value crops could provide a future

stream of intellectual property that could be licensed to the benefit of California growers. Additionally, we should explore opportunities to harness the power of the information revolution for agriculture, both through the use of informatics, and through the development of smart 'tools' based on microchips, robotics, and machine vision.

Theme: 1.02 Agricultural Competitiveness
Title: The Agricultural Biotech-Intellectual Property Revolution: Policy and Management
Description: Evaluate economics of ex situ genetic resource conservation, including the effects of current and prospective innovations in technology and intellectual property rights; 2. Conduct a positive analysis of the impact of patenting and the parameters of patent protection on the timing and level of resources devoted to crop breeding and related innovations; 3. Model and analyze the design of contracts and alternate means of transferring technology for agricultural innovation in a world of public and private proprietary claims. We prepared a study of the economics of ex situ conservation of germplasm for agricultural crops, including an estimate of the cost of ensuring such conservation in perpetuity. We analyzed in detail the challenges for public and nonprofit institutions in utilizing technologies on which intellectual property claims, including patents, have been established. Further, we completed an analysis of the effects of patenting on access to currently needed technologies for staple crops in developing countries. Work also proceeded on a dynamic patenting model applicable to crop breeding, and on a paper on intellectual property for the Handbook of Plant Biotechnology.
Impact: The genebank costing work will be useful for the major international conservation initiative under way to ensure funding of crop genebanks on a sustainable basis. The papers on intellectual property access and international freedom to operate have already been useful in directing attention of researchers and research managers away from some current non-problems and towards some real future concerns that are materializing as the TRIPS (Trade-related aspects of intellectual property rights) agreement is being adopted worldwide.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness
Title: Agricultural Policy, Trade and Economic Welfare
Description: 1) Examine the effects of technological adoption, factor development and policy in developed and developing countries to understand their implications for trade and their domestic and international welfare consequences. 2) Examine the implications of economic and particularly agricultural growth in principle US trading partners to better understand the effects on US and California producers and consumers. Work on this project involves the analysis of how the expansion of China's agricultural trade will affect factor markets in China and global markets in general. There is disagreement in the literature over the impact of WTO entry on China's participation in world markets. We find that China's entry into the WTO should have significant domestic and international market impacts as long as WTO membership is accompanied by domestic policy reform in China. This project also encompasses an analysis of agricultural state-traders, another important WTO issue. The U.S. government has targeted the reform of state-trading enterprises as one of the objectives of the upcoming WTO multilateral negotiations. We have focused on the role of the Canadian Wheat Board, one of the largest agricultural state trading enterprises. Our findings suggest that state traders may have a large distortionary impact on domestic markets, but their international market impact is relatively small.

Impact: An analysis of the effects of China's entry into the WTO and the role of agricultural state-traders (such as the Canadian Wheat Board) will provide US producers and policymakers with a better understanding of future characteristics of world food trade and the implications for U.S. agriculture.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness
Title: Dairy Herdsmen Upgrade Their Skills Through Short Course
Description: On many dairies, herdsmen either lack sufficient general training or they need to upgrade their skills to adequately manage large-sized dairies. In response to requests from throughout the Central Valley, the Dairy Herdsman Short Course was created to present the latest information in dairy herd management and to improve herdsman skills. UCCE dairy advisors developed the short course with the assistance of Extension dairy specialists and California State University-Fresno faculty. Facilities and dairy cattle were made available through collaboration with CSU-Fresno. Two local dairy producers were involved in planning and selecting topics. Speakers came from UCCE dairy advisors, specialists and CSUF faculty. The short course, publicized through newsletters and popular trade magazines, was held for three days in October 2001 and again in April 2002. Attendance was limited to 40 participants to allow for better informal instruction. Simultaneous translation was provided to Spanish-speaking attendees. Although the short course is organized for dairies in the Central Valley, the material could be used throughout the state by UCCE dairy advisors.
Impact: For both short course sessions, a waiting list was generated of participants wanting to attend. Participants were tested at the beginning and conclusion of the short course, and more than 70% improved their scores on the post-test. An evaluation completed by participants rated the short course as excellent to very good. Informal responses from participants were enthusiastic.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness
Title: Muscle Growth and Development in Transgenic Animals
Description: Study the growth pattern and characteristics of skeletal muscle and control mechanism(s) of muscle growth in transgenic animals. The callipyge gene has been known to have a large phenotype effects, increased muscle growth and lean carcass but with poor meat quality. In order to improve the meat tenderness of callipyge lamb the effects of chemical, biochemical and structural attributes to the meat toughness of ribeye muscle during postmortem aging were investigated. A significantly higher protein content, lower intramuscular fat content, more compact fiber structure, reduced postmortem proteolysis, and reduced myofibril fragmentation were significantly related to the greater toughness of ribeye muscle from callipyge lambs. After 14 days aging, a specific breakdown near I-band and Z-disk junction was observed for the normal ribeye muscle; whereas, a few random degradation of thick and thin filaments was observed for the callipyge ribeye muscle. One of the factors affecting postmortem structural changes and meat tenderness was found to be ultimate muscle pH. A high muscle pH resulted in significantly improved meat tenderness even at 1 day after slaughter; whereas, muscles with normal pH showed a gradual tenderization during prolonged aging period. This tenderness-enhancing effect of high muscle pH was investigated with callipyge muscles to improve tenderness. Callipyge lambs were injected with epinephrine to deplete glycogen and to induce

high muscle pH. After 14 days of aging high pH loin chops had an average shear value of 4.2 kg/1.27-cm core samples, which was close to an acceptable shear value of 4.0 kg. A high pH muscle showed an extensive degradation at the Z-disk - I filament junction, resulting in a greater fragmentation of myofibrils. The manipulation of ultimate muscle pH is one alternative method to improve meat tenderness of callipyge lamb to the acceptable level.
Impact: The sheep industry in the US has been losing its competitive edge to other countries because of high production cost. The callipyge gene can greatly improve meat yield and production efficiency if we can find method to alleviate meat toughness problem. This research addresses to the improvement of meat tenderness of callipyge lamb.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness
Title: New Rice Varieties Keep the California Industry Competitive
Description: Improved rice varieties that meet the changing needs of diverse domestic and world markets are central to keeping the California rice industry economically healthy and rice farmers in business. High quality and reliable supply are keys to sustaining the industry. Every year, UCCE conducts seven or eight trials in growers' fields of more than 100 candidate rice varieties. The candidates are compared to standard varieties for adaptation to the local growing conditions, particularly where temperatures differ. Candidates are grown about three years in off-station trials before release. Few make it past the first year but for those that succeed, the trials provide real on-farm information that supports release and tells growers what to expect from them. This program, in place since 1969, is a cooperative project by the California Rice Experiment Station, the USDA rice breeder at UC Davis and UCCE. The rice breeder provides new germplasm from which useful traits can be put into acceptable varieties. Crossing, selection and on-station testing take place at the Rice Experiment Station.
Impact: Varieties from this public program are grown on 96% of California's half million rice acres. Collectively, they have helped push average yields to 20% above national average and captured a worldwide reputation for the highest quality. In addition to steady improvement in the primary medium-grain varieties, recent releases give growers varieties suitable for niche markets such as aromatic rice, high quality Japanese short grain rice, basmati rice and others. In the last five years the program has released ten new varieties with an eleventh on tap for 2003.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness
Title: Risk and Dynamic Incentives in Agricultural Contracts
Description: The proposed research has three main objectives: 1) To design a theoretical framework capable of predicting differences in contracts across different kinds of commodities; 2) To measure the influence of incentives in various real-world contracts on outcomes; and 3) To help agricultural market participants to improve the efficiency of their contracts, thereby improving the competitive position of their various industries. During 2002 a California researcher developed a model of the behavior of producers in California's processing tomato industry, and completed some preliminary empirical work on estimating the efficacy of contracts between growers and processors in improving tomato quality. In work which focused on the value of contractual incentives for high levels of solids in tomatoes, he was able to estimate the impact of these incentives as well as estimating risk preferences for California processing tomato growers.

Impact: The results of this research are already being used by the California Tomato Growers Association to inform the design of contracts in this important industry. Future research will provide even more useful innovations to contracts.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness
Title: Role of Reserve Stocks in the World Grain Market
Description: This project will examine whether changes in grain storage and other policies of major grain exporters and importers such as the United States, Canada, the European Union and China will contribute to more, rather than less, price stability in world markets, as has been suggested by other studies. This will be conducted under alternative trade policy scenarios. The purpose of this project was to develop a comprehensive model of the relationship between domestic grain stocks and stock policies and world price stability. Although our emphasis was on modeling the United States stockpiling behavior, our model also includes the behavior of other important grain traders like the EU, Canada and China. Our model was designed to assess the impact of trade and domestic policy reform and associated changes in stock management policies on market variables such as trade and prices. Cycles in grain stocks were analyzed relative to stock behavior for agricultural commodities such as cotton and coffee. We addressed the question of whether or not stockholding behavior in grains differs in any significant way than for other major agricultural commodities. The motivation for studying other non-grain commodities is that some of these markets are characterized by less government intervention and more private stockholding, compared to grains.
Impact: This research will return dividends in the form of better understanding of world commodity price variability and the role of stockholding. It will also allow us to evaluate the impact of trade openness on the relationship between stocks and price variability.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness
Title: The Rural Mexican Labor Supply to U.S. Farm Jobs: Survey and Analysis
Description: Mexico-born persons represented an estimated 77 percent of the U.S. farm workforce in 1997-98 and an even higher percentage of new entrants into the farm workforce in recent years. An overwhelming majority originate from households in rural Mexico. A number of economic studies offer insights into mobility and earnings of migrant and seasonal farm workers once they are in the United States. The central objective of this project is to understand the determinants and impacts of migration in rural Mexico, where future U.S. farm labor supply decisions will unfold. A major obstacle to such research has been the lack of detailed and representative data from households in rural Mexico. This project will (A) conduct the first representative, nation-wide survey of households in rural Mexico aimed at understanding how U.S. policies, demographic trends, and economic development in Mexico are shaping the supply of Mexican labor to U.S. farms; (B) estimate an econometric model of migration to U.S. farm jobs; and (C) use this model to predict future impacts of policy changes, demographics, and economic trends on the supply of labor to U.S. farms. The survey will represent a Mexico-side complement to the National Agricultural Worker Survey (NAWS), while collecting data not available from the NAWS but critical to model the supply of Mexican migrant labor to U.S. farms. The survey and analysis will be conducted jointly by UC Davis (Department of Agricultural and Resource Economics and the Center on Rural Economies of the Americas and

Pacific Rim; http://reap.ucdavis.edu) and El Colegio de Mexico (Program on Economic Change and Sustainability in Mexican Agriculture; http://precesam.colmex.mx). The objectives of this binational project are (a) conduct the first nation-wide survey of households in rural Mexico aimed at understanding how U.S. policies, demographic trends, and economic development in Mexico are shaping the supply of Mexican labor to U.S. farms; (b) use these survey data to develop an economic model to analyze migration to U.S. farm jobs; and (c) use this model to predict future impacts of policy changes, demographics, and economic trends on the supply of labor to U.S. agriculture. In 2001-2002, we (1) constructed a nationally representative sample of rural communities, coordinating with INEGI, Mexico's national census office; (2) created formal liaisons with universities in each of the 14 states that came out in the sample and identified state survey coordinators in each; (3) trained survey teams in each state; (4) completed a survey of rural communities, based on interviews with community leaders; and (5) made preparations for the survey of 1760 households in these communities, which is being conducted in January 2003. More than 80 individuals are involved in this survey effort.
Impact: Nearly 100% of all new additions to the U.S. farm work force are migrants from rural Mexico. Rural Mexican migrants are thus a critical input to US agricultural production. The survey will provide the first comprehensive, representative data to understand trends in rural Mexico's supply of labor to US farms as well as likely impacts of policies and other changes on the US farm labor supply. Data from the survey will also make it possible to examine interactions between migration and development in rural Mexico.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness
Title: Successful Crop Rotations--Key to Profitable Farming
Description: In the Imperial Valley, annual crops are rotated twice yearly. The most common rotations are winter vegetables or melons with wheat or sudangrass. The decision as to which crop to use for rotation depends on many factors, including soil type, microclimate and, most important, the presence or absence of plant diseases. If a farmer chooses the wrong rotation, the result is likely to be substantial economic loss or even crop failure. UCCE farm advisors have studied various crop rotations in the Imperial Valley, keeping a record of potentially damaging conditions to be avoided. Plant diseases, microclimate, soil quality and proximity to neighboring crops all can create trouble resulting from the wrong rotation. The advisors have widely distributed information on how to properly evaluate a preselected crop rotation. They utilize meetings, consultations, newsletters and Internet web sites to alert the growers about improper rotations.
Impact: Examples:

- A farmer is growing wheat and plans to grow market onions. The plant pathologist farm advisor asks if the onions to be planted are PRR (pink root resistant). They are not, so the advisor suggests the farmer change varieties. Pink root is a soil-borne fungus disease that does not show symptoms on wheat but can be devastating to onions. Potential savings of at least half of the onion crop are about $35,000 per 40-acre field.
- A field of watermelons is wilting and dying. The farm advisor determines that the problem is a soil-borne disease. The melons are lost, but the advisor also provides a crucial warning: Do not, as planned, grow cantaloupes as a rotation crop--they're susceptible. The farmer switches to broccoli and saves an estimated $30,000.
- A farmer harvesting sudangrass will plant lettuce in a month. He asks the vegetable farm advisor if he should apply nitrogen fertilizer to the crop residue to aid decomposition.

The advisor determines that not only is the nitrogen fertilizer unnecessary, but recommends 30 days of moist decomposition for the sudangrass residue to prevent harmful toxins from damaging the lettuce crop.

Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.02 Agricultural Competitiveness
Title: A Time Series and Econometric Analysis of Marketing and Food Demand Systems
Description: Provide explanations for the nonstationarites that exist in food demand data. Employ new time series techniques to measure the effects of advertising and promotion on California food commodities. Investigate where promotional expenditures should be focused in the marketing channel in order to have the greatest impact on the demands for food. Incorporate and estimate the impacts of media reports on the demand for various foods. This includes the effects on quantities demanded, interrelationships that exist among different food groups, and a determination of the length of the media effect. Develop and estimate some joint marketing cost models to determine if economics of scope and cross-price effects exist in the marketing food commodities. Techniques based on time series analysis, specifically intervention analysis and transfer function model specification procedures were combined with a unique high frequency data set to determine the form and magnitude of the linkages between advertising and sales during the development of a new market. The goal was to closely link in time the actual campaign presence in the market to the shipment response, in contrast to studies that assume particular utility functions and necessarily operate at a more aggregate level using annual budgeted advertising expenditures rather than monthly placements. A case study involving market development programs of California walnuts in Japan, during the period when the campaign was mounted 1986-1993, found the advertising effort to be highly successful in creating a long-run product demand.
Impact: The unique data set that we used indicated that market promotion programs that concentrate on developing new markets can have a long-term impact on consumer demand. The advertising effect was found to be much longer than typically found in the promotion/advertising literature. This has important policy implications for opening up new markets for agricultural commodities in California and elsewhere. The long advertising effect found also opens the door to other techniques to analysis long-term memory processes such as fractional integrated processes. This approach will be used on future projects to measure the impact of advertising effects.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability
Title: Artichokes for Everyone
Description: The artichokes is a delicacy that is seldom enjoyed by the average Californian. Although often found on the appetizer menu of upscale restaurants, the cost and availability of artichokes have been beyond the normal household budget. Many consumers would be willing to purchase more artichokes if they could get them at a reasonable price. Artichokes may be prepared in endless ways, from soup to dips to main dishes. Using more artichokes would offer greater diversity and a flavor change in Californian diets. Also, artichoke flowers can be grown for centerpiece or dried flower arrangements. Until a few years ago, 95% of all artichokes produced in the USA were grown in one small area near Castroville, California. Artichokes were grown as perennials requiring year-round care, which made them expensive to produce and

limited in supply. UC Vegetable Crop Advisors developed Imperial Star, a new artichoke variety that can be grown annually from seed. Previously, artichokes had to be propagated by taking cuttings from mother plants. Unlike the standard vegetatively-propagated artichokes, Imperial Star is highly adapted to many areas of California, including coastal, inland and desert production districts. A USDA Plant Variety Protection Patent owned by UC protects the integrity of the Imperial Star variety and ensures that annual artichoke seed is available to all Californians.
Impact: For a grower, Imperial Star artichoke saves thousands of dollars in growing costs by using seed instead of perennial vegetative planting material. In addition, annual artichokes produce higher yields. Another advantage is that a farmer can select a new field to plant the next year. This leaves many of the insect pests and diseases behind, providing the artichoke crop with a fresh start each season. The Imperial Star variety allows any farmer to become an artichoke producer if he or she wishes. Since the seed is available for roadside marketers and backyard gardeners as well as commercial producers, anyone can try his or her hand at growing an artichoke. The Imperial Star variety has become the most widely sold and distributed artichoke variety from seed in the world. There is commercial production of Imperial Star in Mexico, Canada, Central America, South America, Spain, Morocco, Australia, Italy and France.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability
Title: Cotton Production Practices, Variety Choices for Increased Input Use Efficiency and Productivity
Description: (1) To identify relationships for expected fruit retention patterns for newer Pima and CA Upland Cotton varieties as a function of fruit position and plant developmental stage and compare with known relationships for Acala cotton; (2) to evaluate and document information on varietal performance and regional differences in varietal yield and quality characteristics for Pima, Upland and Acala cotton types; (3) to establish cotton nitrogen uptake and responses to applied N and residual soil N with the goal of assessing utility of soil and plant tissue tests in assessing crop N status and needs for current cotton cultivars; (4) to identify casual factors of bronzing problems with Pima cultivars where possible and identify remedial nutrient applications or other actions for growers; and (5) to evaluate and develop recommendations for management changes needed to utilize transgenic herbicide-tolerant cotton varieties and to improve efficacy of growth regulators in Pima and non-Acala Upland cottons. Low prices and increasing input costs strongly impact grower profitability in CA cotton, and together exert a large impact on sustainability of cotton as a crop choice. Interest in production system changes remains high, including diversification in types of cotton grown (Pima, CA Upland, Acala), evaluation of herbicide-resistant transgenic cotton, and improved management to reduce costs and mitigate some environmental concerns. Variety trials were expanded to include Acala, CA Upland and Pima varieties, and provide continuing information on yield performance and fiber quality across different production areas. Research in variety trials has identified consistency of yield performance in CA Upland varieties, but has also identified some important fiber quality differences between CA Upland and Acala varieties that can impact price. Crop irrigation, planting date and growth regulator studies in Acala versus CA Upland and Pima varieties have demonstrated that: (a) moderate mid- and late-season irrigation delays and plant water deficits can save water and can be tolerated with little impact on yield in some Acala and CA Upland varieties; (b) some CA Upland varieties can be over 10 days earlier in maturity than high-yielding Acala varieties, are usually cheaper and quicker to defoliate, but a wide range exists in boll size, earliness, and fiber quality across available varieties. Pima early decline work has

identified that affected plants consistently are deficient in multiple nutrients in late-season, but severity of symptoms and yield losses are more related to factors such as root system limits or damage than to low soil nitrogen, potassium or other nutrients. Evaluations of germplasm for relative tolerance to early decline indicated relatively low heritability and limited tolerance when symptoms were moderate to severe and when symptoms occurred first during early to mid-bloom. Growth regulator and irrigation studies in Pima have shown that moderate to severe fruiting period water stress and early or high rate growth regulator applications typical in some CA Pima production, while useful in management of excess vegetative growth and earliness, can reduce yields by 10 to 15 percent and reduce quality through impacts on late-season fiber development. Specific plant water status measurements that can be used as guidelines for growers have been identified, and a publication is in preparation. A long-term study of nitrogen (N) management practices demonstrated the utility of residual soil nitrate measurements in assessing crop N needs and likely yield responses to supplemental N in Acala cotton. More than two-thirds of grower field sites over a five-year study did not show yield responses to supplemental N amounts higher than 100 lbs of N per acre, usually because residual soil N levels were high enough to supply much of the crop N requirement. Ranges of soil test nitrate levels in the upper two feet of the soil were identified as relative indicators of supplemental N, and petiole nitrate measurements and fruit load estimates are suggested as additional tools to use in crop N fertilizer management.
Impact: Studies provide the basis for improved nitrogen management for Acala cotton. Residual soil nitrate sampling and crop monitoring provide information to improve nitrogen use efficiency and reduce potential impacts on groundwater quality. Improved irrigation,growth regulator recommendations and variety evaluations on Acala, Pima, CA Upland cotton helps growers with best management practice and variety choice decisions.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability
Title: Narrow Row Cotton: More Yield Per Acre
Description: Although California has historically led other states in cotton production, increased production costs and lower commodity prices have led to the need to produce higher yields with lower inputs. Field research beginning in the late 1970's showed that yields could be increased by simply planting cotton in rows narrower than the traditional 40 inches. Increases were about 5% for two rows on a 40-inch bed, 10% for 30-inch beds and 10% for 20-inch beds. Since it is impractical to produce cotton on rows any narrower than 30 inches, this became the standard. Each year, I conducted one or more narrow-row tests in comparison with conventional 40-inch spacing. Various cotton varieties and numerous plant populations were tried. Results consistently showed 30-inch rows outyielding any other row configuration. The first 30-inch spindle cotton harvester in the world was created in Merced County by converting a conventional 40-inch picker. Results of our tests led both John Deere and International Harvester to produce commercial 30-inch spindle cotton harvesters.
Impact: Greater yields from narrow-row cotton have produced an increase of over $3,000,000 per year for growers in Merced County alone. Today, more than 80% of cotton in the county is grown on 30-inch rows. Other counties have adopted this cultural practice, as have most of the cotton producing states in the U.S.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.03 Agricultural Profitability
Title: Transgenic Herbicide Tolerant Cotton
Description: Annual and perennial weeds infesting thousands of acres of cotton in California remain a major stumbling block to efficient and economic cotton production. Early weed competition (first week of the crop's life) cause the greatest yield reduction while late season infestations interfere with defoliation and harvest. Weeds growing outside the crop serve as hosts for insects, mites and pathogens. Strategies employed to control weeds can be quite costly, amounting to 40% of the total pest control costs, and also have negative impacts on the environment. Since 1996 studies have been conducted at UC Research and Extension Centers and with grower cooperators throughout the San Joaquin Valley to evaluate both Roundup Ready and BXN (Buctril) herbicide-tolerant cotton varieties. The trials indicated excellent control of summer annual broadleaves with herbicide-tolerant cotton varieties, including both Roundup Ready and BXN. To control grasses, grass herbicides have to be tank-mixed with Buctril. Annual morningglory, nutsedge and field bindweed can be effectively controlled with two applications of either Roundup or Buctril. Information developed through these studies provided growers the needed guidelines to adopt the use of herbicide-tolerant varieties.
Impact: Herbicide tolerant cotton has now been integrated in our cotton production system. In 2002, 50% of the upland cotton grown in California was genetically modified, either Roundup Ready, BXN or stacked gene (Bt/Roundup Ready). These varieties have reduced grower costs as much as $100 or $150 per acre. Herbicide use has been reduced and growers are now experimenting with alternative production systems (conservation tillage) to further reduce costs and improve soil and air quality. This technology has allowed growers to maintain their economic viability, and at the same time have a positive impact on the environment by reduced use of herbicides and tillage, resulting in better air quality.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.05 Animal Health
Title: Dairy Quality Assurance Animal Health and Well-Being
Description: Consumers have targeted marketing organizations such a chain restaurants and grocery stores with questions on the "humaneness" of production practices utilized in food animals. The California dairy industry has promoted their products to the consumer with sayings such as "Happy cows come from California." With the evolution of these ads -- along with consumer queries -- animal protection organizations have responded by filing national and state law suits, which have yet to be successful in court but have actively used the media to raise consumers' concerns for the well-being of dairy animals. This has paralleled the on-going development of an animal welfare module which will be included in the voluntary California Dairy Quality Assurance Program. Workgroup participants in the animal welfare module have performed an exhaustive review of many different issues -- concerns of both producers and consumers. One collaborative effort was the review of scientific literature associated with the increasing practice of tail docking on California dairies. Findings clearly determined that there are no positive benefits to the animal, while fly predation was a problem in animals with docked tails. This scientifically based recommendation was contrary to a proposal by a nationally approved animal welfare module that was being promoted in California. This review was published in a prominent peer-reviewed veterinary journal, and the article received many letters to the editor. These findings, with an emphasis to discontinue the practice, have been quoted in many articles in lay journals for producer audiences. This issue may become elevated to a regulated practice with the probability of state legislation being introduced in the coming session.

Impact: This program has been extremely well received by producers on environmental issues and will be a viable mechanism to educate producers on production practices that are scientifically based and beneficial to the welfare of the dairy animal. This module will provide the consumer marketing base with assurance in proper handling techniques and facility design. The acceptance of the module as best management practice will give California an edge in marketing its dairy products.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.05 Animal Health
Title: A National Agricultural Program to Approve Animal Drugs for Minor Species and Uses
Description: Identify the animal drug needs for minor species and minor uses in major species. Generate and disseminate data for the safe, effective, and legal use of drugs used primarily in therapy or reproductive management of minor animal species. Facilitate FDA/CVM approvals of drugs fo minor species and minor uses. During this reporting period the following project goals were completed. Florfenicol in sheep (ADR #325): Pharmacokinetic studies were completed. More than 400 serum samples were collected for analysis after IM and IV dosing. Estimated time to completion of samples analysis is 5 months. Human Food Safety protocols are in development and the study is scheduled for early next year. Progesterone CIDRs for sheep (ADR #258): A protocol for Target Animal Safety is being developed. Fenbendazole in game birds (ADR#280 - collaborative project with the southern region): The method validation is being completed. Romet-30 in fish (ADR#313): The western region laboratory continues the analysis of samples. Ceftiofur in llamas and alpacas (ADR #275): Publication Pharmacokinetics of Ceftiofur in Red Deer has been completed and submitted to the Journal of Veterinary Pharmacology and Toxicology. Work continues on the Species Grouping project. Comparative metabolism studies have begun. The assay system is currently being optimized and converted to a 96 well plate assay.
Impact: Pharmacokinetics, human food safety, and target animal safety studies are required by FDA/CVM to obtain minor and specialty animal drug clearances in minor species for drug registration. Data must be obtained for each animal species for which drug use is intended. These minor use animal drug registrations will impact the farmers and ranchers of the Western Region with the potential beneficiaries of this research being consumers in the Western Region and the rest of the United States.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA, FL, IA, NYC

Theme: 1.05 Animal Health
Title: Retroviruses and Animal Diseases
Description: 1) Develop a method of real-time detection of bovine leukemia virus (BLV) provirus DNA to quantify viral genomes within populations of naturally infected lymphocytes. (2) Determine the dynamics of the spread of infection of BLV from an initially infected lymph node and the timing of the immune response to the virus. (3) Use the properties of naturally occurring variants of the BLV envelope glycoproteins to develop a structural model of the receptor binding domain of the surface glycoprotein. (4) Determine whether dileucine and YxxL amino acid sequences present in the cytoplasmic domain of the BLV transmembrane protein govern cell surface expression of the protein. Retrovirus infection of host cells requires an interaction between complexes of viral envelope proteins present on virus particles and receptor proteins present on the surfaces of host cells. Several retroviral envelope proteins are expressed

at low levels on the cell surface because of rapid endocytosis from the plasma membrane. The protein sequences that regulate low surface expression are located in the cytoplasmic domains of the transmembrane (TM) subunits of these envelope proteins. To identify such sequences in the TM protein of bovine leukemia virus (BLV), mutations affecting putative endocytic motifs were introduced into a chimeric gene encoding the extracellular and membrane-spanning domains of the human CD8 cell surface protein and the cytoplasmic domain of BLV TM. An N-terminal deletion in the cytoplasmic tail of TM lacking threonine 461, serine 462 and two pairs of leucine residues and a C-terminal deletion lacking three motifs composed of tyrosine - any amino acid - any amino acid - leucine (YxxL) were generated to determine whether these sequences were important for endocytosis. Amino acid substitutions included mutations of di-leucine pairs to alanines, tyrosines 487 and 498 to alanines and phenylalanines as well as threonine 461 and serine 462 to alanines. The mutant CD8-Stop, lacking all but 3 membrane-proximal amino acids of TM, served as a negative control. None of the introduced mutations affected the expression or stability of the chimeric proteins. Mutation of either of the two di-leucine motifs increased the cell surface display of the chimeric protein. Display was maximal when all four leucines were mutated or deleted altogether, as well as when the C-terminus of TM was deleted to remove the three YxxL motifs. Individual mutations of tyrosines 487 and 498 also increased cell surface display of the chimeras, but not to the same extent as the deletions of N- and C-terminal sequences. Low cell surface display of the chimeric protein was due to rapid internalization from the cell membrane. Together, these findings indicate that the cytoplasmic tail of the BLV transmembrane protein contains leucine- and tyrosine-based endocytic motifs that are capable of conferring low cell surface expression of the protein. All chimeric proteins containing more than 3 amino acids of TM were phosphorylated, but the C-terminal deletion mutant was more weakly phosphorylated than the other proteins. Phosphoserine was present in chimeras the that were tested, but no phosphorylation of the native BLV envelope protein was detected. The endocytosis motifs may be used in virus-infected cells to allow regulated expression of envelope protein, reducing the chances of immune recognition of infected cells. Default internalization of envelope proteins would have to be counteracted during the virus life cycle to allow production of virus particles.
Impact: Understanding when and where the envelope proteins of BLV are present in infected cells is critical to be able to design vaccines and strategies to prevent virus transmission. BLV infection is widespread in dairy herds in the United States, causing cancer and prohibiting export of animals and germplasm. Thus, this work has impact on the economic consequences of animal disease.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Bluetongue Virus Infection of Cattle: Maximal Duration of Infectious Viremia
Description: We have 2 specific objectives: 1. to determine the duration of infectious viremia in cattle infected with bluetongue virus (BTV) by the bite of infected Culicoides insects. The presence of virus in cattle blood then will be detected at regular intervals after infection by PCR assay, virus isolation, and the feeding of either wild or laboratory reared Culicoides insects, and the duration of viremia determined by each method compared. 2. to sequence key genes of BTV during sequential passage of the virus through its vertebrate and invertebrate hosts. Genes to be evaluated are those that encode (a) VP2, which is responsible for virus attachment to mammalian cells, (b) VP7, which is responsible for virus attachment to insect cells, and (c) NS3/3A, which is responsible for virus egress from infected cells. Bluetongue (BT) is an insect-transmitted disease

that occurs in sheep and wildlife throughout much of the world. Cattle are considered to be virus reservoirs. As the only List A disease of the Organization International des Epizooties (OIE) that is endemic in the US, BT is a costly impediment to livestock trade. There are just 15 diseases in OIE Schedule A, including foot and mouth disease, rinderpest, and BT, with each deemed to "have serious socioeconomic consequences and major implications for international trade in livestock and livestock products." International trade of livestock and livestock products now is "rules-based," as mandated by GATT (SPS regulations). The member countries of OIE voted in 1999/2000 to adopt a new Code pertaining to BT. This Code directs the international trade of ruminants and germplasm from BT- endemic areas such as California, but critical portions of the revised Code such as the maximal duration of infectious viremia in cattle (which dictates the period of quarantine) and the utility of new diagnostic tests (PCR) remain somewhat uncertain. Our studies showed that BTV can be isolated from vector insects that feed upon naturally infected cattle and sheep for less than 30 days after infection and less than 60 days by conventional virus isolation, whereas BTV nucleic acid can be detected in the blood of infected ruminants for up to 220 days after infection by nested PCR assay. We also showed that genetic diversification of individual BTV gene segments occurs as a consequence of quasispecies evolution and founder effect during serial transmission of virus between the vertebrate and invertebrate hosts of BTV. Our studies confirm that BTV infection of ruminants is prolonged but not persistent, and that rational international trade policies for ruminants and their germplasm from BTV-infected regions of the world should reflect that reality.
Impact: Our studies confirm that BTV infection of ruminants is prolonged but not persistent, and that rational international trade policies for ruminants and their germplasm from BTV-infected regions of the world should reflect that reality. Furthermore, that the nested PCR assay is a consevative anmd accurate test for the continued safe movement of ruminants from BTV endemic regions of the world.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Cellular and Molecular Characterization of the Spider Lamb Syndrome, an Heritable Chondrodysplasia
Description: Characterize the genetic basis of a heritable chondrodysplasia in sheep, the Spider Lamb Syndrome (SLS) at the molecular and physiological levels and to develop guidelines to capitalize on this naturally occurring mutation by relating the mutation to overall body composition. The objective of this research centers on utilizing the genetic basis of the Spider Lamb Syndrome (SLS), a genetic defect that impacts the sheep industry, to improve market lamb production. As we have previously shown, lambs homozygous for the mutant allele die early postnatally, while carriers appear physically normal. A genetic test is available to detect broodstock carrying the deleterious allele which has reduced the incidence of the disorder in the general sheep population. Identification of the causal gene (fgfr-3) and the development of a test for the SLS mutation have been major breakthroughs for the sheep industry. We have recently shown that although carrying two copies of the defective gene is lethal, carrying a single copy of the defective gene offers a growth advantage over the homozygous normal animal. We have evaluated mature homozygous normal ewes and ewes heterozygous for the mutation for linear growth parameters as well as body fat and muscle indicators. Although body weight and spine length is unchanged due to a single copy of the mutated fgfr-3 allele, height at withers, metacarpal bone length, and body fat are altered. Body height and bone length are significantly increased by approximately 6% in the heterozygous ewes, while fat is significantly reduced by

50%. This suggests that judicious use of this mutation may provide a means of improving the growth of market sheep without exogenous manipulations by providing dietary growth promotants or implants. We are continuing the characterization of the expression and developmental profile of the gene involved as it significantly influences linear bone growth. We are also initiating a study to evaluate the overall body composition of animals carrying one copy of the defective gene to further substantiate our hypothesis.
Impact: Potentially enhancing body growth by 6% by incorporating a naturally occurring genetic mutation into breeding schemes will have a significant economic impact on sheep production. Characterizing body growth and composition of the fgfr-3 mutation during development will allow the determination of how useful this mutation will be to sheep producers.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Control of Carcass Composition and Meat Quality in Livestock
Description: To study the control of growth, carcass composition and meat quality in livestock, including the effects of: a) genotype; b) nutritional history; and c) endocrine state.
Over three consecutive years, 180 (60/yr) fall-born steer calves were weaned in May (initial BW 238 kg) and allocated to one of three groups: calf-fed steers entered the feedlot at weaning; short yearlings grazed irrigated pasture for another four months and entered the feedlot in September; long yearlings grazed with short yearlings during the summer, remained on annual California foothills range through the fall, winter and spring, and entered the feedlot the following May. All steers were fed until the average group backfat (BF), determined by ultrasound, reached 10 mm. Grazing steers gained weight in the summer and the spring, but slightly lost weight in the fall and winter. Average days on feed were 188, 158 and 94 days for calves, short yearlings and long yearlings, respectively. Feedlot DMI and ADG increased with age (and weight) at feedlot entry, with no difference among groups in gain:feed. BF gain was nil on pasture, even when animals were gaining weight, then increased rapidly when animals were placed on a high energy ration. Final body and carcass weights were heaviest in long yearlings, followed by short yearlings and then calves, indicating that a prolonged growing period increases the apparent mature size of the animal. Moreover, dressing percentage, marbling scores, % Choice, and intramuscular and total carcass fat contents were all lower ($P < 0.05$) in cattle that were older at feedlot entry (i.e., long yearlings) compared to the other groups. In conclusion, increasing the backgrounding period reduced time on feed and total feed requirements of Angus-Hereford steers. Older cattle reached 10 mm BF at heavier weights. Grazing animals gained weight without increasing BF; BF increased rapidly in the feedlot. Prolonged grazing may reduce quality grade, either by impairing the animals' ability to deposit intramuscular fat, or by reducing the time during which dietary energy supply is adequate for intramuscular fat deposition to occur.
Impact: Beef producers must balance variable feed costs and returns from sale of finished cattle. This information allows ranchers and feeders to make more informed decisions about the optimal production system for different forage years and price scenarios.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Dairy Farmers Save Money, Prepare for Regulations Using Manure as Fertilizer
Description: A UCCE farm advisor in Stanislaus County uses a hand-held spot meter to check the flow rate of dairy wastewater mixed with irrigation water being applied to cornfield. Growers

have long known that dairy manure water pumped onto adjacent farmland contains useful plant nutrients. However, because it hasn't been easy to estimate the amounts of nitrogen and other nutrients in the water, farmers have added commercial fertilizer. Under the US EPA'a revised Clean Water Act requirements, most dairy farms will have to prepare management plans documenting all plant nutrients applied to fields. Eventually, the revised regulations will require producers to submit documents showing they are applying manure nutrients at appropriate rates. Final compliance with the regulations will be required by January, 2006. Growers are concerned about the complexity of complying with the new regulations. Now, data from the Biologically Integrated Farming Systems (BIFS) program and other UC research projects using flow meters and nitrogen "quick tests" have made it possible for farmers to measure nutrients in the lagoon water. This enables them to reduce or eliminate use of synthetic fertilizers. BIFS is administered by UC's Sustainable Agriculture Research and Education Program (SAREP). A UCCE associate hydrologist's project on the impact of dairy waste and nutrient management on groundwater quality was conducted in conjunction with the UCCE farm advisor's project on the use of dairy lagoon water in the production of forage crops. The projects laid the groundwork for the dairy BIFS project, involving farmers and pest control consultants as well as UC farm advisors, specialists and other researchers. Field days, workshops, grower surveys and other tools that directly link researchers with farmers have been used extensively in the project.
Impact: In one on-farm demonstration project, eight BIFS dairy farmers in partnership with UC farm advisors and researchers have optimized the use of animal manure on their forage crops, reducing the use of nitrogen, phosphorus and potassium and lessening the leaching of nitrates into the soil. Cost savings to the growers averaged $55/acre and went as high as $116/acre. In a related project, Harter found an overall 25% decrease in average shallow groundwater nitrate concentration over four years where cooperating dairy farmers were managing the nutrients on their fields.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Ecology and Management of Arthropods in Poultry Systems
Description: Objectives: 1) To study the biology of pest species, with emphasis on characteristics affecting population density and movement (e.g. moisture requirements, dispersal) and control. 2) To document interactions of pest species with natural enemies (pathogens, parasites and predators) including evaluation of cultural manipulations, alternate biotypes and field releases, if appropriate. 3) To test potential new, preferably specific, pesticides for fly and ectoparasite control, including effects on nontarget (beneficial) species. These will include, but will not be limited to, selective larvicides, residual adulticides, and bait-toxicant formulations. Results of a study of Fannia spp. tolerance of low moisture were published. Larvae were unusually tolerant of low moisture (down to 40% water) chicken manure for development, particularly if they were third instars. Results of a survey of house fly, Musca domestica, resistance to toxic baits are about ready for publication. Field populations are almost completely resistant to methomyl baits, and this resistance has a major behavioral component. Northern fowl mites, Ornithonyssus sylviarum, respond to heat cues, vibration, and chemical residues left behind by resting mites. They also are ubiquitous in southern California caged layer production and resistant to pesticides used in the field, and this is ready for submission for publication. Studies of sampling plan development and economic impact of mites are ongoing.
Impact: Fannia spp. probably cannot be controlled using the same moisture reduction techniques that work for Musca. While some Fannia oviposition deterrence occurs due to low moisture,

larvae can still develop. The advantage of the dry manure pad for control is probably due to enhanced fly natural enemy activity. House flies in caged layer facilities are quite resistant to toxic baits containing methomyl. The requirements for their continued use should be removed. Northern fowl mites are ubiquitous in the industry and are seriously resistant to pesticides, especially permethrin. We will lose mite pesticides soon due to resistance and the Food Quality Protection Act. Integrated management strategies for mites are desperately needed.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Ecology, Control, and Epidemiological Role of Vectors of Bluetongue Virus to Ruminants
Description: Objectives: To estimate components of vector capacity of C. variipennis (e.g. biting rates, survivorship, vector competence), study how they react to influence BLU transmission, and apply these and available estimates from the literature to modeling efforts to predict bluetongue disease occurrence. To test integrated control strategies for Culicoides in the context of reducing vector capacity. Recent activity has focused on two Culicoides projects. First, we documented seasonal adult flight activity, size variability related to temperature, and parity in a salt marsh population of Culicoides occidentalis. This species was recently elevated to full species level but is closely related to C. sonorensis, the main vector of bluetongue virus. Adults of this population are active year-round, including high activity in winter. While body size was inversely related to air temperatures, greatly buffered temperature variability (coastal effect) resulted in far more stable body size relative to inland populations of both C. occidentalis and C. sonorensis. Parity was exceedingly low.
Impact: The biology of C. occidentalis is mostly unknown, but its relationship to the main bluetongue virus vector, C. sonorensis, makes it of particular interest. Knowing the Culicoides fauna near and biting horses, plus their developmental sites, is key to developing possible management strategies to reduce their biting rates and thus the allergy problems in horses.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Effect of Nutritive Status on Reproductive Efficiency in Domestic Animals
Description: Objective: To examine the impact of nutrition and nutrition-dependent chemical signals on reproductive function in sheep and cattle for the development and implementation of management techniques that will improve the well being of domestic species. One aspect of our research examines the effect of stress on fertility in sheep. In this regard, most producers recognize that prolonged stress, such as exposure to temperature extremes, isolation and/or restraint, transportation, or repeated laparoscopy, delays or suppresses estrous behavior and reduces ovulation rate in sheep. Short-term or acute stress may have a similar consequence. To examine the effect of acute or short-lived stress on gonadotrope responsiveness castrated male sheep (wethers) were passively immunized against gonadotropin releasing hormone (GnRH). A GnRH agonist that does not react with the anti-GnRH antisera used for passive immunization was administered hourly maintain the normal circhoral pattern of gonadotropin secretion. The effect of stress on the pattern of gonadotropin secretion was assessed by administration of lipopolysaccharide (LPS; 200 ng/kg, iv). Collectively the data indicate that stressors like LPS act a hypothalamic and hypophyseal loci to affect gonadotropin secretion. The immediate target of stress is the hypothalamus, while the more long term response is a decrease in gonadotrope responsiveness due to direct effects of the stressor a hypophyseal sites.

Impact: The fertility of domestic species is reduced during periods of stress. Thus disease, stressful management practices and/or adverse climatic conditions suppress follicular maturation and block or delay ovulation. The long-term goal of our studies is to define the physiological basis for stress-induced infertility in domestic species. We hope that these studies will lead to the development and implementation of management strategies that will reduce the incidence of stress and lessen the impact of unavoidable or inadvertent stress.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Epidemiology of Bovine Viral Diarrhea Virus Infection in Dairy Cows
Description: Objective: to develop pooled sample testing methodologies for BVDV PI and analytic epidemiology methods to assess effects of abortifacients on bovine fetal health. Estimate risks of BVDV I and II infection acquired after birth to identify features of the calf and dam and general management that are associated with the risk of postnatal infection (PNI). Estimate risk of infertility and abortion associated with BVDV exposure under typical drylot management conditions. Bovine viral diarrhea (BVD) is caused by a heterogenous group of viruses that can become established in vaccinated herds as either persistent infection of individual animals or as cycling endemic infection in a herd. The goal of the study was to further define the epidemiology of BVD, including transmission in herds, risk of infection following vaccination, and prevalence of both persistent and congenital infection. The field study design documented a high rate of transmission of BVDV in well-vaccinated herds, predicted the age at which BVDV vaccination would be most effective in dairy calves, and quantified the health and economic impacts of BVDV congenital infection in dairy herds.
Impact: This study further defined the epidemiology of BVD, including transmission in herds, risk of infection following vaccination, and prevalence of both persistent and congenital infection.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Evolving Pathogens, Targeted Sequences, and Strategies for Control of Bovine Respiratory Disease
Description: Objective: 1. Identify emerging and re-emerging agents and develop diagnostic methods for BRD. 2. Characterize mechanisms and intervention targets in pathogenesis of BRD at the molecular, cellular and host level. We have performed an experiment in which four groups of three calves each were immunized with either F protein DNA vaccine, N protein DNA vaccine, or control green fluorescent protein DNA vaccine. Calves immunized with the N (nucleoprotein) gene showed increased survivability compared with other vaccinates after live BRSV challenge. Immunological parameters are being evaluated.
Impact: This research has demonstrated effectiveness of the DNA vaccine technique for protection against BRSV infection.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AL, CA, GA, IA, KS, LA, MI, MN, MO, MS, NE, OH, OK, SD, TX, WI, NADC

Theme: 1.06 Animal Production Efficiency
Title: Gene Identification in a Major Locus that Increases Animal Growth

Description: Objectives: Identify genes important in the control of animal growth utilizing a unique mouse model mutation resulting from a small deletion in chromosome 10. To sequence BAC clones in the contig encompassing the high-growth deletion in the mouse, and identify and characterize expressed transcripts and genes within the deletion. High growth (HG) is a unique mouse model for understanding the control of animal growth in mammals. HG mice have a 30-50% increase in post-weaning growth rate and mature body size and a substantial increase in feed conversion efficiency. We mapped the locus responsible for this phenotype to a 500-kb deletion in mouse chromosome 10. A physical map of bacterial artificial chromosomes spanning the entire deleted region was constructed. By random shotgun DNA sequencing, EST analysis and database comparisons we identified three genes within the deletion: suppressor of cytokine signaling-2 (Socs2), involved in signal transduction; Raidd/Cradd, an adaptor molecule in the cascade of apoptosis; and Plexin C1. The two deletion breakpoints lie in within the second introns of both Socs-2 and Plexin C1, resulting in the formation of a novel expressed fusion transcript between Socs-2 and Plexin C1 in HG mice. Socs2 has been identified as the primary causative gene for hg. We have mapped and sequenced this gene in cattle and pig and have identifyed polymorphisms in these animals to examine association of this gene with growth related traits.
Impact: The identification of the gene responsible for generating the very large growth response observed in high growth mice will provide the basis for studies to understand the effects of homologous genes in domestic animals and man. In domestic animals this presents the potential of identifying specific gene targets to select faster growing more efficient animals.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Genetic Bases for Resistance and Immunity to Avian Diseases
Description: Objectives: 1) Identify and characterize genes and their relationships to disease resistance in poultry with an emphasis on the major histocompatibility complex, as well as other genes encoding alloantigens, communication molecules and their receptors and other candidate systems; 2) Identify and characterize environmental, dietary and physiologic factors that modulate immune system development, optimal immune function and disease resistance in poultry genetic stocks; and 3) Develop and evaluate methodologies and reagents to assess immune function and disease resistance to enhance production efficiency through genetic selection in poultry. Carotenoids play a functional role in many species, in terms of their pigmenting properties as well as potential immunomodulatory activity. The effect of dietary carotenoids on incorporation of carotenoids into immune tissue of hatchling chicks was examined in relation to the maternal carotenoid status (e.g., yolk carotenoid level). Single comb white leghorn chicks were hatched from carotenoid-replete (C+) or carotenoid-deplete (C-) eggs. Chicks were fed for 4 wk on diets ranging from 0 to 38 mg total carotenoid/kg diet. Carotenoid additions consisted of lutein + canthaxanthin at a ratio of 4:1. After 4 wk, the carotenoid concentration of thymus, bursa, liver, plasma and shank epithelium were measured by HPLC. This study demonstrates that carotenoids drawn from egg yolk are detectable in chicks fed 0 dietary carotenoids for 4 wk. In fact, initial yolk carotenoid concentration significantly impacted the incorporation of dietary carotenoids into all tissues (P0.5). In chicks hatched from carotenoid-replete eggs (n=36) and fed dietary lutein (38 mg/kg diet, as above), LPS reduced plasma zeaxanthin, liver zeaxanthin, and liver total carotenoids (P0.6). An IL-1 or LPS-induced acute phase response plasma and liver carotenoids but not those in primary lymphoid organs.

Impact: Use of antibiotics in animal production is being prohibited so new strategies of augmenting health are needed. Dietary carotenoids augment immunity in lab animals. We have shown that the best way to keep carotenoid levels high in growing chicks is to provide high levels to the hen and to avoid inflammatory responses. Optimizing carotenoid levels may enhance immunity, promote health, at increase productivity of chicks.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AL, AR, CA, CTS, DE, IA, NC, NH, NYC, PA, SC, TX, ARS/BARC, ARS/ADOL

Theme: 1.06 Animal Production Efficiency
Title: Host-virus Interactions in BTV-Infected Cattle
Description: Objectives: 1. To determine the duration of infectious viremia in cattle infected with BTV by the bites of infected C.V. sonorensis insects. 2. To determine the sequences of key viral genes during serial passage of BTV through its insect and ruminant hosts. 3. To determine whether differences in the outcome of BTV infection of cattle and sheep reflect differences in the susceptibility of vascular endothelium in the 2 species. The goal of this project is to better define the pathogenesis of bluetongue virus (BTV) infection of ruminants. During the review period we have completed in vitro studies to define the interaction of BTV with primary cultures of ovine and bovine pulmonary artery and lung microvascular endothelial cells (ECs). These studies established that the kinetics and consequences of BTV infection of the various ECs are distinct, and that differences between the response of ovine and bovine microvascular ECs are consistent with the expression of bluetongue disease in sheep but not cattle. We also have continued studies that confirm that duration of infectious viremia is finite in BTV-infected ruminants.
Impact: The fact that the duration of viremia is finite in BTV-infected ruminants has considerable relevance to international trade Codes pertaining to bluetongue, the only OIE List A disease that is endemic in the US. Our studies with primary ECs indicate that these cells provide a very convenient and relevant system for the characterization of the pathogenesis of bluetongue disease.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Improved Diagnosis and Control of Bovine Neosporosis
Description: The overall goal of this project is to improve the diagnosis and control of bovine neosporosis. The specific objectives are: 1) to investigate the humoral and cellular immune responses of cattle to Neospora infections and 2) to evaluate immunologic methods for prevention of Neospora abortions. Neosporosis is a significant cause of infectious abortion in cattle. Most cattle acquire the infection as a fetus from their dam who was persistently infected with the tissue cyst stage of the apicomplexan parasite Neospora caninum. During pregnancy, the slowly-dividing bradyzoites in these cysts become activated and differentiate into the infective, rapidly-dividing tachyzoites which travel via the blood and/or tissues to the placenta and fetus. The infective tachyzoite is an obligatory intracellular parasite, which must invade host cells to survive, replicate and initiate infection. Thus it is necessary to understand the host cell invasion process, since intervention strategies that prevent invasion would effectively block both replication of the parasite and the associated pathology. We hypothesize that serine proteases, including subtilases, play a role in host cell invasion by N. caninum tachyzoites. To test this hypothesis, we evaluate the effects of various protease inhibitors, as well as of an antibody raised against NcSUB1, the first subtilase of N. caninum tachyzoites, on host cell invasion by

tachyzoites and on intra-cellular growth of parasites. Tachyzoites of N. caninum strain Nc-1/lacZ, a transgenic derivative of strain Nc-1 that constitutively expresses cytoplasmic beta-galactosidase (beta-gal) were used for this purpose. We first demonstrated a correlation between the number of viable parasites and b-gal activity, and calculated the optimum numbers of host Vero cells and parasites, needed for the invasion and the growth assay. We then initiated studies to test the effects of various inhibitors of aspartic, cysteine and serine proteases on host cell invasion and intra-cellular development of the parasites. Studies were also performed to test the effects of rabbit anti-NcSUB1 on host cell invasion and intra-cellular growth of parasites. These studies are expected to be completed by August-September 2003.
Impact: Currently there is no effective treatment of neosporosis. The N. caninum vaccine, recently approved by USDA, was shown to reduce abortion, but did not prevent vertical transmission, which is the major route of transmission of the disease, responsible for maintenance of the infection in cattle herds. Therefore, there is an urgent need to identify novel targets for drug and vaccine development. Results from this preliminary study will reveal whether serine proteases, including the subtilase NcSUB1, play a role in host cell invasion by N. caninum tachyzoites. This knowledge will lead to novel strategic approaches to chemotherapy and vaccine development for neosporosis, and is therefore expected to have a significant impact on the livestock industry.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Interpreting Cattle Genomic Data: Biology, Applications and Outreach
Description: Objectives: 1. Determine the location, structure, function and expression of genes affecting health, reproduction, production, and product quality in cattle. 2. Interpret and apply genomics and proteomics information by developing statistical/bioinformatics methods and utilizing molecular tools in cattle. 3. Develop and deliver educational materials about bovine genomics research to consumers and stakeholders.
1) Genetic Modification of the Composition of Milk Fat: The objective of this study is to clone genes affecting the composition of milkfat, to identify polymorphisms in these genes, and study their associations with milk composition in dairy cattle. We have cloned and characterized the bovine stearoyl-CoA-desaturase and acyl tranferase gene LPAAT, and mapped these genes to bovine chromosomes 26 and 23, respectively. 2) Development of an AA and BB kappa-casein and beta-lactoglobulin herd of lactating dairy cows, application of marker assisted selection: The genetic variants of milk proteins have an important influence on the composition of milk, on the cheese making properties of milk and structural properties of whey-protein concentrates. We have bred two herds of dairy cattle, in one herd we have increased the frequency allele A of kappa casein and beta-lactoglobulin and in the other herd we have increased the frequency of the B allele. Herd B milks have a higher solids non-fat and casein content in milk, and in 3 trails have produced about 5 percent more cheddar cheese. Data has been collected from these herds to examine the effect of markers assisted selection on reproduction and other production traits.
Impact: Modification of the composition of milk fat by reducing the proportion of saturated fatty acid and improving the structure of milk fat will have an economic impact on the marketability of milk products and on the nutritional health quality of milk. Genetic selection of cows using molecular markers to increase the yield of cheese in the range of five to eight percent can have a significant economic impact for the dairy industry.
Funding Source: Hatch Multistate Research and State

Scope of Impact: AZ, CA, IA, IL, KY, MA, MI, MN, OH, PA, TX, VA, VT, NON-SAES: NADC

Theme: 1.06 Animal Production Efficiency
Title: Mapping of the Pacific Oyster Genome
Description: Construct a moderately dense linkage map of the Pacific oyster genome, using ~150 randomly spaced microsatellite DNA markers. Associate linkage groups with specific chromosomes by analysis of trisomic (2n+1) lines of oysters developed at Rutgers University. Map QTL for growth heterosis in large F2 hybrid populations. Conduct inheritance experiments to reveal whether identified lethal genes are defects in single genes that can be transmitted to progeny or result from interaction among multiple genes ("synthetic lethals") which will be broken up by recombination and not transmitted. Previously we reported that unexpected non-Mendelian inheritance of genetic markers was caused by a large number of highly deleterious recessive mutations in the oyster genome. This year, we showed that our earlier estimate of about 12 such mutations per oyster genome was probably an underestimate by finding 22 in one F4 family. We also showed that most of these mutations are passed predictably from one generation to the next, as single recessive mutations, with no evidence that loss or reduced numbers of expected genotypes owes to complex interactions among genes. Most mutations were expressed at the late larval or early juvenile stages. Separately, we completed the construction of a moderately dense, genetic linkage map of microsatellite markers, by using outbred families and 11-day-old larvae to reduce the segregation distortion caused by homozygosity for recessive deleterious mutations. The consensus map comprises ten linkage groups and has a total length of 700 to 750 map units, in agreement with cytological observations of chromosomes. The male consensus map is shorter than the female consensus map, and there is significant heterogeneity among families within sex, in both the order and spacing (recombination) of markers. We also constructed a preliminary gene-centromere map for 56 markers, using six, unrelated, triploid families. Triploidy was induced by chemical inhibition of the second meiotic division of fertilized eggs, and distance between the centromere and a marker was estimated from the proportion, y, of heterozygous progeny from a heterozygous female parent. Two previously published studies of gene-centromere recombination for protein markers (allozymes) in bivalve molluscs had shown very high proportions of heterozygous progeny, which was interpreted as evidence for one and only one crossover in each chromosome arm (complete interference). For microsatellite DNA markers, we instead find that most y-values are less than 0.67, suggesting absence of interference among crossovers. As for the linkage map, there appears to be substantial variation in the gene-centromere maps in different families, in both the order of markers and their distance from the centromere.
Impact: The primary, immediate impact of our work is on other participants in this Regional Research project. Primers for microsatellite markers have been exchanged among participants to facilitate coordination of gene-mapping efforts on three continents. Eventually, linkage maps will enable the mapping of economically important traits and increased efficiency in selection and crossbreeding.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Organization and Regulation of Chicken Fast Myosin Heavy Chain Genes
Description: The long-term goal of this project is to elucidate the physical map and the molecular mechanisms controlling gene expression of the chicken fast sarcomeric myosin heavy

chain locus. During the course of this three-year project, the arrangement of 5 characterized fast myosin heavy chain genes will be determined. Studies will be performed to characterize the neural induction of a late fetal myosin heavy chain gene in myogenic cultures containing neural tube explants. The last objective will be to isolate and identify the regulatory sequences within the late fetal myosin heavy chain gene that control neural regulation. The objective of this project was to describe the complexity and regulation of the chicken fast myosin heavy chain multigene family. Over the course of this project we were able to determine the full length sequences of 7 chicken fast myosin heavy chain mRNAs and determine the organization and arrangement of the 7 genes that encode these myosin heavy chain isoforms. We also characterized the expression of these genes in developing pectoral and leg muscles of the chicken, as well as in a dozen different muscles in adult chickens. This represented the major objectives of this project. During the course of these studies, we also found that regulation of one of these genes was under neural regulation and began studies to identify the cis-acting sequences upstream of this gene that controls its expression in nerve muscle co-cultures. This part of the project is still ongoing. Lastly collaborative studies with Professor Benjamin Rosser were undertaken to analyze mechanisms of gene regulation during muscle development. These studies found that myosin transitions within developing skeletal muscle fibers originate near motor endplates and that myonuclear domains are smaller at the ends of muscle fibers.
Impact: Myosin is the major protein found in muscle tissue and accretion of muscle mass is the direct result of myosin gene expression. The results of our project on the regulatory mechanisms of myosin genes in chickens will enable growers to ultimately employ novel methods for improving the efficiency of muscle growth.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Reproductive Performance in Domestic Ruminants, UC PI #1
Description: Examine basic concepts regulating gonadal and uterine physiologic mechanisms limiting and influencing pregnancy in domestic animals.
The objective of our studies is development and implementation of management techniques that will improve the well being of domestic species. One aspect of our research examines the effect of stress on fertility in sheep. In this regard, most producers recognize that prolonged stress, such as exposure to temperature extremes, isolation and/or restraint, transportation, or repeated laparoscopy, delays or suppresses estrous behavior and reduces ovulation rate in sheep. Short-term or acute stress may have a similar consequence. To examine the effect of an acute stressor (bacterial infection) on the magnitude and duration of the preovulatory surge of LH the estrous cycles of sheep (n = 11) were synchronized by use of lutalyse (PGF2 alpha) and intravaginal progesterone release devices (CIDR). The effect of stress on follicle maturation and ovulation was assessed by administration of saline or bacterial endotoxin [lipopolysaccharide (LPS; 200 ng/kg, iv)] beginning at the onset of behavioral estrus. Animals received saline or LPS at 2 h intervals for 12 h. The preovulatory surge of LH was evident in control (n = 5) animals 48.5 +/- 2.1 h after CIDR removal. In contrast, surge-like secretion of LH was not evident during the 5 d period following CIDR removal in 67% (4 of 6) of sheep receiving LPS. Moreover, the onset of the surge was significantly delayed in those LPS-treated ewes that showed surge-like secretion of LH. Collectively, these data indicate acute or short-term stress can block or delay follicular development and the preovulatory surge of LH in sheep.
Impact: The fertility of domestic species is reduced during periods of stress. Thus disease, stressful management practices, and/or adverse climatic conditions suppress follicular maturation

and block or delay ovulation. The long-term goal of our studies is to define the physiological basis for stress-induced infertility in domestic species. We hope that these studies will lead to the development and implementation of management strategies that will reduce the incidence of stress and lessen the impact of unavoidable or inadvertent stress.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AK, AZ, CA, CO, HI, ID, KS, MI, MN, MO, MT, NE, NM, NV, OH, OR, TX, WA, WY, USDA/ARS

Theme: 1.06 Animal Production Efficiency
Title: Reproductive Performance in Domestic Ruminants, UC PI #2
Description: 1. Investigate molecular, cellular and endocrine mechanisms that limit or control reproductive efficiency in domestic ruminants. Since the last report, we have experimentally infected virgin heifers with Tritrichomonas foetus or with one of two previously described non-T. foetus trichomonad isolates from the bovine prepuce, namely Tetratrichomonas species and Pentatrichomonas species. Heifers were slaughtered 6 weeks after infection, and reproductive tract tissues were collected. Culture results from weekly cervico-vaginal mucus (CVM) aspiration showed that - contrary to our expectations - 2/6 heifers had positive CVM cultures for the Tetratrichomonas species as much as five weeks after infection. This finding does not agree with two previous trials in which we attempted to infect virgin heifers with non-specific preputial trichomonads that we had not characterized at the time. In those trials, none of 15 heifers inoculated at estrus with one million organisms had a positive CVM culture at any of the weekly samples collected before slaughter at 6 weeks. The only element that we are aware of that may explain the discrepancy between these trials is that we used both the InPouch T method and Schneider's eggshell medium in the most current trial, whereas we used InPouch and Diamonds TYM in the previous trial. The positive cultures were detected only in Schneiders. We will further study the histopathology of the experimentally infected heifers, including immuno-histochemical analysis using monoclonal antibody for a T. foetus-specific lipo-phospho-glycan surface molecule.
Impact: If there is detectable pathology in the reproductive tracts of heifers inoculated with non-specific trichomonads, it will suggest that extensive characterization of this group of organisms be undertaken. At the moment, if the diagnostician can say that the trichomonad seen in InPouch-cultured smegma samples is not T. foetus (by PCR assay), the bull is presumed to be uninfected, i.e., to be free of trichomonosis. We need to be certain that is true.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AK, AZ, CA, CO, HI, ID, KS, MI, MN, MO, MT, NE, NM, NV, OH, OR, TX, WA, WY, USDA/ARS

Theme: 1.06 Animal Production Efficiency
Title: Serologic Detection of Salmonella Dublin Carrier Cows Using Elisa
Description: Continue serologic surveillance of cattle for evidence of exposure to Salmonella serogroups B, C, D, and E (these constitute the most prevalent serogroups in cattle). Serve as reference laboratory for veterinarians who request Salmonella serology as an aid in designing on-farm Salmonella control programs and for researchers studying the biology of Salmonella on farms. These findings can then be applied to a HACCP program to control Salmonella on these farms, and change a heavily contaminated farm to a lightly contaminated farm.
The biology of Salmonella on large western dairies was studied using culture techniques and an ELISA which detatects antibodies directed against LPS from groups B, C, D, and E Salmonella, which are the most common pathogenic serogroups found in cattle. A high proportion of cows on

Salmonella culture positive dairies became seropositive. Salmonella was found to widely cotaminate animals and the environment, and could be regularly found in bulk tank milk prior to pasteurization. Feed was a source of Salmonella , and the feed contamination on three dairies studied was traced to irrigation water which had been contaminated by human sewage effluent of three separate origins. The same water is used to irrigate crops for human foodstuffs on neighboring farms and probably also contaminates these products.
Impact: The study clearly indicates that dairies are a part of the entire regional ecosystem. They contribute to environmental contamination, and they are the unwilling recipients of environmental contamination from other sources. Salmonella can nad does go full circle, from human sewage effluents to human food. The importance of considering the entire ecosystem in designing programs to reduce Salmonella contamination was demonstrated.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: Unique Promoter Regulating Trophoblastic Differentiation
Description: We have identified a unique palindromic promoter that dries expression of CYP17 and possibly other genes involve din the differentiation of the trophectoderm of, and the establishment of pregnancy by, pre-attachment porcine blastocysts. This project will: 1. Define the core sequence required for promoter activitya nd binding of nuclear transacting proteins that activate expression of porcine CYP17 and, 2. Clone and characterize the 66 kD transcription factor that activates the core promoter of CYP17 expressed in the trophectoderm of pre-attachment porcine blastocysts. Trophoblastic differentiation is essential for the establishment and successful completion of pregnancy. This process proceeds in porcine pre-attachment blastocysts with the expression of the CYP17 gene that encodes for the enzyme 17 - hydroxylase/17,20-lyase cytochrome P450 (P450c17). The expression of this enzyme, exclusively in the trophectoderm layer, is associated with trophoblastic differentiation and is essential for conceptus survival in utero. We have cloned the entire CYP17 gene in the domestic pig, and have begun defining sequence elements in the regulatory region that are unique in driving trophoblastic expression. The specific aims of the project are: 1) To define the core sequence of the palindromic promoter driving CYP17 expression in porcine trophoblast, 2) To clone transcription activating protein(s) associated with the core palindromic promoter. Results We have defined a novel, non-TATA promoter element directing the assembly of a transcriptional complex at a position on the gene that is uniquely used for the expression of CYP17 in the porcine trophectoderm. The essential core element exists within a 34 base pair fragment of the porcine CYP17 gene, 142 bp 5' of the transcription start site utilized in gonadal and adrenal tissues. It has extensive homology to previously described 'initiator elements', but with a very different core structure. Site-directed mutagenesis experiments, together with gel shift and southwestern blotting experiments have defined the essential nucleotide bases associated with promoter activity. These do not correspond to those identified as core for initiator elements. Finally, we have only just begun screening of expression libraries, with a plan to use our defined promoter element, and inactive point mutants, as probes to clone the protein(s) that bind and thereby modulate the activity of his unique trophoblastic porcine CYP17 promoter. These experiments will completed, and the final goal of the project pursued further, even though the current project will be officially terminated with this report.
Impact: The placenta is the organ that determines the growth rate and well-being of the fetus, and diseases or conditions such as the large calf syndrome associated with cloned animals are believed to arise from derangements of placental development. The research described adds to

our understanding of the transcriptional and other regulatory mechanisms that are unique to the placenta and therefore are likely to provide insight into diseases afflicting offspring before and after birth.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.06 Animal Production Efficiency
Title: The Use of Micro-Colony PCR for Detection of Mycobacterium paratuberculosis from Bovine Manure
Description: Our objective is to assess and optimize the PCR confirmation of M. paratuberculosis microcolonies. The primary hypothesis to be tested is that PCR analysis can be performed on micocolonies of M. paratuberculosis appearing between 7-14 days afer spirally plated on Middlebrook agar plates. The use of PCR on micro-colonies will circumvent the problems of sensitivity and PCR inhibition when this technique is used directly on broth cultures, manure or tissues. Johne's is a contagious bacterial disease of ruminants that has significant animal health, economic, and potential human health consequences. This grant provides additional funding to optimize the confirmation component of a modified culture assay for the detection of the Johne's agent from bovine manure. Traditional culture methods rely on certain growth requirements (such as mycobactin J dependency), and other biochemical testing to confirm the identity of isolates as Mycobacterium paratuberculosis. These additional tests can add weeks to months onto the time required to confirm a positive culture. Research funded by other grants have provided a modified culture technique that can recover high numbers of M. paratuberculosis within weeks of sample processing (compared to months for conventional culture methods). However, before the assay can be tested on naturally infected animals, a more rapid test to confirm the genus and species of the mycobacteria recovered must also be developed and incorporated into the culture test. A PCR based assay previously developed to directly test manure samples, is being modified and optimized to test the microscopic colonies resulting from the modified culture assay. To date, isolates of M. paratuberculosis from spiked manure have been detected and identified via PCR within 14 days after sample plating.
Impact: Johne's is a contagious bacterial disease of ruminants that has significant animal health, economic, and potential human health consequences. This grant provides additional funding to optimize the confirmation component of a modified culture screening assay for the detection of the Johne's agent from bovine manure. Traditional culture methods rely on certain growth requirements, and biochemical testing to confirm the identity of mycobacteria isolates as the causative agent of Johne's disease. These additional tests can add weeks to months to the time required to confirm a positive culture. Research funded by other grants have provided a modified culture technique that can recover the Johne's agent within weeks of sample processing (compared to months for conventional culture methods). However, before the assay can be tested on naturally infected animals, a more rapid test to confirm the identity of the mycobacteria recovered must also be developed and incorporated into the culture test. A PCR assay previously developed to detect a specific gene from the Johne's agent directly from manure samples, is being modified and optimized to test the microscopic colonies resulting from the modified culture assay. To date, isolates of the Johne's agent from spiked manure have been detected and identified via PCR within 14 days of sample processing.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.07 Apiculture
Title: An Alternative to Honey Bees for Pollination
Description: Managing bees for pollination is becoming more difficult as beekeepers face challenges from the Africanized honey bee, the Red Imported Fire Ant, Varroa and tracheal mites and several other pests and diseases. Colony strength, winter survival and restrictions on movement of bees in to and out of the state all affect the economics of beekeeping. Growers who rely on honey bees for pollination are concerned about future availability of bees as well as increasing costs for pollination. Leafcutter bees are used for pollination on certain crops in Canada and the Pacific Northwest, but they had not been used in California due to their higher cost and more intensive management requirements. If leafcutter bees could be used to pollinate several commodities in this area, there would be greater incentive to establish the necessary infrastructure, the cost would go down, custom pollinators might become involved and more growers could take advantage of the leafcutter bee's superior pollinating activity on certain crops. Leafcutter bee pollination was evaluated in alfalfa seed, almonds, boysenberries, kiwis, squash, strawberries and melons. In addition to pollination ability, bee survival and reproduction were evaluated. Alfalfa seed, strawberries and melons were the most promising crops for leafcutter bee pollination. Subsequent research helped determine best management practices for leafcutter bee pollination in these crops. Beekeepers and growers were informed at meetings, field days, and in newsletters.
Impact: Alfalfa seed growers achieved significantly higher yields when leafcutter bees were used alone or in combination with honey bees for pollination. Growers were able to set seed in difficult areas of the field more easily, and the pollination period was reduced because of this bee's efficiency. Strategies have been developed to maximize bee survival and pollination effectiveness. Several companies now provide custom leafcutter bee pollination for seed growers in California. Leafcutter bees can successfully pollinate melons, but are no better than honey bees. The life cycle of the leafcutter bee is well matched to the bloom period of melons, and they can survive and reproduce under commercial production conditions. If honey bees become more expensive due to reduced availability, leafcutter bees may provide a suitable alternative. Research is under way to develop strategies to improve the effectiveness of leafcutter bee pollination in melons. Strawberry growers do not currently pay for custom pollination. However, as the industry becomes more sophisticated and may have to compete for limited market share, leafcutter bee pollination may provide the quality and yield advantage that pays for itself.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.08 Aquaculture
Title: Determining Lysine and Methionine Requirements of Juvenile White Sturgeon
Description: Sturgeon fisheries have been reduced drastically since their historic peak at the turn of the century as a result to over-fishing, poor fishery management, and inadequate habitat protection. Because of its high quality of meat and the high price of caviar produced from the eggs of sturgeon, there has been a growing interest in culture of these fishes for mitigation of natural stocks and for foods in several countries. In 1996, more than 600 metric tons of fresh and several metric tons of caviar from white sturgeon were produced by the California fish farmers. There is, however, no commercial sturgeon feed in the market because there is a lack of information on the nutrient requirements, especially those of the two expected first limiting amino acids, lysine and methionine. The lack of a cost-effective and yet ecologically and environmentally friendly feeds prevents the growth of sturgeon aquaculture to its fullest

potential. Objectives of the project is to determine the lysine and methionine requirements of white sturgeon. Four one-week trials were conducted to determine the effects of feeding rates on growth performance and body proximate composition of white sturgeon (Acipenser transmontanus) larvae during the first four weeks after initiation of feeding. Feeding rates (% body weight.d-1) were 10, 20, 30, 40, 50, and 60 for trial I; 5, 10, 15, 20, 25 and 30 for trial II; and 2.5, 5.0, 7.5, 10.5, 12.5 and 15.0 for trials III and IV. Four tanks with 200 larvae each were randomly assigned to one of the six feeding rates. Average initial body weights of the larvae were 49, 94, 180, and 366 mg, respectively, for trials I-IV. The larvae were kept at 18-20 degrees C in circular tanks and fed continuously one of two commercial salmonid soft-moist feeds using automatic feeders. Proximate composition (%) of the feeds for trials I-III and trial IV were 13.9 and 14.9 moisture, 52.5 and 50.0 crude protein, 10.3 and 12.9 crude fat, and 8.1 and 8.7 ash, respectively. Except mortality in trial I, feed efficiency in trial III, and body ash and nitrogen free extract in all trials, growth performance and body composition were significantly (P
Impact: Information on the optimum feeding rates of white sturgeon larvae will be used to construct a feeding table that will allow California sturgeon farmers to feed their fish efficiently. Furthermore, excellent growth achieved in the sturgeon larvae using this table will have compounded effects on the later grow-out of market size or caviar producing sturgeon.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.08 Aquaculture
Title: Enhancing Reproduction of Sturgeon
Description: Objectives: 1) To investigate physiology of final ovarian maturation and early identification of sex in white sturgeon; 2) to evaluate reproductive characteristics and develop captive breeding of green sturgeon. The analysis of maturational hormones produced by the ovarian follicles of white sturgeon during the germinal vesicle breakdown revealed secretion of C21 steroids, which were identified by high performance liquid chromatography and gas chromatography-mass spectrometry. The HPLC fractions of these steroids induced in vitro oocyte maturation, confirming their roles in final ovarian maturation. Gravid females held at constant and elevated water temperature (18-20o C) before their spawning or caviar harvest, had low plasma concentrations of ovarian steroids and exhibited ovarian follicular atresia. Histology and electron microscopy of the ovarian follicles revealed the roles of transformed granulosa cells in a phagocytosis of the oocyte. The early development was characterized in green sturgeon embryos and larvae obtained from the wild broodstock (Klamath River, California). The descriptive illustrated stages of early development and observations on growth from hatching to metamorphosis gave insight in reproductive biology of this rare species.
Impact: Studies with white sturgeon improved the knowledge of physiological mechanisms involved in environmental control of the ovarian maturation. They contributed to development of sturgeon breeding on farms and production of white sturgeon caviar, which exceeded 5 metric tons in 2002 and may double within few years. Studies with green sturgeon contributed to understanding life history of this species, petitioned for listing under the Endangered Species Act. These continuing studies will provide information on environmental requirements for reproduction of green sturgeon and its potential use in aquaculture.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.08 Aquaculture
Title: Genetics of Fish for Aquaculture and Conservation

Description: Objectives: To simultaneously develop a molecular genetic map of the genome and identify quantitative trait loci and tilapia; apply standard breed improvement techniques for the improvement of tilapia and coho salmon; extend the breed improvement methodology as genetic markers become available and apply the genetic marker technology to studies of natural populations with reference to fishery management and conservation activities by local and national agencies. The project completed a 20-year program on the application of advanced animal breeding methodology to the production of farmed fish. Working with both rainbow trout and tilapia, an extensive analysis provided estimates of phenotypic and genetic parameter estimates, including heritability estimates and genetic correlation estimates for a wide range of growth and reproduction traits. Estimates of rate of inbreeding and its effect were obtained for a ten-generation series with rainbow trout; estimates were near zero for body weight and growth and ranged from 3 % to 8 % per 10 % inbreeding for reproductive traits. The project also demonstrated the effectiveness of mixed model and animal model procedures applied to fish broodstock populations. For example, mixed model methods used to estimate breeding values as the criterion for selection resulted in a 20 % to 30 % improvement in rate of selection response relative mass selection in a population of tipalia.
Impact: The results of the project have provided the industry with an extensive list of parameter estimates of value in designing advanced breed improvement programs. The trout and salmon farming industry have used the results widely. In addition, a number of farm breeding programs have adopted the mixed model, selection index approach to improving the performance of salmon populations.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.08 Aquaculture
Title: Measurement of Enzymatic Reaction Rates in Aquatic Organisms Via NMR as Indices of Sublethal Toxic Effects
Description: To establish relevant biochemical markers to provide quantitative in vivo measurements of sublethal chemical toxicity in living aquatic organisms using two representative pesticides, dinitrocresol and copper. Our general research approach is to establish biomarkers of toxicity for pesticides (such as phenols and copper) via measurement of sublethal toxic actions in live aquatic organisms using in vivo 31P NMR spectroscopy. In addition, we are extensively involved in discerning the impacts of agrochemicals in both marine and freshwater systems. Therefore, we have recently completed a number of studies aimed in these broad directions. First, we have described the sublethal toxic actions of the commonly used pesticide copper in native California red abalone (Haliotis rufescens) and found negative impacts to energy production. In particular, copper was shown to cause severe respiratory inhibition, as measured by changes in ATP, inorganic phosphate (Pi), and phosphoarginine. We have also discovered that the general biocide pentachlorophenol causes similar actions in abalone larvae, which could potentially impair their development to adults. We are currently developing m metabonomic methods for use with aquatic invertebrates and fishes via 1H NMR. Such methods will provide a complete assessment of the sublethal metabolic impacts of agrochemicals. Second, we have developed in vivo 31P NMR methods to determine the sublethal metabolic actions of pesticides (diazinon and esfenvalerate) on developing embryos of killifish (Medaka spp.), a common test species, and chinook salmon (Oncorhynchus tschawytscha), an important anadromous species that spawns in the Sacramento River. Overall, both pesticides were found to cause sublethal respiratory inhibition, again as measured by reductions in available ATP and phosphoarginine. Inhibition of energetic processes, while not necessarily acutely lethal, may decrease

developmental success, reducing population recruitment of anadromous fishes over time. Third, we are interested in the sublethal actions of pesticides on immune function in marine animals, particularly the abalone (which is currently impacted by withering syndrome), and the harbor seal (Phoca vitulina). With adult abalone, we have described the immunosuppressive actions of pentachlorophenol via measurement of chemiluminescence activity. In seals, using whole blood we have used several immunological assays to describe the suppressive actions of the historical insecticide DDT as well as a number of PCB congeners. Fourth, we are currently characterizing the glutathione-S-transferases (GSTs) in anadromous chinook salmon and white sturgeon (Acipenser transmontanus). Important for the detoxication of electrophilically reactive pesticides such as atrazine, we are also developing the methods to compare their activities in different water salinities, as would be encountered during seaward migration. Finally, through the use of the toxicity identification and evaluation (TIE) approach, we have identified the sources of agrochemical toxicity to native aquatic organisms in San Francisco Bay, Los Angeles Harbor, Grizzly Bay (CA), both the Pajaro and Salinas Rivers, and the Calleguas Creek Watershed of Southern California. In most cases we have determined them to be sediment-sorbed historical pesticides, such as the now banned organochlorine insecticides.
Impact: The overall goal of our research is to describe the toxic actions and sources of agrochemicals in marine and freshwater organisms. In particular, we are interested in the sublethal actions of pesticides. Most water quality standards adopted by the State of California are guided by the knowledge of chemical lethality in test species (as determined by standard bioassays). However, at much lower concentrations most chemicals can exhibit sublethal actions, including metabolic disruptions and suppression of immune function. Sublethal actions can result in reduced reproductive success or increased disease susceptibility; both of which may ultimately reduce adult populations. For instance, currently abalone populations all along the California coast have been decimated by withering syndrome, which is caused by a bacterial vector. However, susceptibility is enhanced by chemical (possibly pesticide) and other stress factors. Therefore, better knowledge of sublethal chemical actions will allow regulators to set more protective water quality standards, thus ultimately better protecting adult populations. In a similar vein, we have employed the TIE approach to discern the source of toxicity in sediments from a number of watersheds throughout the state. Over the past several years we have worked closely with the California State Water Resources Control Board to identify the specific agrochemicals responsible. In particular, we have been able to provide guidance too on how best to manage both pesticides and watersheds to reduce future impacts to native organisms.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.08 Aquaculture
Title: Ornamental Fish Culture: Nutrition and Feeding
Description: To elucidate nutritional needs of cultured ornamental fish using both live and formulated feeds used in the production and maintenance of aquarium fish. Ultimately, it is hoped that the development of appropriate expertise in the culture of these ornamental species will lead to a new aquaculture industry in the state. In contrast to freshwater aquaculture and the culture of anadromous species such as salmon, marine fish culture is in its infancy. The small larval size of many marine species presents significant challenges to culture, however if appropriate husbandry conditions can be defined these fish could provide considerable promise both as laboratory models and new aquaculture industries. Unfortunately, at present, specifications for ideal culture conditions for marine fish are limited. Careful studies are needed to determine optimum culture conditions with marine species. Work this year was carried out

with two species; the common clown fish Amphiprion ocellaris and the California halibut, Paralichthyes californicus. The clown fish was chosen in that it is one of the few marine species already being cultured and thus removal individuals from besieged wild populations would not be necessary. After completing baseline studies on normal morphology last year, the focus shifted to studies on ammonia toxicity in relation to shipping stress this year. Ammonia toxicity was found to be more severe than previously indicated by the literature. In subsequent experiments, the addition of Amquelr, sodium hydroxymethanesulfonate, was found to decrease ammonia significantly, and lead to higher survivability under simulated shipping experiments. Work was also carried out with larval California halibut that were available as part of a larger project. Flatfish are of considerable interest in that following metamorphosis, juveniles and adults, spend the majority of their time lying motionless on the bottom. This should make provision of inputs such as oxygen and removal of wastes less of a challenge than for actively swimming fish species. This unique adaptation to a benthic existence makes them potentially interesting laboratory species. This year experiments were carried out to define the normal morphological development and the requirements for feeding of the larvae to enhance high levels of survival to settled juveniles.
Impact: Today's global aquarium fish trade is valued at around a billion dollars. While the majority of fresh water aquarium fish species are now being raised in captivity, this is not true of marine ornamentals. In that culture techniques have yet to be developed for most of the desirable exotic marine species these are supplied by capture from the wild. Destructive capture techniques such as cyanide poisoning or the dynamiting of reefs used in these fisheries have had a horrific effect on many tropical coastal and marine environments. In particular, coral reefs, which are among the most fragile and threatened ecosystems globally, have been savaged by such collection practices. It is hoped that development of appropriate culture techniques and feeds in the future will allow these marine species to be cultured as are most freshwater aquarium species and thus spare wild populations as well as their habitat. In addition to the value arising from their intrinsic beauty, aquarium fish are rapidly becoming popular experimental animals. There is also a need to culture other marine fish in the laboratory to help answer a variety of questions associated with there biology. The flatfish are a potentially interesting model that would appear to have a number of advantages in relation to laboratory culture. As with other animals, until optimal husbandry conditions are defined, research studies with marine fish are going to be hampered by potentially abnormal physiological and biochemical responses.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Advanced Technologies for the Genetic Improvement of Poultry
Description: Objectives: 1) Develop high resolution integrated maps to facilitate the identification of poultry genes and other DNA sequences of economic importance. 2) Develop methods for locating new genetic variation in poultry by gene transfer and chromosome alteration. As reported last year studies on the molecular organization and cytogenetic localization of the chicken 5S ribosomal RNA gene complex were completed. A manuscript was submitted and accepted by Chromosome Research and will be published in 2003. New studies were initiated to study non-coding, chromosome structure repetitive DNA, the centromere sequences. To date we have no knowledge of the molecular nature of avian centromeres which are responsible for correct segregation of chromosomes to daughter cells. My laboratory has initiated studies to begin to dissect these regions of DNA. Genetic diversity studies continued and a competitive grant proposal is being readied based on our preliminary findings studying

microsatellite locus variation in broiler and layer foundation populations. Clearly the amount of genetic variation differs among foundation populations of poultry. Several lines were homogenous whereas others showed evidence of heterogeneity. Industry companies were contacted and have agreed to supply updated samples for analysis.
Impact: Understanding the molecular organization of avian centromeres will allow for the development of novel technologies to use pieces of avian DNA to transfer genetic information stably without need for integration into a chromosome (current method which is fraught with problems). Our studies on genetic diversity in industry stocks and breeds populations will improve our understanding of the location and extent of the poultry genetic reservoir in the US.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AR, CA, DE, IA, IL, IN, MD, MI, MN, NC, TX, VA, WI, NON-SAES: City of Hope Nat'l Med. Ctr., USDA/ARS

Theme: 1.11 Biotechnology
Title: Biochemical Mechanism of Homologous Recombination
Description: The specific objectives of this proposal are to continue our studies of the biochemical steps of genetic recombination, by rconstituting the genetic recombination process IN VITRO. In the past year, we made progress in each of the following areas: 1) RecO protein anneals ssDNA complexed with its cognate ssDNA-binding protein. Evidence for a common step in genetic recombination. 2) Rad54 protein possesses chromatin remodelling activity that is stimulated by the Rad51-ssDNA nucleoprotein filament. 3) The Biochemical Basis of the Constitutive Coprotease Activity of RecA P67W Protein. 4) The Biochemical Characterization of a Mutant RecA Protein Altered in DNA-Binding Loop 1. 5) A novel presynaptic function of Rad54 protein: stabilization of the Rad51 nucleoprotein filament.
Impact: This research is important because it provides insight into the ways that DNA is processed during the process of genetic recombination, a biological process that is responsible for genetic rearrangements, both normal and aberrant. This research has significance to the areas of agriculture that deal with gene targeting/gene replacement used to produce genetically altered organisms.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Biotechnology, Developing Countries, and the Rural Poor
Description: Objectives: 1. Identify the determinants of adoption of specific technological traits by a heterogeneous farm population subjected to differential market failures and institutional gaps. 2. Identify types of contracts that can create incentives for the private sector to cater to markets where poor people participate. 3. Identify types of contracts that can be used for the public (or non-profit) sector to engage in joint research with the private sector when proprietary rights are involved. 4. Anticipate the institutional mechanisms to put into place regulatory mechanisms for environmental protection that will not discriminate against small farmers. 5.Identify types of potential contracts between biotechnology firms and farm communities that control access to bio-diversity within the context of the FAO agreement on farmers' rights. We conducted field work in Argentina and India to collect data on adoption of Bt(Bacillus thurengensis) cotton, and on the impact of adoption on yields, pesticide use, and pest resistance. We find the interesting result that adoption in Argentina has been slow due to the high price charged for Bt seeds, more than four times the price of conventional varieties. Using contingency valuation methods to assess willingness to pay for Bt technology, we find that

farmers' willingness to pay is less than half the current market price. We also show that company profits would be maximized by charging a price of $65 per ha instead of the current $103. Hence, current prices are far above privately and socially optimal levels. Further analysis shows that Bt seeds have strong yield effects, especially among small farmers who cannot afford pesticides (a 40% gain compared to 17% for large farmers). Bt seeds can thus create larger gains for the poor than for the rich because they substitute for chemicals that the poor could not afford. Use of Bt seeds among current users allows a 50% reduction in the application of toxic chemicals, creating significant environmental gains. Finally, we use Professor Gutierrez' biological model calibrated to Argentine conditions to analyze the possible rise of pest resistance over time. We find that rapid resistance buildup and associated pest outbreaks are unlikely if minimum non-Bt refuge areas are preserved. These optimistic results must be interpreted with caution as technical coefficients are still poorly established and because it is hard to predict whether the country would have the capacity to enforce non-Bt refuges.
Impact: Improve adoption of Bt technologies in developing countries by proposing a different pricing policy. Help increase yields among small farmers who cannot afford chemicals, creating progressive welfare gains, and reduce use of toxic chemicals among large farmers, creating environmental gains.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Bringing Biotechnology to Wheat Fields
Description: The overall goal of this proposal is to transfer new developments in biotechnology to wheat breeding and production through a better integration of public research, public and private breeding programs, and wheat industry. The specific objectives are A) Pyramid rust resistance genes into bread wheat, B) Improve seed protein content of bread and pasta wheat, C) Improve breadmaking quality of high yielding bread wheat varieties, D) Transfer new transgenic storage protein genes to adapted bread wheat, E) Develop new hard white varieties with improved noodle quality. This project was completed in 2002. The objective of this proposal to incorporate valuable genes into wheat varieties from California and Arizona using marker-assisted selection was completed. Marker assisted selection for disease resistance genes: The transfer of leaf rust resistance genes Lr37, Lr47 and Lr51 was completed in 15 different backcrossing programs. We also completed the transfer of stripe rust resistance gene Yr17 and stem rust resistance gene Sr38 into seven different cultivars and advanced breeding lines. All this lines are currently under seed increases or final field-testing. We also advanced the backcrossing program for Yr15 to BC5 in five cultivars and breeding lines. Leaf rust resistance tests performed in collaboration with the Leaf Rust Laboratory at Minnesota indicated that the transferred leaf rust genes are still effective to most North American leaf rust races. Marker assisted selection for quality-related genes: The backcrossing program for the high protein gene was completed for seven common wheats and five durum wheats. Other durum lines, including nine lines from Arizona Plant Breeders were advanced to the last backcrossing generation. For the high-molecular weight (HMW) glutenins six generations of backcrossing were completed for Anza, RSI5, UC1037, and UC896, and UC1107. The introduction of a low-molecular weight glutenins allele was completed in Anza, RSI5, Yecora Rojo and UC1037. This last variety is a promising candidate for variety release in the common red class. We completed a second year of field experiments to determine the effect of different deletions and allelic variants in the hardness locus. Highly significant differences were detected among lines.

Impact: The utilization of molecular markers allowed the pyramiding of different resistance genes within the same varieties, increasing the durability of the genetic resistance and reducing the requirements of pesticides. The use of molecular markers has also accelerated the development of hard white varieties and pasta varieties for California.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Bringing Genomics to the Wheat Fields
Description: General objective: The overall goal of this proposal is to transfer new developments in genomics to wheat breeding and production through the combined expertise of genomics researchers, breeders, and wheat end-users. Our vision is an integrated network of collaborative public wheat breeding programs using new molecular technologies to accelerate the transfer of valuable genes into locally adapted wheat cultivars. Two marker development laboratories will complement these efforts by transforming RFLP markers into PCR-based markers. Rapid incorporation of new and efficient cultivar enhancement technologies into breeding strategies will improve grower and end-user profitability and international competitiveness of US wheat. Specific objectives A) Enhance market demand of major classes of US wheat through end-use quality improvements: A1) Improve seed protein content and protein quality of bread and pasta wheats; A2) Improve semolina and pasta color of durum wheats; A3) Modulate water absorption through changes in grain hardness and pentosan content; A4) Adjust starch properties of grain for specific end-products; A5) Enhance resistance to pre-harvest sprouting in white grained cultivars B) Reduce pesticide use in wheat production through improved host plant resistance B1) Improve resistance to fungal diseases including rusts, Fusarium, and Eyespot; B2) Improve resistance to viruses (BYDV, WSMV, and WSSMV); B3) Improve resistance to insects (Russian wheat aphid, and the Hessian fly) C) Strengthen Marker Assisted Selection as a cultivar improvement tool by converting RFLP markers into efficient, user-friendly PCR-based markers D) Enhance public awareness of the potential of biotechnology for providing a stable and safe food supply: D1) Develop a WEB site for MAS in Wheat linked to Grain Genes and other relevant sites; D2) Develop hands-on courses on wheat molecular markers for private breeders, growers, wheat commissioners, millers, bakers and wheat end-users The overall goal of this IFAFS project is to transfer new developments in wheat genomics and biotechnology to wheat production through the organization of a National wheat Marker Assisted Selection (MAS) consortium including 12 wheat-breeding and research programs across the US. Available molecular markers are being used to transfer 19 resistance genes to fungi, virus, and insect, and 11 genes variants related to bread, pasta, and noodle quality into 75 different recurrent programs belonging to the different market classes: 34 whites, 33 reds and 8 durums. Genes are being transferred by normal recombination and backcross marker-assisted selection and, therefore, the resulting lines will not be classified as transgenic. This will facilitate public acceptance and increase the awareness of the potential benefits of plant biotechnology. Backcrossing programs were initiated in all the laboratories and most of the crosses are currently in BC1 as expected for the first year of the project. Of the 346 backcrossing programs currently in progress 82 are more advanced that BC1 because they were initiated before the beginning of the funding for this grant. The WEB site for marker-assisted selection was initiated and one third of the traits have been already incorporated and are available at http://maswheat.ucdavis.edu/. The members of the project made numerous presentations in growers meetings, field days and symposiums to improve the current understanding of the potential benefits of biotechnology in wheat breeding.

Impact: The utilization of molecular markers allows the different public breeding programs to pyramid different resistance genes to leaf and stripe rust, septoria tritici blotch, fusarium, eye spot and different viruses and insects that reduce wheat productivity. Molecular markers are also accelerating the incorporation of genes to improve bread, pasta, cookie, and noodle quality, increasing the value of the wheat crop. Presentations of the participants to the growers have increased the awareness of the potential benefits of Marker Assisted Selection in wheat improvement.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: California's "Clean Seed" Sweetpotato Program
Description: Sweetpotatoes are vegetatively propagated. Roots are sprouted and the sprouts are transplanted to the field to produce more roots. True seeds are not used in commercial production because sweetpotatoes rarely flower. An unfortunate consequence of not using true seed, however, is that viruses can accumulate in the plants, greatly diminishing both yield and quality. California's "clean" sweetpotato seed program began in the 1960s in response to russet crack disease, which is caused by a strain of sweetpotato feathery mottle virus. At the time, it was well known in the industry that new seedstock was required to prevent this disease as well as "variety decline," the gradual loss of yield that occurred in many varieties. To address this problem, in 1961, a farm advisor and Extension specialist began testing a process called meristem culture on sweetpotatoes. The procedure developed then is still in use today to provide growers with high quality seedstock. It involves aseptically removing the meristem (usually 0.5 mm long) from an apical or lateral bud of shoots produced in a greenhouse from a sprouted root. The meristems are placed in test tubes and grown on synthetic nutrient agar to produce a new plant. After three to four months in culture, the plant is transplanted in the greenhouse and grown out for virus testing. To determine if a meristem-generated plant is free of virus, it is grafted onto an indicator plant (Brazilian morning glory). If that plant shows no disease symptoms, then the sweetpotato plant is assumed to be virus-free, or "clean." At this point, it can be propagated through cuttings and grown to produce roots for variety evaluation. By 1966, enough plant material had been developed using this process that they could conduct large scale field tests. The results showed a significant yield increase from virus-tested plants, compared to those that had not gone through meristem culture. Furthermore, there was a substantial decrease in the number of cull potatoes caused by viruses.
Impact: Since these early tests, the benefits of virus-tested material has been well recognized in California and other states. Beginning in the mid 1990's, Louisiana and North Carolina dropped their traditional seed programs and began producing virus-tested material in greenhouses for their farmers, based on the clean seed program developed by UCCE. Most growers in California now use virus-tested seed for at least part of their production. The process is performed by Foundation Plant Materials Service (FPMS) on the University of California Davis campus, which provides plants to growers for a minimal fee of $1.00 per plant. The use of virus-tested seed is one of the reasons for the substantial sweetpotato yield increases in the last 30 years. In 1967, average yields were 5 tons per acre; in 2001, 12 tons. UCCE continues to test and promote the sweetpotato clean seed program. Trials conducted in Merced County in 1999 - 2001 showed improved yield, shape, and color in five commercial varieties from using virus-tested plants. The use and acceptance by the industry in California as well as other states demonstrates how UCCE research and extension programs can have long standing positive impact for the industry. Consumers throughout California and the West have also benefited, as

the clean seed program gives them a more consistent, high quality potato that is significantly less likely to have internal defects.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Conservation and Restoration of Grassland and Oak Savanna Productivity and Biodiversity
Description: This program focuses on 1)understanding the mechanisms and impacts of invasive species on rangeland biodiversity and productivity, 2)the use of native grassland species in ecological restoration and revegetation and 3) the impacts of habitat fragmentation on the population biology and conservation of grassland and woodland species.
An additive planting design, with two N. pulchra populations (a local source and a commercially available non-local source from Southern California) was used. The two populations were known, from previous work, to differ in banding patterns for several isozyme stains. Twenty-five local seedlings were planted in the winter of 1998/1999 into each of 18 fenced plots at the Sierra Foothill Research and Extension Center. Plots were located a minimum 30 meters apart within a matrix of exotic annual grasses. In each plot, the local plants were planted in a 5 x 5 grid with an 18 cm spacing between plants. In six of the plots, 16 individuals from the non-local population were planted within the spaces between the local plants, while in another 6 plots, 56 individuals from the non-local population were planted. The remaining six populations were controls, containing no non-local plants. Seed was collected from the central nine local plants. This seed, along with seed of the two parental populations, were germinated and fresh plant extracts run on starch gels. The proportion of seed collected from the mixed plots that contained banding patterns associated with the non-local source was evaluated. Number of culms were counted on both the local and non-local plants to provide a measure of plant size. Culms were not counted on plants at the edges of each plot. Plant size differences were used to determine extent of interpopulation competition. Within the plots with a high density of non-local plants, we found that 30.0% of seed harvested from the local plants contained isozyme banding patterns characteristic of the non-local population. The percentage of plants with this non-local isozyme signature was 8.0% in the plots with a low-density of non-local plants. No seed from the control plots contained the non-local isozyme signature. During the spring of 1999, seed was collected from the central nine local plants. This seed, along with seed of the two parental populations, were germinated and fresh plant extracts run on starch gels (using starch gel electrophoresis techniques). The proportion of seed collected from the mixed plots that contained banding patterns associated with the non-local source was evaluated and rates of hybridization were estimated. Mortality was measured in each of the plots and the relative vigor of surviving plants estimated using plant size measurements. Major conclusions from this study to date include: 1) confirmation of an outcrossing mating system in N. pulchra and 2) evidence of density dependent genetic contamination. The percentage of plants with an isozyme genotype characteristic of the non-local population was proportional to the number of non-local plants within the plot. The planting of non-local, poorly adapted plant material may be detrimental to ecosystem function and may compromise the genetic integrity of existing native plant species by introducing non-native genes into the population.
Impact: The last decade has seen an enormous increase in using native plant species for restoration and revegetation projects. Our research provides critically needed information on whether genetic pollution is a real risk when translocating different genetic stocks from their source of origin to different locales within the State for use in restoration and revegetation.

Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Controlling Citrus Tristeza Virus Infections in Citrus by RNA Silencing
Description: The long term objective of our research is to modify a natural plant defense mechanism to recognize and degrade citrus tristeza virus (CTV) RNAs, thereby providing protection to citrus against CTV infection. Our present grant has three primary objectives. These are to construct and evaluate CTV silencing using conserved CTV sequences, to develop transformation and regeneration systems specifically for the scion Washington navel and the rootstocks sour orange and Carizzo citrange, and to transform and evaluate a CTV replicon silencing delivery system in citrus. We have begun efforts to construct artificial resistance genes for use in controlling Citrus tristeza virus (CTV) in citrus. We have generated specific cDNAs that contain sequences corresponding to highly conserved regions of the CTV genomic RNA. These have been engineered to induce post-transcriptional gene silencing in plants, and will be used to transform citrus cultivars. As a complementary aspect of our research, we also have begun optimizing conditions for transforming/regenerating citrus. So far we have been successful using the rootstock, Carrizo, and we will continue to optimize conditions and apply our findings to additional cultivars.
Impact: We anticipate that our efforts will have practical agricultural as well as basic science impact. We will develop and optimize methods for transforming and regenerating citrus. This will be of importance to the worldwide citrus industry. If we can develop broad spectrum resistance against CTV, this will be of immediate importance for controlling the most important virus disease of citrus.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Dissection and Transgenic Introgression of Disease Resistance Genes
Description: Objectives: 1) To characterize the domains within disease resistance genes that determine recognition specificity in lettuce. 2) To identify several resistance genes with known specificities. 3) To introgress new resistance genes from wild species using a transgenic approach to generate agriculturally useful genotypes. There were three objectives: 1) To characterize the domains within disease resistance genes that determine recognition specificity in lettuce. 2) To identify several resistance genes with known specificities. 3) To introgress new resistance genes from wild species using a transgenic approach to generate agriculturally useful genotypes. This project progressed slowly due to the difficulties of manipulating these large (approx. 13 kb) genes. These studies are still underway. We are using domain swaps between closely and less-closely related resistance gene candidates (RGCs) from lettuce to identify domains determining specificity and domains responsible for effector function. The first round of constructs has been transformed into lettuce and we are awaiting the transgenics. Based on these results, we will develop expression cassettes for the specificity domain(s). We will then amplify the specificity-determining domains from genomic DNA (and BACs) using PCR and test them for function in the expression cassette using transient assays. We will validate the approach by cloning known resistance gene specificities, then use it to access resistance genes from wild species. Genes expressing different resistance specificities to downy mildew will be pyramided into a single construct and introduced to provide potentially more durable resistance. We are

developing an Agrobacterium-mediated transient assay system to speed up the analysis of chimeric transgenes and the cloning of genes with new resistance specificities.
Impact: We are developing and implementing technology that will be widely applicable to crop species for the efficient introduction of disease resistance genes from wild species into cultivars. The specific resistance genes cloned will be useful for protection of lettuce.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Engineering Transgene Integration in Arabidopsis
Description: Great strides have been made in plant transformation; transgenic DNAs can be introduced into almost all crop species. These transformed tissues can be regenerated and the transgene stably inherited. However, the transformation process is far from precise. The transforming DNA is usually modified at its 5' and 3' ends, the transgene is often present in multiple copies, and the target site (the site on the host chromosome at which the transgene integrates) is randomly selected. Because of this, the products of plant transformation vary widely. This means that many transformed plants must be generated in order to identify a single plant with a useful insertion, the transformed lines must be carefully characterized at the molecular level to make sure that the transgene is in a stable conformation, and that there is no possibility that a chimeric protein has been generated through fusion with an endogenous gene. Another difficulty presented by this random insertion process is that fact that genes can only be added to the plant genome; they cannot be replaced. It is often desirable, particularly in basic research, to alter the expression of an endogenous gene, (to replace one allele with another) rather than to simply add a novel gene. This isn't feasible in plants; transgenes with homology to endogenous genes replace the endogenous locus in only 1 out of 10,000 transformed lines. This is because transgenes are integrated via a process termed nonhomologous end joining (NHEJ, which produces random integration products) rather than homologous recombination (HR), a distinct recombinational pathway that inserts transgenes only by simultaneously deleting a nearly identical sequence. In many organisms (such as bacteria, yeast, certain mosses, and some mouse cell types) transgene integration via HR is the norm. Plants possess the HR pathway as well as the NHEJ pathway, but the NHEJ pathway outcompetes HR, effectively 'grabbing' the ends of the transgene and sequestering them away from the proteins involved in HR. For this reason, we plan to inactive the NHEJ pathway in Arabidopsis, in the hope of increasing the fraction of transformation events that occur via the HR pathway. This year we developed a marker for transformation via homologous recombination. The transgene carries a dominant herbicide resistance gene homologous to a chromosomal locus and also a nonhomologous gene conferring resistance to a second herbicide. This transgene construct enables us to directly determine the rate of homologous vs. nonhomologous transformation in a single batch of transformed plants. We have used the in planta procedure to transform wild-type, ku80, and DNA ligase IV defective plants (the Ku80 protein binds to broken DNA ends, sequestering them and facilitating their repair via nonhomologous end joining (NHEJ); DNA ligase IV reseals the broken ends). We have already determined that the later 2 lines are defective (down 40-60%) in nonhomologous transgene integration. We predict that the ratio of homologous vs. nonhomologous transformation events should be elevated in the Ku or DNL 4 mutants, simply due to the decrease in NHEJ events. It will be more interesting to determine whether, in the absence of competition for ends by Ku, the absolute efficiency of homologous recombination will increase. We should be scoring herbicide resistance in a week or two. Another related project involves the characterization of the gamma plantlet response to ionizing radiation. Plants, when irradiated at

very high doses, produce miniature plantlets that germinate normally and expand their embryonic organs, but do not proceed to produce new, adult organs. We have searched for mutants that are hypersensitive to this effect of gamma radiation, in the hope of identifying genes involved in double strand break repair. We have found that there are two classes of mutants hypersensitive to this effect; mutants defective in nonhomologous end joining (Ku and ligase IV defective) and mutants defective in a repair endonuclease, the Arabidopsis homolog of the XPF/Ercc1 complex. The gamma plantlet phenotypes are very different between the two classes; endonuclease defective plants arrest expand their embryonic tissues to full size, and arrest transiently (for 10 days) before proceeding with normal development, whereas NHEJ mutants produce small, stunted plantlets that never recover. Further analysis suggests that the endonuclease mutants are transiently arresting in G2 (just prior to mitosis) in response to a defect in the repair of interstrand crosslinks, while the meristematic cells NHEJ mutants are dying due to the lack of efficient DSB repair. We are performing further analysis to confirm or disprove this model (and to determine whether the cell death is an active or passive process), and plan to continue to investigate the gamma plantlet phenomena.
Impact: Great strides have been made in plant transformation; transgenic DNAs can be introduced into almost all crop species but the transformation process is far from precise. The transforming DNA is usually modified, the transgene is often present in multiple copies, and the target is randomly selected. Because of the effects of local chromatin domains on gene expression, the products of plant transformation vary widely. Many transformed plants must be generated in order to identify a single plant with a useful insertion. Another difficulty is genes can only be added to the plant genome; they cannot be replaced. It is often desirable to alter the expression of an endogenous gene but this isn't feasible in plants; transgenes with homology to endogenous genes replace the native locus in only 1 out of 10,000 transformed lines because transgenes are integrated via nonhomologous end joining (NHEJ, which produces random integration products) rather than homologous recombination (HR), a distinct recombinational pathway that inserts transgenes while deleting a nearly identical sequence. In many organisms transgene integration via HR is the norm. Plants possess the HR pathway as well as the NHEJ pathway, but the NHEJ pathway outcompetes HR, effectively sequestering DNA away from the proteins involved in HR. We plan to inactivate the NHEJ pathway in Arabidopsis, in the hope of increasing the fraction of transformation events that occur via the HR pathway. This will enable genetic engineers to more precisely alter the plant genome. The approach should also be applicable to animals.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: ETTIN and the Gynoecium: Probing Auxin Signaling and Complex Morphogenesis
Description: The mechanisms that coordinate the terminal floral meristem to develop into the gynoecium are currently unknown.The ettin (ett) mutation provides a remarkable window for viewing many aspects of gynoecium development, as the phenotype results from misspecifications along both the longitudinal and transverse axes. ETT is homologous to ARF (auxin response factors) transcriptional factors involved in auxin signalling.Preliminary results support ETT acts via auxin. That ETT is expressed in the early floral meristem as well as throughout gynoecium development implies it acts with numerous regulatory factors. Further analyses of ETT and identification of its partners are essential to decipher how this complex organ forms and functions. The mechanisms that coordinate the terminal floral meristem to develop into the plant female reproductive organ, the gynoecium, are unknown. The Arabidopsis

ettin (ett) mutation provides a remarkable window for viewing many aspects of gynoecium development. The gene product, ETT, is homologous to ARFs (auxin response factors) transcriptional factors involved in auxin signaling. Indeed, ETT acts via auxin, as transient application of a polar auxin transport inhibitor to wild type flowers phenocopies ett mutations. Current efforts are to uncover other genes involved in the auxin-ETT pathway. We have performed an activation-tagging modifier screen of a weak allele, ett-2. Mutations resulting in a more severe phenotype are enhancers of ett-2, and mutations resulting in a wild type phenotype are suppressors of ett-2. During the last year we have characterized one activation tagged mutation dubbed 1771. Molecular cloning revealed the T-DNA insert in 1771 to reside in MFT, MOTHER OF FLOWERING LOCUS (FT) and TERMINAL FLOWER 1 (TFL1). Indeed, MFT mRNA was increased in line 1771. FT protein has been previously shown to be homologous to TERMINAL FLOWER 1 (TFL1); both proteins share sequence similarity with mammalian Raf kinase inhibitor proteins. Directed transformation of ett-2 plants, with constructs to over-express MFT, recapitulate a strong ett phenotype. FT induces flowering in Arabidopsis while TFL1 is suggested to be an inhibitor of flowering. Our studies suggest a role for MFT in the ETT pathway regulating gynoecium development, likely via a regulation of auxin signaling as MFT also exhibits stem bending and thickening, suggestive of a role in auxin perception or transport. An additional mutation, dubbed S27, was originally isolated as a suppressor of the strong ett phenotype. Molecular mapping revealed it localized close to a recently characterized gene, SEUSS, a co-repressor (with the gene LEUNIG) of the floral homeotic genes. Genetic crossing as well as sequencing revealed S27 and SEUSS were allelic. While SEUSS has been studied with regard to its role in transcription of floral genes, our new data suggest that SEUSS also is involved in auxin perception. For example, besides its interaction with ETT, S27/SEUSS exhibits reduced apical dominance, and insensitivity to exogenous auxin. In summary, we have identified two loci, previously not suspected to play a role in auxin signaling, by their interaction with the ETT signaling pathway in the gynoecium. These studies enhance our understanding and appreciation of the complexity of morphogenetic pathways, and the novel roles played by the plant hormone auxin. We are preparing several manuscripts for publication that will acknowledge USDA support.
Impact: Our work on flower development in Arabidopsis particularly focuses the gynoecium, the most complex organ that flowering plants produce. Gynoecia develop into fruit, which account for approximately 90 % of agricultural production for human consumption. Basic research in gynoecium development is an essential foundation for more applied research, for example, in areas where improving fruit yield and composition, or altering compatibility and restricting fertility are desirable. The identification of genes involved in gynoecium development will provide a direct handle on engineering desirable traits into fruit.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Functional Genomics in Arabidopsis and Rice
Description: Advances in genome sequencing and analysis have made it possible to identify all the genes in the model plant Arabidopsis. The same will soon be true for rice and other crop plants. In the case of Arabidopsis, less than 10 percent of the genes have been assigned definite biological functions. Therefore, an important challenge facing molecular plant breeding as well as genetic modification is the determination of gene functions one a large scale, known as functional genomics. The approach used here will over a five year time period provide resources for large scale analysis of genes from Arabidopsis and rice. Arabidopsis is a model plant,

selected for its small genome size 125 Mb and ease of handling and laboratory manipulation, that has been proven to be valuable for understanding the biology of all crop plants. We have generated 22,000 transposon insertion lines in Arabidopsis, of which nearly 11,000 have been assigned genomic locations by sequencing. The sequenced insertion lines permit rapid identification of gene disruptions through computer searches, which can be used to determine the functions of the large number of genes whose sequence is known but function is unknown. Our approach has two advantages over approaches using T-DNA insertional mutagenesis. First, the transposon insertions are mostly single insertions which facilitates genetic analysis, especially in reverse genetics and subsequent localized mutagenesis. Second, the use of a reporter gene within the gene trap transposons gives important information on the expression pattern of the disrupted genes, which can be critical to assessing and assigning functions for these genes. Rice is a major crop plant in the world, and is grown in California for export as well as domestic consumption. Because of its relatively small genome 430 Mb and ease of transformation, rice also serves as a useful model system for the grasses, which includes all of the major cereal crops like maize, wheat, etc Therefore it is an ideal plant for extension of the Arabidopsis methodology for functional genomics. The specific aims of the project are 1. Sequence the flanking DNA for the remaining 11,000 of the 22,000 transposon insertions that we have generated in Arabidopsis. 2. Generate a searchable insertion site database for gene knockouts in Arabidopsis. 3. Perform genetic screens of all of the insertion lines for mutations that affect gametogenesis and or embryogenesis. 4. Use the flanking sequence database to identify genes that perform essential functions in togenesis and/or embryogenesis. 5. Construct vectors for transposon mutagenesis of rice. 6. Generate a collection of 20,000 transposon insertion lines of rice.
Using the model plant Arabidopsis (the first plant species whose genome has been sequenced) we have identified a large number of genetic loci that are required for normal reproduction. These include about 200 mutants in which gametophyte function is impaired. We have begun the molecular characterization of some of these genes. We have shown that two genes called FILAMENTOUS FLOWER and YABBY3 which affect flower development, are required both for the specification of polarity in leaves and flowers, as well as the repression of genes that promote formation of the shoot meristem. We have also identified several genes which are involved in gametophyte or embryo development. These include the TORMOZ gene which we have found to be important for proper orientation of cell divisions within the embryo, and several genes that are required for gametophyte function either in the male (pollen) or the female (embryo sac) or both. A second project is the establishment of an effective system for insertional mutagenesis in rice. Rice is the only plant other than Arabidopsis for which the genome has been sequenced. It is currently the best model for the agronomically important cereals. We have shown that transposable elements from maize (Ac-Ds and Spm/En) can transpose at useful frequencies in rice. We have engineered vectors using fluorescent markers to permit efficient detection of transposition events. We plan to scale up our experiments for large-scale transposon mutagenesis in the coming years, and provide a resource for both forward and reverse genetics in rice.
Impact: The studies on Arabidopsis should identify genes important for plant reproduction that can be used for the control of reproduction in crop plants. The studies on rice will help elucidate the functions of the sequenced genes in the genome of rice, which has twice the number of genes as Arabidopsis. The information that we generate will be useful not only for rice breeders, but also for research on other cereals such as maize and wheat.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Genetic Improvement of Beans (phaseolus Vulgaris L.) for Yield, Disease Resistance and Food Value
Description: Broaden the genetic base of common bean through: (a) use of wild bean populations; (b) increase cross-pollination; (c) use and conversion of promising tropical and sub-tropical germplasm; and (d) intra-racial and inter-racial gene pool hybridizations.
The major thrust in this year was the QTL analysis of the performance of two recombinant inbred (RI) populations resulting from the cross between the cultivar Negro Tacana and either a weedy line W 10 or a wild line W15. These populations had been evaluated in previous years in the field in Mexico. Except in one year, the W10 accessions had exceptionally high yields above that of Negro Tacana. The QTL analyses did not identify any yield QTLs in the NT x W10 RI population derived W10. We identified a single positive yield QTL originating in the domesticated genotype, and it was detected only in the second year of evaluations. These results point to the fact that both parental lines might share very similar yield genes, thus W10 did not seem to contribute any yield increasing genes within the resolution limits of the analysis. The significantly higher yield of W10 can be explained based on its higher days to maturity, days to pod fill, biomass growth rate, and its growth habit type compared to NT. For most of the QTLs identified for these characters, the alleles of W10 increased the value of the character. In contrast, even though W10 had significantly higher seed weight, seed growth rate and economic growth rate were larger than those of NT, which are factors accounting for the higher yield of W10, all the QTLs detected for these characters had a positive effect derived from the domesticated genotype (NT) and not from W10. The QTL analysis for the NT x W15 RI population identified two yield QTLs. The allele increasing yield for one of these QTLs originated in the wild accession, which has a significantly lower yield than NT, although this QTL was detected only in one year. This yield QTL was associated with other desirable QTLs, such as an increased yield per plant, biological growth rate (biomass/days to maturity), seed growth rate (yield/days of pod fill), and economic growth rate (yield/dates to maturity). This result confirms the possibility to increase yield in the domesticated genotypes using wild accessions, with the aid of molecular markers. This positive contribution of the wild accession would not have been detected without the aid of the QTL analyses.
Impact: The use of wild beans to broaden the genetic basis of common bean will have substantial effects in bean breeding by opening up a whole new segment of the germplasm. This will allow breeders to introduce additional genes not only for disease and pest resistance, but also - most importantly - for yield. The markers developed here will assist in transferring those traits and simultaneously eliminate undesirable traits from the wild parent.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA, CO, FL, GA, ID, MI, MT, ND, NE, NYC, OR, PR, WA, WI, USDA/ARS

Theme: 1.11 Biotechnology
Title: Genetic Variability, Selection and Inbreeding in Ornamental and Wild Plant Populations
Description: 1. Apply the new breeding methodology we have developed to the actual development of new cultivars of GERBERA for California cut-flower growers. 2. Plant PICEA lines that have high and low levels of heat tolerance in the growth chamber studies into a test environment outdoors to verify whether the tolerance in controlled environments carries over to outdoor environments. 3. Make crosses between LUPINUS genotypes to test for Mendelian ratios, establish allelism and epistasis, and estimate linkages between loci. Track changes in gene frequency in experimental populations to determine the effects of natural selection and

outcrossing. Cultivars and breeding lines of Gerbera from the Italian Breeding Company Gallo Bros and selected lines from the Davis Population have been crossed between and within gene pools and heterosis found between the gene pools for flower productivity. In addition, measurements of scape elongation before and after harvest were made to determine better selection strategies for flower breeding programs. Genotypes with less postharvest growth had shorter vase life. Further crosses have been made to estimate genetic parameters for vase life components. Breeding lines were selected that combined higher flower yield with higher flower quality. They are currently under study. LUPINUS MICROCARPUS DENSIFLORUS lines are still being crossed to determine if a non-fading yellow gene exists in the population. 16 populations of 8 different species of LUPINUS were seeded in a protected area in order to follow changes in the frequencies of various genetic loci. Populations did not establish last year but appear to have established this year. A superior clone of RHAMNUS CALIFORNICUS was propagated and is being evaluated in a garden study.
Impact: The genetic studies in Gerbera will indicate the importance of occasional outcrossing from breeder's gene pools. A non-fading yellow gene would be very important to breeding programs in which yellow flower color has traditionally faded. The gene could be cloned for applications in important flower crops such as roses.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Genetics, Breeding, and Evaluation of Citrus Rootstocks
Description: I. Develop genetic maps of Citrus, Poncirus, and intergeneric hybrids that have many shared markers. Compare these maps to evaluate the amount of recombination in wide hybrids. II. Determine the mode of inheritance of traits important in citrus rootstock breeding and identify easily scored molecular markers closely linked to genes for disease resistance, dwarfing, and other desirable characters. III. Obtain or clone genes that are likely to improve citrus rootstocks and transform these genes into appropriate citrus rootstock cultivars. IV. Develop improved citrus rootstock for California.
GENETICS OF CITRUS TRISTEZA VIRUS RESISTANCE. In a collaborative project with Texas A&M University, we are using positional-cloning to clone a trifoliate orange gene for resistance to citrus tristeza virus (CTV). Analysis focused on a fully assembled and annotated 282 kb sequence contig that contains a total of 22 putative genes, seven of which are resistance gene homologs that contain CC-NBS-LRR sequence motifs. Fine mapping using markers derived from the DNA sequence data localized the CTV resistance gene to a 173 kb region, and additional new recombinant progeny were identified that may reduce this to 120 kb when CTV resistance of these progeny has been determined. Transformation of candidate genes into CTV susceptible varieties was largely completed. Remaining tasks are to further localize the resistance gene, compare sequences of resistant and susceptible alleles of candidate genes, and test CTV resistance of transgenic citrus containing various candidate genes. GENETICS OF APOMIXIS. Inheritance of nucellar embryony (a type of apomictic seed reproduction used in citrus rootstock propagation) was studied in two populations derived from trifoliate orange. Using an AFLP marker map, QTL analysis located two major QTLs for nucellar embryony, the larger of which explains about 50% of the variance. AFLP markers linked to the major QTL for apomixis were identified, cloned, and BAC clones containing these sequences were identified. cDNA-AFLP analysis was used to identify genes differing in expression between nucellar and zygotic genotypes. BREEDING. Testing of hybrid populations for nucellar embryony continued. EVALUATION. We annually evaluate trees in more than 20 field trials to identify superior new

rootstocks for various citrus cultivars. C-32 and C-35 citranges continue to perform well as citrus rootstocks at most locations in California. Unreleased rootstocks that show promising characters include hybrids of Sunki mandarin and trifoliate orange, and a pummelo x trifoliate orange hybrid. Many 25-year-old navel orange trees on the commercial rootstock Swingle citrumelo were in poor health, apparently due to a bud union incompatibility. This was the first time this problem has been detected.
Impact: Work on resistance to citrus tristeza virus should benefit growers and consumers when varieties with resistance to this disease are produced. Development of new rootstocks with better disease resistance and other traits may reduce environmental impacts of disease control chemicals. The project has provided citrus growers with information on choosing rootstocks to improve yield and fruit quality.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Identification and Characterization of Processes Critical to the Development of the Fibers of Cotton
Description: The overall objective of this research is to gain a more comprehensive understanding of processes that are most important for the regulation of development of the fiber of cotton with the ultimate goal being to use this information to engineer cotton plants for improved fiber quality. The research has three major goals: 1. Identification of genes that play key roles in fiber development; 2. A study of the mechanism and regulation of the synthesis and pattern of deposition of microfibrils of cellulose (1,4-beta-glucan) in the fiber cell wall; and 3. To gain an understanding of the signal tranduction pathway that is involved in regulation of the initiation of secondary wall formation.
Impact: Cotton is one of California's major crops and our research has provided many new insights into the mechanism and regulation of cellulose synthesis in cotton fibers-studies that are obviously relevant since the mature fiber is >90 cellulose. Cellulose is also important for other agronomically important plants since its deposition controls plant form and strength and represents a major sink for biomass on earth. Characterization of promoter regions of DNA that drive fiber-specific gene expression provides new tools for genetic engineering of fibers.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Know GMOs
Description: Factual information needs to be introduced into the debate over foods derived from biotechnology (genetically modified, or GM, foods). This helps individuals make informed decisions about the desirability of the technology and its products. But rapid technological advances and the wide-ranging scope of issues related to this technology and its applications make it difficult for scientists, educators, and interested individuals to stay up-to-date on the facts. The ANR Statewide Biotechnology Workgroup created the website ucbiotech.org to provide comprehensive information and resources on biotechnology to facilitate scientific evaluation, education, and fact-based public discussion on GM foods. The unique aspect of the Biotechnology Information section is that the responses to the issues are linked to peer-reviewed scientific literature. The site also has a Resources section that provides aids to enter the dialogue (downloadable images and videos) and Education and News sections.

Impact: Since its inception in May 2001, ucbiotech.org has received over 15,000 visits. In addition, it received the American Society of Agronomy award for an outstanding educational website in 2002. Scientists and educators worldwide use information on the site to explain the science behind GM foods and to introduce facts into the frequently emotional debate.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Light-Regulated Phya Gene Expression in Dicotyledonous Plants
Description: To identify the photoreceptors responsible for regulation of Arabidopsis PHYA transcription. To define in the complex Arabidopsis PHYA promoter cis-acting DNA elements responsible for transcriptional initiation at multiple sites. To determine whether the multiple promoters in this gene have a role in its temporal, spatial, and light-regulated expression. To identify signaling components and trans-acting factors between the photoreceptor(s) and the PHYA gene.
The Arabidopsis PHYA gene has three distinct transcription start sites driven by three separate subpromoters. Previously, we created transgenic Arabidopsis expressing the selectable marker, hygromycin phosphotransferase, driven by various variants of the PHYA promoter. We have now identified single-copy insertion lines and run kill-curves with increasing hygromycin concentrations to identify the minimum required for 100% kill in the light. Two uniformly responding lines, pPZP1.5 and pPZP2.5, were selected, and the optimal hygromycin concentration of 200 microg/ml for light-grown seedlings was determined. In contrast to the lethality in light-grown seedlings, this concentration of hygromycin did not affect hypocotyl growth in the dark. These results indicate that the PHYA -promoter-driven transgene was fully effective in conferring resistance in its actively transcribing state in the dark, but was incapable of conferring such resistance once suppressed in the light. We conclude, therefore, that these transgenic lines will be suitable for future mutagenesis and screening for mutants defective in light-regulated repression of PHYA transcription.
Impact: Understanding of the molecular basis of the light-regulated expression of the PHYA gene derived from this study has the potential for biotechnological applications by providing a defined, negatively-regulated promoter for use in dicotyledonous crop plants.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Mechanism for Aluminum Inhibition of Plant K + Channels
Description: This project is to address the molecular mechanism underlying aluminum toxicity.In particular, the studies will focus on aluminum inhibition of plant potassium channels. Two specific aims are as follows: 1. To characterize Al effect on AKT1 and other Shaker family channels expressed in the roots. Because AKT1 is preferentially expressed in root cells and functions as a K transporter responsible for K uptake from soil into root, AKT1 may be the predominant K channel gene in root cells and may serve as a target for Al inhibition. We plan to test the effect of Al on AKT1 channels expressed in oocyte or insect cells. We will also continue to further characterize Al inhibition of SKOR channel. 2. To identify Al-tolerant K-channel mutants using functional complementation in yeast and site directed mutagenesis in oocytes. We will generate random mutants of KAT1 by DNA shuffling mutagenesis. KAT1 mutants will be transformed into the yeast strain lacking K uptake. Al tolerant KAT1 mutants will be selected by growing yeast transformants on low-K medium in the presence of Al. The mutation responsible

for Al tolerance will be determined and tested further by expressing KAT1 mutants in the oocytes. Studies on AKT1 channels will be carried out in a similar way. The amino acid residues identified to be critical for Al inhibition of inward channels can be compared with SKOR protein and corresponding residues may be identified and their function tested in the oocyte system. Aluminum block of k-channels was observed for not only the inward family channels but also outward family channels. Further studies also begin to delineate the mechanism of how Al works in this process. Briefly, there are at least two "gates" in the channels and only one of them may be blocked by Al. This new information will be prepared into a high impact paper soon.
Impact: Understanding mechanism of Al action in plants will help engineer crop plants resist heavy metals including Al in the soil and increase yield.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Molecular Genetic Analyses of Nectary Development and Establishment of Carpel Polarity in Arabidopsis
Description: Objectives: 1) Continue developmental genetic analyses of the establishment and maintenance of lateral organ polarity in Arabidopsis. 2) Continue genetic analyses of carpel and nectary development in Arabidopsis, screening for carpel and nectary mutants representing new genes and new alleles of already identified genes. We have isolated several mutations representing genes that act redundantly in controlling abaxial-adaxial polarity in the carpel. In these mutants, cells in the abaxial regions appear to incorrectly assess their position and differentiate inappropriately into structures that are normally only found adaxially, or vice versa. In the past few years we have cloned many of the respective genes. The general theme to emerge is that members of three plant specific gene families of transcription factors, the YABBY gene family, certain members of the GARP gene family (in particular the KANADI genes), and some Class III HD-ZIP genes, act to specify abaxial cell fate in the above ground organ of the plant. One member of the family, CRC, is specific to the carpel. When both CRC and KANADI1 are rendered non-functional by mutation, placental tissue with ovules and septum with transmitting tissue develop on the outside (abaxial) of the carpel as well as the inside (adaxial). Most other members of the gene families act in all above ground lateral organs. Both the YABBY genes and the KANADI genes act together to specify cells as abaxial, while Class III HD-ZIP genes such as PHABULOSA and REVOLUTA act to promote adaxial fates. Interactions between adaxial and abaxial cells promote lamina outgrowth. We hypothesize that complex interactions between these three families of transcription factors might account for a substantial part of the morphological variation in lateral organs of seed plants. Present work focuses on identifying the signaling pathways by which cells in the adaxial and abaxial domains communicate. CRC is also required for nectary development in Arabidopsis, and likely many other core eudicot species. We are working to identify how CRC is activated specifically in cells that will give rise to the nectary.
Impact: Cereals, legumes, nuts, and fruits of angiosperms provide a large portion of the food that is consumed by both humans and livestock. Each of these products is ultimately derived from carpels. By cloning and characterizing the relevant genes in the model species Arabidopsis, we can apply the knowledge gained to commercially important crop species. Manipulations in crop species may lead to improvements in the amount and diversity of our food supply.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Molecular Genetics of Developing Cotton Fibers
Description: Cotton fiber yield and quality are quantitative traits governed by the spatial and temporal expression of genes that may require >25% of the cotton transcriptome, or somewhere in the range of ~10,000 genes. The main goal of the project is the identification of fiber genes with pivotal roles in determining agronomically important fiber traits using genomic and reverse genetic approaches and to apply this knowledge to advance cotton biotechnology and molecular breeding programs. A major effort will be devoted to comparative studies that determine gene function by correlating changes in gene expression to altered fiber phenotypes, with focus on genes that encode regulatory factors and cell wall related proteins. The nature and scope of the proposed project will entail a major effort in bioinformatics to store, archive, manipulate and convert the vast amount of data into a meaningful context. Tools and resources will be developed in the form of framework EST-derived molecular DNA markers to apply biologically-relevant information to genetic diversity and molecular breeding programs for the cotton community via a web-based interface to aid in assembly of functionally-anchored consensus genetic and physical cotton maps. The main goal of the cotton project was to identify fiber genes and determine their functional role in terms of development, and hence, in the determination of agronomically important fiber traits using molecular approaches, and in latter years of the project, high-throughput functional genomics. The gene discovery component of the project revealed that >25% of the cotton transcriptome is transcribed in rapidly expanding cotton fibers, leading to RNA populations of very high genetic complexity. Molecular modeling based on expression studies detailing the spatial and temporal regulation of cotton fiber genes has provided a framework for designing strategies for the genetic improvement of cotton fiber yield and quality using molecular approaches. The successful implementation of such strategies and innovations in cotton transformation and regeneration has resulted in the development of novel germplasm with improved fiber properties.
Impact: This ground-breaking work has resulted in the development genomic tools and resources, novel germplasm, innovative technological advances and a developmental framework that is revolutionizing molecular breeding programs. Benefits gained as a result of this work include production systems that are more environmentally friendly, improved and novel fiber products for the health and well-being of the consumer, and the offset of rising production costs and other concerns that threaten the health of the U.S. cotton industry.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Molecular Genetics of Transposition Rate
Description: The long-term goal of this experimental program is to infer the relative contribution of different selective forces on the maintenance of a stable TE copy number in the host genome, and on the TE-host coevolution. Current experiments will be focused on a model TE COPIA of D. MELANOGASTER. Short-term goals of the proposed experiments are (1) the mapping of quantitative trait loci (QTLs) responsible for variability of transposition rates; (2) relating QTLs to candidate host genes modulating COPIA transcription; and (3) inferences on the frequencies of QTL alleles in natural populations of flies. Transposable elements (TEs) are sequences capable of multiplying in their host's genome. They survive by increasing copy numbers due to transpositions, and natural selection washes them out because hosts with heavier loads of TEs have lower fitness. The available phylogenetic evidence supports the view that TEs have existed in living organisms for hundreds of millions of years. A fundamental question

facing the field is how can an equilibrium be attained between transposition and selection which allows these parasitic genetic elements to persist for such a long time period? To answer this question, it is necessary to understand (i) how the rate of TE transposition is controlled and (ii) to describe the mechanisms with which natural selection opposes TE accumulation. My colleagues and I developed 'COPIA as the best understood TE' (Futuyma, EVOLUTIONARY BIOLOGY, 4th edition). We measured the rate of COPIA transposition in nature and in the laboratory, mapped the genes controlling copia transpositon, and formulated a hypothesis about the forces defining transpositions in natural populations, i. e. that variability of TE positions between flies of natural populations is caused by frequent transpositions in rare flies with the permissive alleles. This work is valuable for the goals of the AES, especially for assessment of long-term performance of domesticated stocks. We argue that domesticated stocks carry alleles restricting transposition. We recommend assessment of TE activity in those stocks that were improved by introgressing genes from non-domesticated ones. Short-term improvement from desirable introgressed alleles might be completely negated by the following adverse multiplication of TEs. Further, segregating of permissive restrictive alleles is highly relevant for deriving new domesticated populations from wild isolates. Suppose the hypothesis about the segregation of permissive/restrictive alleles in natural population is correct. When TEs multiply due to temporary decrease in the effective size of population, the fitness of individuals carrying permissive alleles becomes reduced more severely in comparison with the bearers of restrictive alleles. Thus, the frequency of restrictive alleles in a population with exploding TEs should increase, decreasing the average rate of transposition. This negative loop should prevent TEs from further increasing in copy number.
Impact: Information on population dynamics of transposable elements will impact the design of breeding programs aimed to improve domesticated animals and crop plants. Knowledge of the properties of quantitative trait loci will optimize the procedures of stock improvement by selecting for desirable traits.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: National Animal Genome Research Project
Description: Develop high-resolution comparative genome maps aligned across species that link agricultural animal maps to those of the human and mouse genomes. Objective 1: Develop high-resolution comparative genome maps aligned across species that link agricultural animal maps to those of the human and mouse genomes. The High Growth (HG) mouse mutation is a 460 Kb deletion of chromosome 10 which causes a 30-50% increase in growth in the homozygous animal. We have identified three genes within the deletion, suppressor of cytokine signaling-2 (Socs-2), caspase and RIP adaptor with death domain (Raidd/Cradd), and Plexin C1 (Vespr). The two deletion breakpoints lie in within the second introns of both Socs-2 and Plexin C1, resulting in the formation of a novel expressed fusion transcript between Socs-2 and Plexin C1 in HG mice. We have mapped and sequened Socs-2 in cattle and pig and have identified polymorphisms in these species to examine association of Socs-2 and growth related traits. Objective 2: Increase marker density of existing linkage maps used in QTL mapping and integrate them with physical maps of animal chromosomes. An in silico approach was developed to identify homologies existing between mapped livestock microsatellite flanking sequences and GenBank nucleotide sequences. A total of 67 bovine, 44 porcine and 21 chicken microsatellite flanking sequences had significant matches to human genomic sequence, genes or expressed

sequence tags. These microsatellites were mapped in human providing useful links between the comparative maps of humans and livestock.
Impact: The understanding of the genetic process controlling animal growth in a model organism will allow the isolation and study of homologous genes in domestic animals that could be used to select faster growing and more efficient animals. The development of our in silico mapping approach significantly increased the number of genes and EST sequences anchored to the bovine, porcine and chicken genome maps, as well as the number of links between various human-livestock comparative maps.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AL, AR, CA-D, DE, HI, IA, IN, KY, LA, MI, MN, NE, NJ, NM, NYC, OK, RI, SC, TX, UT, WA, WI. NON-AES: USDA/ARS, NCA, NAAB, TUFTS U, CHNMC, UBC, NIL, AB, DPR, NTBF, ASI, BYU, Stormont Lab (CA), INRA (France), United Kingdom

Theme: 1.11 Biotechnology
Title: Novel Signaling Pathways and Elicitors in Whitefly-Plant Interactions
Description: Study expression of genes (SLW1 and SLW3) induced by the phloem-feeding silverleaf whitefly. Determine the levels and subcellular localization of SLW1 and SLW3 proteins after whitefly feeding, during floral and fruit development, after treatments with jasmonic acid and ethylene, and after water-deficit stress. Determine the levels of SLW1 and SLW3 proteins and mRNAs in (1) squash, pea, and tomato lines that spontaneously silver, (2) Cucurbita lines that resist leaf silvering, (3) other plants that exhibit developmental disorders after silverleaf whitefly feeding, and (4) squash plants treated with gibberellic acid and chlormequat chloride. If time permits, determine the substrate specificity of the squash SLW1 and SLW3 using established substrate assays. Determine if Arabidopsis can be used as a model plant to investigate silvering and to identify the signaling pathways essential for SLW1 and SLW3 gene expression. Silverleaf and sweetpotato whitefly infestations of Arabidopsis plants will be evaluated for evidence of leaf silvering and stem blanching and expression of the Arabidopsis SLW1 homologue and Beta-glucosidase genes. Expression the Arabidopsis SLW1 homologue and the five Arabidopsis Beta-glucosidase genes in response to water-deficit stress, and during development will also be determined. To understand changes in gene expression in response to phloem feeding insects, squash responses to the silverleaf and sweetpotato whiteflies are being determined. SLW1 and SLW3 protein and RNA levels are correlated. A peptide antiserum was developed to monitor SLW3 protein levels, in addition to the previously made polyclonal antiserum. SLW3:GFP and SLW1:GFP constructs were constructed to examine the location of these proteins within plant cells. We have made subtractive suppressive libraries to identify squash genes that are induced or suppressed by whitefly feeding. If funds are sufficient, we propose to use the clones in microarray experiments. We continue to characterize the roles of SLW1 and SLW3 in water-deficit signaling and whitefly signaling. We have constructed transgenic tomatoes and Arabidopsis to examine the role of these proteins in disorder development or in defense. SLW3:GUS have been constructed and the expression of the squash promoter in transgenic tomatoes and Arabidopsis is being evaluated. We anticipate these plants will be good reporter genes for the identification the novel signaling pathway used to induce SLW3 expression in response to the silverleaf whitefly.
Impact: Identification of genes activated 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 us to develop cogent transgenic strategies for broad-based resistance to herbivores.

Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Physiological and Genetic Mechanisms of High Salt Stress Tolerance in Lophopyrum Elongatum: Genomic Approach
Description: Salinization of land represents one of the principal dangers to the sustainability of the irrigated agriculture in California and other western states. The conventional means of coping with salinity, viz. soil and water management, must be supplemented by the development of salt-tolerant plants. The objective of this project is to enhance the understanding of the genetic and physiological mechanisms of salt tolerance. We assume that most of the differences in salt stress tolerance between wheat and the highly salt tolerant L. elongatum, a close relative of wheat, are due to quantitative differences in gene expression rather than differences in gene function. Identification and isolation of such genes will facilitate manipulation of salt stress tolerance in wheat. To identify genes showing differenetial expression in the two species under salt stress, gene expression in L. elongatum during a time-course of the acclimation to stress with 100 mM NaCl will be compared with that in wheat by cDNA microarray hybridization. Genes showing differences in expression will be identified. To develop a population of cDNA clones for arraying on glass slides (microarrays), cDNA libraries of salt-stressed Chinese Spring wheat were produced and two thousand random clones were selected from each cDNA library and sequenced, thereby producing their expressed sequence tags (ESTs). ESTs of these clones were compared with the existing pool of 80,000 wheat ESTs and putative unigenes were selected. Unigenes from salt stresses wheat along with the entire pool of unigenes are being mapped in a collaborative project utilizing a set of common 101 Chinese Spring wheat stocks with 159 overlapping deletions. To date, loci detected by 720 ESTs were mapped in my laboratory. These loci are part of a total of over 10,000 wheat loci detected by hybridization of 4,300 ESTs in the collaborativne laboratoris. A pooling technique was developed for ESTs integration into contigs of bacterial artificial chromosomes (BACs) harboring wheat genomic DNA fragments. To date, 93 ESTs have been integrated into BAC contigs.
Impact: The goal of this project is to identify regulatory elements responsible for the high expression of genes controlling salt stress response in L. elongatum, the highly salt-tolerant relative of wheat. This knowledge will make it possible to engineer cereals with enhanced salt stress tolerance, which is an important breeding goal for irrigated agriculture in California.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Protein Import Into and Within Chloroplasts
Description: This project's objectives are to study the mechanism of protein targeting to chloroplasts as a means to understand chloroplast biogenesis. An understanding of the mechanisms of protein translocation to and within chloroplasts is critical for the realization of the full potential of molecular genetics to improve crop yields. This project seeks that understanding through examination of the energetics of these processes and the roles of different molecular components in facilitating protein transport. The mode of energy input for protein transport into different sub-cellular organelles is well understood. However, little work has been carried out to quantitate the energy input. Our experiments are aimed at determining the amount of energy required per protein translocated on each of four protein transport pathways in plastids. This work will allow the assessment of the cost in terms of metabolic energy of protein trafficking in

plant cells. We are also continuing our efforts to exploit the unique advantages offered by the use of moss as an experimental system in which to study protein targeting to chloroplasts. DNA introduced into the moss undergoes homologous recombination in the nucleus, offering the possibilities of directed gene knockout and allele replacement. We have ongoing projects to knock out two genes thought to be involved in protein transport across the chloroplast envelope membranes. We are further developing the techniques for gene replacement, which will allow us to generate, for instance, temperature-sensitive mutants in the chloroplast import machinery.
Impact: Genetic engineering of plants holds great promise for the solving the problems related to feeding the world's growing population. Much of this effort is directed toward altering the metabolism of the plant cell, which in many cases, requires the delivery of new or modified proteins to the chloroplast. The work ongoing in my laboratory provides fundamental insights into the mechanism of this targeting, and accordingly, this information is essential to realize the full promise of genetic engineering in plants.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Thyroid Hormone Regulation of An Entire Gene Expression Network During Amphibian Metamorphosis
Description: Transcriptional activity of nuclear receptors is controlled by the presence of biologically active ligand in target cells. In this proposal, we plan to create transgenic reporter embryos that will allow us to determine the temporal and spatial presence of bioactive ligands in target cells throughout development. We will first apply this technology to uncover new areas of ligand accumulation for known nuclear-ligand pairs, such as the thyroid hormone receptor and retinoic acid receptors. The technology will then be applied to the discovery of potential areas of ligand synthesis for receptors with no known endogenous ligand, the orphan receptors. We have chosen the frog Xenopus laevis as our model system due to its rapid external development, simple transgenic assay, and phylogenetically conserved receptor sequences and ligands. Our objectives are outlined below. 1. Develop transgenic Xenopus laevis bearing thyroid hormone and retinoic acid response element controlled reporter genes. 2. Determine the activation pattern of the thyroid hormone receptor (TR) and retinoic acid receptor (RAR) ligand binding domain in specific tissues during development. 3. Determine the activation pattern of retinoid-X receptor (RXR) and other orphan nuclear receptor ligand binding domains in specific tissues. 4. Identify biologically active ligands for the retinoid-X receptor (RXR) and/or other orphan nuclear receptors. The control of amphibian metamorphosis by thyroid hormone (TH) is one of the most dramatic examples of hormonal control of animal development in nature. In the frog Xenopus laevis, TH induces the death and resorption of larval tissues, growth and differentiation of adult tissues, and remodeling of other organs for new adult functions. In order to understand how TH governs such complex events, we have characterized the DNA sequences that allow rapid TH mediated transcriptional up-regulation of target genes. We discovered a strong binding site for the nuclear TH receptor in one target gene that confers TH responsiveness on heterologous genes. The TH responsive sequence is virtually identical to an optimized sequence based on mammalian gene sequences demonstrating the conservation of the TH signaling pathway. This work was published in the journal Endocrinology. In order to investigate the role of the TH receptors in metamorphosis, we have also characterized the first synthetic thyroid hormone receptor antagonist NH-3. NH-3 competitively binds to the thyroid hormone receptor and blocks its function by inducing a distinct conformational change than the agonist bound receptor. Remarkably, NH-3 completely blocks both spontaneous and induced metamorphosis as well as

preventing up and downregulation of TH response genes. This work was published in the Journal of Biological Chemistry. In a related effort, we have developed a means to degrade the mRNAs for the two TH receptor isotypes, TRa and TRb, using ribozyme-based technology. The ribozymes cleave their targets specifically and inhibit TH induced transcription in a cultured cell line. The ribozymes are important reagents for specifically interfering with one receptor isotype versus another because NH-3 binds equally well to both. This work was published in Nucleic Acids Research. We use Xenopus laevis as a model system because of the recently developed transgenic technology available in this organism. We have recently used transgenesis to create genetically modified animals that detect endogenous and exogenous sources of hormones and environmental hormone mimics, such as pesticides. Transgenic tadpoles were created that express a fusion of the hormone binding domain of the TH receptor (or other related receptors) to a yeast transcription factor DNA binding domain. Activation of the fusion protein is detected by transcription of a green fluorescent protein reporter that contains binding sites for the yeast factor. We can detect exogenously added thyroid hormone when the TH receptor sequences are used, or endogenous ligand for the retinoid-X receptor in the developing hindbrain when those sequences are used. This is the first report of a method to detect the distribution pattern of a biologically active hormone within a live animal. This work was presented at the national Endocrine Society meetings this year, and is currently being prepared for publication.
Impact: The way that animals develop from a single cell to an adult remains a central question in biology. To date, the influence of hormones on development has been under investigated. Besides research on hormone action, we are improving means to efficiently create transgenic frogs, methodology that may be transferred to other animals. Finally, chemicals such as pesticides can mimic or inhibit the action of natural hormones and disrupt animal development, from amphibians to humans.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.11 Biotechnology
Title: Wheat Breeding and Molecular Genetics
Description: The goal of the UC Wheat-breeding program is the development of new common red, common white and durum wheat varieties and germplasm adapted to California. The specific goals are to introduce new disease resistance genes, increase grain yield potential, and improve end-use characteristics. The main wheat-disease targeted in the program are leaf rust, stripe rust, septoria tritici blotch, and barley yellow dwarf virus. The gluten strength and water absorption; for the HWS, the desired traits are improved color stability, gluten strength and failling number; and for the durum wheats, targeted end-use characteristics are semolina color, protect content, and gluten strength. New breeding materials with adequate disease resistance, competitive yields, and improved end-use quality, for bread making properties, pasta and noodle making were produced or advanced during the 02 cropping cycle. The breeding lines that are closest to release in the common red class are: 1) A line of UC1037 with an introgressed 5+10 High Molecular Weight (HMW) glutenin allele and a gene for high grain protein content from T. dicoccoides. This material is in its second cycle of seed increase. 2) A new line with excellent yield potential that was entered into the 2002 regional trials as UC1358. 3) A line of Yecora Rojo with two new leaf rust resistance genes (the first of the two generations required to combine both genes was made this year). In the white class the line UC1110 (highest yielding in the San Joaquin Regional trials previous years) showed weak gluten due to the presence of the HMW subunits 2+12. An accelerated backcross program was initiated to correct this problem and three generations were advanced. The most advanced material for release in the common white class is

UC1361. This line has excellent breadmaking quality and also low polyphenol oxidase activity for noodle production. An additional promising hard white line is UC896. We have finished the introgression of the HMW subunits 5+10 in UC896 and we are now combining this trait with low PPO activity. The 02 growing cycle had a high pressure for stripe rust and a late invasion of leaf rust that provided a good opportunity for selection against these two diseases. The new leaf rust resistance gene Lr47 incorporated into Yecora Rojo by Marker Assisted Selection (MAS) was resistant to these leaf rust races. Isogenic lines with and without this gene in three different varieties are currently planted in Elite trials to evaluate the effect of the chromosome segment including Lr47 on the agronomic performance in the field. Seeds are also being increased in head-rows for five lines with the additional adult plant leaf rust resistance gene Lr37. We continued with the backcrossing of the stripe rust resistance gene Yr15 and added a new program to incorporate resistance gene Yr5. These two genes are currently resistant to the new races present in the central Valley. Marker assisted selection programs for quality traits were advanced one or two cycles. Six generations of backcrossing were completed in 20 lines and seed is being increased in head-rows. The high research productivity of the program received national recognition with the award of a 3.25 million dollars grant to develop a National Marker Assisted Selection Program, leaded by our laboratory.
Impact: The release of new varieties with better yield and improved quality is an efficient way to transfer the value of research to the growers. The incorporation of new resistance genes will reduce the requirements of pesticides resulting in a direct benefit to the environment. Incorporation of the T. dicoccoides gene for high grain protein content may improve the efficiency of nitrogen utilization.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.12 Bioterrorism
Title: Biological Control Offers Control of Eucalyptus Pest
Description: The eucalyptus snout beetle, Gonipterus scutellatus, was discovered defoliating eucalyptus trees in Ventura County in March 1994. This insect has been introduced accidentally into several eucalyptus-growing regions around the world from Australia and has caused extensive damage wherever it has become established. Female beetles deposit hard brown egg capsules on shoots and young leaves. Both adults and larvae consume young and tender leaves, buds, and shoots. Extensive feeding completely defoliates trees and kills branches, while intermediate levels of defoliation retard growth and affect tree shape. UC Riverside entomologists responded rapidly to the invasion of this pest by introducing a specific parasitoid of snout beetle eggs, the wasp Anaphes nitens, as a natural biological control agent. The wasps were mass reared and released in Ventura County in 1994 and 1995, and they rapidly became permanently established.
Impact: Snout beetle populations declined dramatically within less than a year. By 1997, snout beetle populations had dropped to barely detectable levels (Hanks, et al. 2000). Although reduced to non-damaging levels, the beetle has continued to expand into adjacent counties. However, in all cases, the parasitoid distribution has expanded in tandem, to mirror the distribution of its host. Consequently, where pesticide use has not disrupted the actions of the parasitoid, there have not been further reports of damage. The rapid implementation of a biological control program nipped a serious problem in the bud, providing an effective and permanent solution that requires no further input.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.12 Bioterrorism
Title: Biological Control Research Helps Address New Avocado Pests
Description: Two exotic pests, avocado thrips and persea mite, appeared in California in 1990 and 1996, respectively. A model based on 1998 harvest data predicted that growers in the state, who produce about 95 percent of the nation's avocado crop, would experience an estimated $13 million in short-term losses, with annual losses decreasing to $6 million as the industry developed means to deal with the pests. After more than four decades of largely pesticide-free insect control, many avocado growers now find it necessary to spray their orchards to minimize foliage and fruit damage. A Biological Control Specialist from the University of California, Riverside has worked closely with growers to develop biological control strategies to suppress avocado thrips and persea mites. Combating the mites involved three years of evaluation to identify an effective natural enemy, a predator mite known as Neoseiulus californicus that is raised commercially in California, and recommend for use by growers. He developed a motorized sprayer to apply the predator mites directly onto avocado tree leaves. The first step in controlling avocado thrips (Scirtothrips perseae) was to classify the pest and its home range, both of which were unknown until the pest became a nuisance in Ventura County in 1996. He also identified Franklinothrips as an effective predator species. He has successfully mass-reared these ant-mimicking predators, and has developed a new harvesting mechanism and automated sorter that makes it possible to collect predators from their rearing cages and transport them to groves. Field trials evaluating mass-reared Franklinothrips for control of avocado thrips are underway. Another method determined to be useful to combat thrips is the use of composted organic mulches around the trees. Not only do the mulches aid in retaining water and benefit the soil, they also increase fruit yield by 13 percent and reduce populations of avocado thrips, which fall off trees to pupate, by as much as 50 percent. In addition, mulches help suppress avocado root rot.
Impact: Persea mites can be largely controlled through non-chemical strategies developed by Dr. Hoddle. Biological and cultural control of avocado thrips that reduces reliance on pesticides has progressed substantially, and techniques developed at UCR are employed by growers. The benefits to the state's $300 million-a-year avocado industry include the curbing of significant financial losses due to damaged fruits. Urban residents living near avocado groves also benefit from non-chemical solutions, as do state growers, who are proud of their "green" tradition that relies more on biological control techniques than pesticides.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.12 Bioterrorism
Title: Yellow Starthistle Management Makes Progress
Description: Yellow starthistle is the most conspicuous of the noxious weeds that are a serious concern on rangelands and forestlands of El Dorado County. This introduced species significantly reduces biodiversity, recreational opportunities, forage production and the value of habitat for wildlife. UC Cooperative Extension has conducted cutting edge research on various strategies to control yellow starthistle, including burning, chemical control, grazing, mowing, pulling and biological control. CE has worked with the El Dorado County Noxious Weed Management Group and through educational programs to teach landowners and land managers how to control yellow starthistle.
Impact: Research and educational efforts in El Dorado County have had a significant effect on the control of yellow starthistle. In collaboration with the local Weed Management Group, the

project has resulted in treatment of over 12,000 acres of yellow starthistle-infested range and forest land. This has significantly reduced the overall population of yellow starthistle in the county, improving forage production, increasing biodiversity and benefitting wildlife habitat and recreational opportunities.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.13 Diversified/Alternative Agriculture
Title: New hay, kleingrass, exported to Far East
Description: Almost half of arable land in the irrigated Sonoran Desert, including Imperial County, is dedicated to forage production. New forage resources are always of interest to local growers. In the early 90's, grass hay introduction trials were conducted at UCDREC by Juan N.Guerrero, area livestock advisor. One of the grasses evaluated was kleingrass (Panicum coloratum L.), a perennial crop that thrives in desert heat and can be grown on less productive soil.
Impact: Using results of that trial and starting in about 1993, several growers in Imperial County began cultivating kleingrass as a crop for export to the Far East, where milk production practices require forage that is relatively fibrous and will extend productive life of the cow. Once established, kleingrass requires only water, fertilizer and baling costs, thus is inexpensive to produce and economically competitive in Japan. In 2001, 10,262 acres of kleingrass hay were grown in Imperial County for export, with a gross economic value of $7,711,000. In the Palo Verde Valley of Riverside County and along the Arizona side of the Colorado River about 15,000 additional acres of kleingrass are grown for export with similar gross economic values.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.16 Grazing
Title: Management of Spatial Patterns of Plants and Livestock Impacts
Description: Determine spatial pattern of grazing by cattle on grass-legume pastures seeded with different spatial distributions. Document community dynamics of grass-legume pastures seeded with different spatial distributions. Develop and test a conceptual model of spatial-temporal reinforcement schedules as a means to control spatial pattern of food search by livestock.
An international research team has been formed and experiments have been planned. A laboratory to extract alkanes for determination of dietary intake and botanical composition was established at the Department of Agronomy and Range Science. We tested a laser and GPS collar to determine position and movement of cattle at the Sierra Research and Extension Center. Please, not that the project started only 45 days before the writing of this report.
Impact: The target clientele are mangers of grazed lands. Results will improve the planning and monitoring of grazing, and will help prevent negative impacts of grazing on sensitive habitats. Prediction of location of impacts before livestock grazing, will be a tool for rangeland use and mitigation planning. The study of spatial pattern of planting will help maximize the duration and productivity of pastures.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.17 Home Lawn and Gardening
Title: Home Gardener On-Line Publications

Description: In light of the increasing need to bring up-to-date information on landscaping and gardening to urban audiences, the web offers an efficient way to provide on-line information in an accessible format to home gardeners and horticulture professionals. In 2001-02, the following on-line publications were made available without charge through DANR's Communication Services on-line catalog and also through the Ornamental Horticulture Research and Information Center webpage. A Farm Advisor wrote, co-wrote or facilitated the publications through a grant made possible by the Elvinia J. Slossen Endowment.

- The UC Guide to Solving Garden and Landscape Problems (Interactive CD ROM.) #3400
- Turfgrass Selection for the Home Landscape #8035
- Water Conservation Tips for the Lawn and Garden #8036
- Compost in a Hurry #8037
- Navel Orange Split #8038
- Sago Palms in the Landscape #8039
- Lawn Watering Guide for California #8044
- Fruit Trees: Thinning Young Fruit #8047
- Fruit Trees: Planting and Care of Young Trees #8048
- Fruit Trees: Training and Pruning Deciduous Fruit Trees #8057
- Fruit Trees: Pruning Overgrown Trees #8058
- Vegetable Garden Basics #8059
- Calendar of Operations for Home Gardeners: Almonds #7257
- Calendar of Operations for Home Gardeners: Apples and Pears #7258
- Calendar of Operations for Home Gardeners: Apricots #7259
- Calendar of Operations for Home Gardeners: Cherries #7260
- Calendar of Operations for Home Gardeners: Peaches and Nectarines #7261
- Calendar of Operations for Home Gardeners: Plums #7262
- Calendar of Operations for Home Gardeners: Walnuts #7263
- Lawn Diseases: Prevention and Management: Pest Note For The Home Landscape #7497
- Carpenter Worm: Pest Note for the Home Landscape and Professional Horticulturists #7499

Impact: The free publications listed above are accessed in high volume by home gardeners and others. Last year the number of hits or downloads of some of the most popular publications were: Fruit Trees: Planting and Care of Young Trees, 3,954; Turfgrass Selection for the Home Landscape, 3,390; Compost in a Hurry, 3,656; Sego Palms in the Landscape, 6,240; Lawn Watering Guide for California, 3,583
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.17 Home Lawn and Gardening
Title: Master Gardeners Protect the Environment
Description: Environmental problems related to urbanization in California include rapid depletion of landfill capacity, excessive use of water resources and contamination of waterways from garden pesticide runoff. In 1993, UCCE's Sonoma County Master Gardeners started a home composting project to teach urban gardeners how to make their own compost from yard wastes and kitchen scraps that were normally going into the local landfill. They also developed a special project called PURE (Pesticide Use Reduction Education) to teach the general public about alternatives to the use of garden pesticides. Another project promoted water-wise gardening techniques, including demonstration urban gardens to teach water conservation.

The home composting project was the first in the state to link UCCE Master Gardener volunteers and Waste Management Agency funds to teach home composting. In the last seven years, the home composting program reached 109,755 residents with composting brochures, bin distribution programs, educational booths at large public events, library talks, farmers market booths, seminars, and a resource desk for call-in questions in Santa Rosa and Sonoma. Last year, almost 2,000 children were contacted through school classroom presentations with worm composting programs. Through the PURE program, Master Gardeners created a unique demonstration garden at the county fair that introduced the public to environmentally friendly gardening. Reaching over 30,000 people in the last three years, the garden includes plants that attract beneficial insects and regionally-adapted plants that are less likely to have pest problems. The water conservation efforts have included distribution of thousands of UC fact sheets on proper water use techniques, alternatives to lawns, and a booklet on native drought-tolerant garden plants. The Master Gardeners also developed two permanent public display gardens where they hold frequent seminars and workshops for the public. Small demonstrations, workshops and classes are held at the Sonoma County Fair, Harvest Fair, Spring and Fall Garden Shows, Celtic Festival, Herb Festival, regional libraries and at about 250 farmers markets throughout the year.
Impact: Every year the home compost education program diverts about 12,000 tons of yard waste and kitchen scraps from the landfill. Compost made in the back yard reduces environmental pollution and provides a valuable additive to the garden soil. The PURE program has drastically reduced amounts of unwanted pesticides turned in at toxic materials roundups. Surveys of nurseries and businesses selling pesticides also have indicated public interest in alternatives to conventional pesticide usage. The water conservation educational efforts by UC's volunteers has helped to ceate a 20% reduction in average houshold water use over the last few years in many of Sonoma County's cities.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.17 Home Lawn and Gardening
Title: QAC/QAL Exam Prep Course Helps Landscape Gardeners
Description: With pesticide application becoming increasingly complex and regulated, many landscape gardeners are now trying to get their Qualified Applicator license or certificate in the Landscape Maintenance Gardener category. The exam can be difficult for those who are not comfortable taking tests or who haven't had any formal training in the concepts of pest management. Well-presented information is reqired so that those preparing for the test have the knowledge to pass, and also become more effective applicators. A six week, six-session class is offered annually and usually 15 to 30 people participate. Some come to prepare for the QAC/QAL test and others just want to update their pest management and applicator skills. Each three-hour session covers a major aspect of laws and regulations or a topic in pest management such as weeds, insects, plant diseases or application technology. The UC IPM program and DANR Communication Services offer excellent publications to assist in the class content. Also, in order to encourage study of the materials, a syllabus is made available to participants. The class presentations are updated each year to accommodate changes in regulations or in the exam process.
Impact: The normal first-time pass rate for this exam is less than 30%. When students participated in the QAC/QAL class and studied the materials, the pass rate has been 60% or better. This trend has been consistent over the six years the course has been offered.

Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.18 Innovative Farming Techniques
Title: Dried-on-Vine Raisins (DOV)
Description: As the raisin industry has struggled with low prices for several years, labor costs have escalated. Traditional tray drying is an important component of total labor costs.
To reduce labor costs, our viticulture farm advisor envisioned a unique method of pruning that would allow raisins to be dried on the vine for machine harvest without any trellis retrofitting or additional cost. Research began in 1999 and is in progress. We have learned that fresh weights and raisin yields are similar to traditional tray drying, and the DOV (dried-on-vine) raisins can be successfully harvested with a standard wine grape harvester. The system eliminates discing to prepare a terrace for tray drying and also eliminates burning of paper trays after harvest. This could significantly improve air quality in the San Joaquin Valley, considering that more than 200,000 acres of raisin are produced. Raisin growers have been kept informed through symposia, field days, newsletters and articles in the popular press.
Impact: Sun-Maid indicates that their growers committed more than 5,000 acres to our traditional-trellis DOV system for the 2002 season. This acreage is anticipated to more than double in the upcoming 2003 season. Potential savings to the grower are $400 to $500 per acre. Grape growers are excited because other DOV systems require expensive trellis systems and retrofitting. This project could have a profound impact on raisin production in California, perhaps returning this industry towards profitability. Farm Advisors Stephen Vasquez and Bob Beede and KREC Superintendent Fred Swanson have collaborated on this project.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Bioinvasions of Exotic Insects: Molecular Genetics, Database, and Modeling Approaches
Description: Recent and ongoing invasions of non-indigenous (exotic) insects will be examined with the goal of making the study of invasive species more predictive. The project has 5 objectives: (1) To document using a searchable computer database the most serious invasive insect pests in California, the Insular Pacific and the Pacific Rim. (2) To accumulate a reference collection to be housed in the Essig Museum of Entomology, which will include not only voucher specimens but also DNA samples from different geographic regions. (3) To evaluate the variety and quantity of genetic data necessary determine the origins of non-indigenous insects as well as the pathways through which non-indigenous pests are introduced and spread. (4) For potentially damaging species, to determine whether genetic markers exist, and if such markers do not exist, to develop such markers. This will enable new invasions of these organisms to be studied immediately without the need for several years of work on the development of genetic tools. (5) To modify for the study of insect populations, existing statistical methods used in determining origin of human and fish populations. These methods, while aimed at invasive species, can also be applied to the study of natural colonization events or to the manipulated establishment of species used for classical biological control. This project contains 3 elements, molecular genetics, databasing, and modeling. 1. Molecular Genetics. We are continuing to develop genetic methods for the studies of origins and biology non-indigenous, invasive (exotic) insects. In addition to collecting data for nuclear intron sequences that we have used previously, we are exploring the use of other co-dominant nuclear markers, such as microsatellites (VNTR's) and single nucleotide polymorphisms (SNP's). Insects that we have worked with this year

include Medflies, Mexican fruit fly, walnut husk fly, pumpkin fruit fly, other fruit flies in the Bactrocera dorsalis complex, rice brown planthopper, and invasive ants. This work is in collaboration with postdocs, Drs. J-H Mun, P. dos Santos, A. Suarez, andY. Chen. 2. Database. We are continuing to develop a prototype of a database (Sun Sparc/Oracle) of exotic organisms which will include 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 Drs. A. Bohonak (San Diego State University) and N. Davies (UC Gump Lab, Moorea) as well as genetic database scientists at the Lawrence Berkeley Lab. 3. Modeling. We have updated and distributed a computer program to analyze recent histories of populations (available on the web at http://www.bio.sdsu.edu/pub/andy/ESP.html). This program compares actual genetic diversity found in invading organisms to that from the simulations to assess critical features of biological invasions.
Impact: Methods are 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: Controlling Invasive and Noxious Weeds Through a Weed Management Area
Description: Invasive and noxious weeds do not respect property lines or jurisdictions. To help prevent their introduction and spread, a public-private partnership that combines resources and expertise is required. These invasive plants are often detrimental or destructive to agriculture. They also degrade wildlife habitat and impair plant biodiversity. In San Benito County, a UCCE Farm Advisor and the local Agricultural Commissioner's office jointly took the lead in creating a Weed Management Area, concentrating on:

- Organizing public and private landowners.
- Inventorying the existing invasive and noxious weeds.
- Organizing educational programs.
- Controlling weeds.

Memorandum of Understanding (MOU) agreements were developed among 10 local agencies. To survey the existing weed situation, participants inspected 2,000 miles of county roads and rights-of-way. Weed types, density and populations were recorded, using a GPS (geographical positioning system) unit. This information was converted to detailed maps which were then used to help determine control activity. Our weed control work has been focused primarily on yellow star thistle, purple star thistle, artichoke thistle, and scotch thistle. We have organized property owners to spray over 3,000 acres in heavily infested areas, following the UCCE recommendations for rates and spray timing. In addition, 350 miles of county road right-of-way adjacent to rangelands have been sprayed to control yellow star thistle. Twenty biological control sites have been identified and natural predators released. A weed identification book describing the top 20 invasive and noxious weeds in San Benito County was produced and distributed to land owners. Each spring, UC weed, livestock, range and wildlife specialists have presented their latest weed control research. UCCE specialists have appeared at these educational programs and also developed a web site to both inform and receive input from the public on the work of the Weed Management Area group.
Impact: Our implementation plan, based on UC research, clearly has helped prevent the further spread of invasive and noxious weeds in San Benito County. This cooperative program has also increased local awareness of invasive weed prevention, detection, control, biology,

identification, economics and environmental impacts. In addition, our efforts continue to help landowners improve their management techniques for control of those weeds.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Domestic and International Effects of Exotic Animal Diseases and Their Eradication
Description: Objectives: 1) Examine the potential economic effects of an outbreak of exotic animal diseases like Foot and Mouth Disease (FMD) and Bovine Spongiform Encelphalopathy (BSE) on the US (California) economy and on international markets if an outbreak of such a disease were to occur in the United States, and to analyze how changes in US policy can mitigate the expected economic damage from a potential outbreak. 2) Examine the expected domestic and international effects of eradicating exotic animal diseases like FMD and BSE in countries where they exist of have recently existed. Following successful eradication of FMD in Uruguay (1995) and Argentina (2000), both countries suffered new outbreaks of FMD in early 2001 that apparently occurred as the result of infected cattle entering Argentina from Paraguay. The outbreak was not controlled and, indeed, may have been occulted for some time, contributing to its spread. Both Argentina and Uruguay lost access to the FMD-free markets that they had previously gained and the livestock industries in both countries suffered badly as a result. However, Uruguay was able to control the FMD outbreak quickly and, by November 2001, had regained approval to export fresh beef to Canada. Other markets should follow. Following a benign winter and a very large calf crop, the Uruguayan livestock sector is in surprisingly good condition given the previous loss of important markets. We plan a new study to evaluate the effect of the outbreak. The Argentine livestock industry is in much less solid condition as it has not regained external markets and the domestic market, which accounted for 90% of output, is severely depressed by an economic recession. We completed revisions of two papers, one estimating the cost of an FMD outbreak in California, with policy recommendations to suggest consideration of ring-vaccination instead of stamping out in the event of a California outbreak, and the other estimating the cost of an outbreak of Bovine spongiform encephalophy (BSE), with policy recommendations.
Impact: Argentina and Uruguay have latent potential to become important exporters to FMD-free markets. Both countries could be tough competitors for the US in foreign markets, though currently Argentina and Uruguay export mainly grass fed beef that is significantly differentiated from the grain fed beef exported normally by the US. The US could also import from Argentina and Uruguay, benefiting US consumers. BSE is not a threat to the US herd or to US consumers at this time.
Funding Source: Hatch 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: Objectives: 1. Characterize the roles and mechanisms by which biotic and abiotic factors predispose trees to bark beetle attack and subsequent mortality.
In studies of feeding by the bark beetle, Ips paraconfusus, two pine stilbenes (pinosylvin and pinosylvin methyl ether), ferulic acid glucoside, and enantiomers of the four most common sugars present in ponderosa pine phloem (sucrose, glucose, fructose, and raffinose) did not stimulate or reduce male feeding when assayed on wet alpha-cellulose with or without stimulatory phloem extractives present. When allowed to feed on wet alpha-cellulose containing

sequential extracts (hexane, methanol, and water) of ponderosa pine phloem, methanol and water extractives stimulated feeding but hexane extractives did not. Males confined in wet alpha-cellulose containing aqueous or organic extracts of culture broths derived from phloem tissue and containing the root pathogen, Heterobasidion annosum, ingested less substrate than beetles confined to control preparations. In an assay using logs from uninoculated ponderosa pines, the mean lengths of phloem in the digestive tracts increased as time spent feeding increased. Males confined to the phloem of basal logs cut from ponderosa pines artificially inoculated with H. annosum ingested significantly less phloem than beetles in logs cut from trees that were (combined) mock inoculated or uninoculated and did not contain the pathogen. However, individual pathogen-containing treatments were not significantly different from uninoculated controls. It was concluded that altered feeding rates are not a major factor in explaining why diseased ponderosa pines are colonized by I. paraconfusus. Concentrations of soluble phenolics and lignin in the phloem of ponderosa pines inoculated with the pathogen Heterobasidion annosum, were assessed over a period of two years in a 35-year-old plantation in northern California, USA. The major effect of the pathogen on phloem soluble phenolics consisted of a significant accumulation of ferulic acid glucoside: 503 +/- 27 Og/g FW, compared with 366 +/- 26 Og/g FW for mock-treated and 386 +/- 27 Og/g FW for control trees. Lignin content was negatively correlated with ferulic acid glucoside concentration and there was an indication of lignin reduction in the cell walls of inoculated trees. Lignin had a negative effect on the in vitro growth of two common bark beetle fungal associates, Ceratocystiopsis brevicomi and Ophiostoma minus. For this reason it is hypothesized that lower lignification may facilitate the growth of beetle-associated fungi, resulting in greater susceptibility of the pre-symptomatic host to bark beetle colonization.
Impact: Our research on the interactions among bark beetles, pathogens and trees is focussed on two introduced pathogens. Fusarium circinatum and Phytophthora ramorum. These pathogens cause pitch canker of pines and sudden oak death of oaks and tanoaks, respectively. Through our studies we attempt to determine 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.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA, CO, FL, IA, MN, OH, OR, UT, WI, USDA/ARS. NON-SAES: Univ of MT, MN

Theme: 1.19 Invasive Species
Title: Invasion Genetics of the Walnut Husk Fly, Rhagoletis completa
Description: Objectives: Assess the importance of genetic processes such as genetic drift, selection, or founder effects in impacting invading populations. Determine the historical pathways of invasion and current levels of gene flow. Measure the adaptability of the diapause trait between founder and derived populations. We have successfully developed ten microsatellite primers. After determining the variability for each primer, we will use them to genotype native and introduced populations of the walnut husk fly, Rhagoletis completa, recently collected from the Midwest, California, and Oregon. This information will also be used to identify the source of the introduced California populations, identify population bottlenecks, and trace the historical pathway of invasion within California. We will also use allozymes to genotype the populations to link it with another dataset that was studied 30 years ago. This will provide a rare opportunity to assess how much population genetic structure has changed in the

native and introduced ranges over a 30 year period. Additionally, we are examining how R. completa was able to adapt to Californian climatic conditions, and whether understanding these patterns can explain why R. completa displays unusual and variable patterns of phenology in walnut orchards throughout the state. We coordinated with nine other researchers throughout the U.S. to collect and ship R. completa on the same day. Through this coordinated sampling effort, we are able assess diapause variation of native and introduced populations to Midwestern and Californian fall climatic regimes. This is an opportunity to examine whether climatic differences can be a major barrier against the establishment of introduced insects.
Impact: Introduced insect pests have a significant impact on US agriculture, yet very little is known about how populations colonize and become established in new climatic regions. This work examines both genetic and ecological changes that are associated with the introduction and establishment process.
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: The analysis of patterns of alien species invasion and remnant native species diversity in Californian grasslands. Major variables to be analyzed include soils, slope, land-use, and distance from sources of invasion (primarily roads). The study area includes the Putah and Cache Creek watersheds (Napa, Yolo, Lake and Colusa Counties). A primary goal is to determine whether within this region, spatial isolation from roads provides a refuge for remnant native grasslands. Since initiating this project, my collaborators and I have found that (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, in press). (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, in press). (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, in press). (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 in prep). (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, in prep).
Impact: This project has successfully demonstrated the effect of roads, interacting with natural environmental variation, on the distribution of exotic species at a landscape scale. This project has also successfully identified how the impacts of livestock grazing on exotic species invasions and native species persistence may vary along natural environmental gradients. Both aspects of the work are being utilized in the development landscape-scale plans for the restoration of natives and the strategic control of exotics. Incorporation of the findings are playing an important role in the successful development and implementation of these restoration and exotic species control programs.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Invasions of Exotic Weedy Species and Their Interactions without Native Vegetation and Cultivated Plants
Description: Objectives: (1) To test the hypothesis that invasiveness of plant species in disturbed environments is positively related to relative growth rate, leaf area ratio, and relative leaf production rate, and negatively related to genome size, length of minimum generation time and seed size. Additionally, to understand the relationship between genome size and relative leaf production rate by examining the relationships between genome size, cell size, shoot meristem size, cell cycle times, and the proportion of actively cycling cells in the meristem. (2) To develop a protocol for impact assessment of alien plants and prioritization of their control, containment, and eradication. (3) To assess global patterns in naturalized and invasive plant species diversity (Eurasia vs. other continents, continents vs. islands, tropical vs. extratropical areas). (4) To quantify the relationship between eradication effort, eradication success, and the initial size of exotic weed infestations. 1) Invasive (non-native) woody species in California can be ordered based on their impact on the light environment: FICUS CARICA equals RUBUS ARMENIACUS greater than TAMARIX RAMOSISSIMA equals CYTISUS SCOPARIUS greater than AILANTHUS ALTISSIMA greater than ROBINIA PSEUDOACACIA equals EUCALYPTUS GLOBULUS. 2) Phylogenetically constrained analyses of relationships between minimum generation time, seed mass, serotiny, genome size, and latitudinal range of 85 pine (Pinus) taxa revealed that invasive pine taxa exhibit distinct trends in the values of these attributes: small genome size, small seed mass, and short minimum generation time. These trends are more distinct in the subgenus Pinus and less pronounced in the subgenus Strobus. 3) The extent of plant invasions in the Stebbins Cold Canyon Reserve was evaluated: QUERCUS WISLIZENII savanna is the most invaded community in terms of both the species number and total cover. 4) A general theory of seed plant invasiveness was further elaborated.
Impact: Evaluations of biological attributes and environmental impacts of invasive plants give rise to both general and habitat-specific procedures for screening of introduced plants and prioritization of their control.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Marine Biodiversity: Importance for Ecosystem Function and Resistance to Exotic Species Invasion
Description: To determine the effect of decreasing biodiversity on primary production, secondary production by key forage and commercially valuable fishery species, and resistance of natural communities to invasion by non-indigenous species. The specific objectives are: (1) To experimentally produce communities of differing algal diversity by "gardening" large plots of the rocky shore to produce plots of 1, 2, or 4 species. (2) To measure producer biomass and productivity in communities at each level of diversity to assess the relationship between diversity and productivity within a trophic level. (3) To measure invertebrate diversity and productivity in the communities produced in (1) to assess the effects of producer diversity on higher trophic levels, including fishes and invertebrates that consume algae or use it for shelter. (4) To manipulate diversity in marine invertebrate communities to assess the relationship between diversity and the susceptibility of communities to invasion by non-indigenous species.
This project is focused on two main issues: the effects of the loss of biodiversity on the functioning of marine ecosystems, and the causes and consequences of invasion of marine systems by non-indigenous species. In experimentally assembled marine invertebrate

communities, increasing native diversity decreased the survival and final percent cover of invaders. This was apparently because increasing native diversity decreased the availability of open space, the limiting resource in this system, by buffering against fluctuations in the cover of individual species. Experimental results were consistent with field surveys, suggesting that native diversity plays a major role in determining patterns of invasion success in the field. Because these experiments identify the mechanism by which diversity increases the resistance of communities to invasion (reduced resource availability) the results should be applicable to any system in which resources are limiting. This would include many natural and agricultural plant communities that are limited by soil nutrient availability. I have also been following up on previous field work on the invasive seaweed UNDARIA PINNATIFIDA with laboratory manipulations to examine the effects of temperature and grazers on the ability of this species to complete its life cycle. Thus far, I can report that temperatures over 17 C strongly inhibit survival of fertilized 'eggs' and development of adult plants, suggesting that the species will remain restricted to colder waters along the California coast, although it could become seasonally prevalent during cold water periods in southern California. Perhaps more importantly, within colder water regions the spread may be limited by intense herbivory by a native herbivorous crab. The crab appears to recruit rapidly to new stands of UNDARIA and consume it as readily as its preferred native foods. I am coming to the conclusion that biocontrol by native species may limit the invasive potential of this species. Finally, I have been using a long-term record of weekly sessile marine invertebrate recruitment to assess the likely effect of climate change on the success and spread of introduced species. For the three most abundant introduced species at our study location, invaders arrived earlier in the season and were much more abundant overall in years with warm winters. In contrast, the timing of native recruitment was unaffected by temperature and the magnitude of recruitment decreased with increasing temperature. In manipulative laboratory experiments, two introduced species grew faster than an ecologically similar native species, but only at temperatures near the maximum observed in summer. By giving introduced species an earlier start, and increasing the magnitude of their growth and recruitment relative to natives, we suggest that global warming may facilitate a shift to dominance by non-native species, accelerating the homogenization of the global biota. Indeed, the recent acceleration in the rate of invasion of marine communities since the 1970's corresponds with a similar increase in sea surface temperatures.
Impact: Understanding the relationship between species diversity, ecosystem function and invasion resistance helps quantify tangible benefits of managing ecosystems for high local diversity. Similarly, understanding the effects of temperature variability on the biology of invasive vs. native species will help us predict the success and spread of invasive species in a changing world.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Mechanisms for the Maintenance of Biological Diversity in Arid Environments
Description: Objectives: 1) To gain a better empirical understanding of mechanisms of diversity maintenance in variable environments by fitting mathematical models to data from herbaceous plant communities in both arid and moist environments. 2) To improve theoretical understanding of diversity maintenance mechanisms through a theoretical study of the relationships between environmental factors and competition between species. 3) To generalize theoretical studies of diversity maintenance in temporally variable environments to include diversity maintenance in spatially and temporally varying environments. 4) To develop a better

empirical understanding of diversity maintenance mechanisms through experiments on germination of desert annual plants subjected to a range of weather conditions. Studies were continued on an introduced winter annual plant (ERODIUM CICUTARIUM) and its impact on the native community at a the field site in the Chihuahuan Desert, USA. These studies continue to monitor the increase of the invader and its apparent displacement of the native community of winter annual plants. Field experiments have shown that this species competes strongly with native species at the desert site and may explain their displacement. This last year, a new study of the effects of E. CICUTARIUM was begun at a coastal California site near Bodega Bay. In conjunction with these field studies, new statistical methods were developed to determine how the effects of plant competition are modified by the physical environment. These methods have now been extended to cover a range of common designs for field experiments so that they can be used broadly by researchers studying competition between plant species. In particular, these methods have shown that E. CICUTARIUM would not be found to limit itself intraspecifically if standard methods had been used. Our methods showed that proper accounting for spatial environmental variability does reveal intraspecific competition, and therefore that this species is beginning to limit its own density at our Chihuahuan Desert site. The understanding of ERODIUM CICUTARIUM's environmental requirements, and its competition with other species, should have broad application, as this species is an invader in many different habitats, especially in California. To gain a better understanding of invasive plants, research was continued on a theory of invasion resistance, and invasion impact. This work involves both theoretical models of invasions, and applications of existing theory in community ecology to the context of invasions of alien species. Given the importance of environmental variation as revealed by field studies of invasion, development of plant competition theory for variable environments was continued. Features lacking in previous work were (a) an understanding the role of variation in rainfall patterns within a year, and (b) an understanding of the interaction between spatial environmental variation and local seed dispersal. In both cases strong effects were found. Different reaction times of species to rainfall events promotes their coexistence. Also, consideration of the local nature of seed dispersal showed that large scale spatial variation in the favorability of the environment for a species is particularly important in coexistence of competing plant species. This effect of the scale of variation was not appreciated previously because the effects of localized dispersal had not been considered. Both of these findings improve understanding of the situations in a which an alien invader may successfully enter a community, and they also improve understanding of the situations where the invader is unable to eliminate native species, but instead coexists with them.
Impact: An invasive weed is having strong negative effects on native species in Arizona and California. Specific environmental conditions may limit the weed's impact. Statistical methods were developed to help better estimate the effects of different environmental conditions on the impact of an invader on native species. Theoretical models of plant competition were developed for predicting such impacts. These methods and models are being utilized to develop invasive species management plans, greatly improving their effectiveness and efficiency.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Mixed-Conifer Stand Development and Stocking Control in Even-Aged and Multiaged Stands in California
Description: This research will attempt to develop stocking assessment models to assist forest land managers with developing stocking prescriptions for complex stand structures in the mixed-

species conifer type in Northern California and the Sierra Nevada. Complex stand structures include mixed-species compositions, and more than one age class. The stocking assessment model will predict stand volume increment given various arrangements of growing space occupancy and tree densities as prescribed by a user. Leaf area index is used to represent growing space occupancy. Ultimately, this tool will provide recommended stocking guidelines for creation and manitenance of multiaged mixed-conifer stands.
GSY=6 Development of stocking guidelines for mixed-conifer stands in the Sierra and redwood stands on the north coast is coming to a conclusion and should be completed in summer of 2003. Fieldwork is completed and a light model has been developed for the Sierran forests that displays light levels at different canopy heights for forest of different structure. In redwood forests, the stocking guideline project is entering its third year of fieldwork. We anticipate a guideline on multiaged management of redwood in 2003. Our results indicate some of the highest leaf areas recorded in these productive forests. Reconstruction of forest stand development in the mixed-conifer forests in the Sierra is continuing to examine the effects of white pine blister rust on sugar pine decline. Additionally, we have begun work looking at stand development of mixed tanoak-redwood forests on the California coast. This work involves spatial patterning, historical height development, and relation to sudden oak death spread. Pruning studies in sugar pine, giant Sequoia, and coast redwood are continuing.
Impact: Traditional even-aged management is under considerable social pressure that has placed a sense of urgency on our work as both the forest products industry and land management agencies are clamoring for our guidelines. These guidelines will provide the technology to manage complex structures in the Sierra mixed-conifer and coastal redwood forest types. Our activity related to exotic pests (sudden oak death, white pine blister rust) will help in the development of suitable management for forests affected by these pathogens.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Mortality Dynamics of Insects
Description: (1) To conduct basic biological and demographic research on the medfly and other model insect species at the fruit fly factories in Tapachula, Mexico, and on the medfly in Greece; (2) To test hypotheses concerning the relationship between mortality and reproduction including whether: (i) the effects on longevity of dietary restriction and other types of dietary stress are mediated through reproduction; (ii) fruit flies enter reproductive diapause during unfavorable periods in the wild; (iii) the genes and mechanisms elevating longevity in waiting and reproductive mode are different, and possibly mutually exclusive; and (iv) the effects of nutrition and reproduction on survival rates are mediated through changes in numbers of active ovarioles, modulations of yolk protein synthesis, and changes in hormone titers. The major contributions to the scientific literature over the past year are contained in the results of two research papers. these include: (1) supine behaviour predicts time- to -death in male Mediterranean fruit flies (Papadopoulos et al. 2002). we found that 97% of the 203 male medflies monitored in a lifetime study of their behavior exhibited what we term supine behavior (temporary upside-down orientation) starting an overage of 16.1 days prior to their death (mean life span = 61.7 days). Supine onset increased moortality risk by 39.5 fold and a unit increase in supine level increased mortality by 26.3%. the discovery that behavioral traits in insects can be used as biomarkers of their health and to predict their time-to-death has important implications regarding research on morbidity dynamics, behavioral neuroethology and gerontology, and the interpretation of longevity extension in model organisms. (2) Life history response of Mediterranean fruit flies to

dietary restriction (Carey et al. 2002). The purpose of this study was to investigate changes in medfly longevity and reproduction across a broad spectrum of dietary restriction levels using a restriction methodology similar to that used in most rodent studies (i.e. dietary reduction). Age-specific reproduction and age of death were monitored in a total of 1,200 individual flies of each sex maintained on 1-of-12 different dietary doses from 100% of a `mother stock' solution used as the ad libitum baseline to a 30% dilution (near starvation). Three main results emerged. First, unlike the majority of findings from previous studies on other species, the increased longevity was not observed in any of the food restricted cohorts. Second, reproductive patterns revealed that when medfly females are given the opportunity to reproduce they do so at the expense of increased mortality even under the most harsh dietary conditions. Third, the life expectancy of DR males exceeded that for females by 40 to 90% depending on level of dietary dose. Surprisingly the greatest decrease in survival occurred for both sexes at approximately the same level of restriction even though the energetic requirements required for females to manufacture eggs do not have an obvious counterpart in males. We believe that a more nuanced and complex but also more complete picture of the life table response to dietary restriction will begin to emerge when DR studies are conducted on a wider range of species and include both sexes, larger ranges of restriction levels, and treatments which allow individuals the opportunity to mate and reproduce.
Impact: The results of the mortality studies of the medfly are useful in two contexts: (1) because the medfly continues to be a threat to California agriculture, information on the basic biology and demography of this important pest is important in mass rearing, in ecology and in developing control and eradication policy. We now have accumulated data on over 5 million medflies-the largest data set on any non-human species that has been collected under the same set of controlled conditions. (2) the medfly is now an established model system used in aging research. The results build on previous work on the biodemography of longevity and aging and thus contribute to the basic biology and demography of aging literature. We believe that the supine behavior we discovered in the medfly will provide new opportunities to use the medfly to study morbidity (as distinct from mortality) dynamics. No model system currently exists to study morbidity.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Providing the Tools to Manage Yellow Starthistle
Description: In recent years, yellow starthistle has infested much of California's rangelands and parks. Starthistle is toxic to horses and its spiny seedheads are an irritant to people. More important, yellow starthistle has profound environmental effects on watersheds. UC research has shown that it can consume as much as 66% of the water stored in the soil profile at the end of the rainy season, which greatly reduces the water flowing into streams and rivers. It also significantly inhibits desirable plant species in an infested site. UCCE studies focusing on the plant's biology were used to develop more effective integrated control strategies for landowners and agencies. Under the leadership of a UCD Weed Specialist, team research was conducted at two main locations and then replicated in counties throughout California. Work at the Davis campus included seed bank dynamics and mowing as a control method. Field applications were evaluated by his colleagues at the UC Sierra Foothill Research and Extension Center (SFREC) in Browns Valley. This included an integrated approach, using burning, tillage, herbicides and revegetation with competitive plants. The findings were presented at a starthistle field day at SFREC, sponsored by the local Weed Management Area. The information has also been widely

disseminated at annual field days and professional society meetings. Also, articles were published in California Agriculture and in an eight-page publication that succinctly captures all the information for landowners to use in making management decisions.
Impact: More than 220 landowners who have attended DANR field meetings are armed with better understanding of (1) the biology of yellow starthistle and (2) control approaches that integrate herbicide and non-chemical options. They are now able to develop programs to manage or eradicate the pest with a much greater prospect of success. Field-scale cost estimates developed at SFREC also allow them to evaluate the return on their investment in these newly-developed approaches. Three land management agencies (US Forest Service, California State Parks, and USDA Natural Resources Conservation Service) have used the research information to add fire and seeding into land management plans addressing the starthistle problem.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: The Role of Landscape Heterogeneity in Ecosystem Function
Description: Objectives: 1. Classify forest types at landscape scale based on geology, mean annual temperature, mean annual precipitation, soil texture, elevation, slope, aspect, and nutrient distribution for the Hawaiian Islands. 2. Document changes in forest cover and successional trends for a range of different aged forests. 3. Quantify the influence of forest edges on the rate of forest succession. 4. Identify and evaluate key ecosystem level parameters that are functionally significant within forest edges and influence rates of successional change. 5. Model carbon and nitrogen dynamics in these systems using a spatially explicit model that incorporates current drivers of vegetation change (cf. edge effects, biological invasions, etc.)
GSY=1. Research activities for the past year encompassed two projects that were aimed at capturing significant ecosystem level changes in Hawaiian rainforests. The first activity involved the acquisition of high resolution aerial photography to assess to the changes in forest composition between 1965 and 1992 for the Pahoa region on the Big Island of Hawaii (south and east of Hilo). Special emphasis was placed on identifying changes in canopy cover of the invasive tree species, Albezia. Preliminary results from the analysis of aerial photography show that Albezia canopy characteristics are very different from that of the dominant native tree, Metrosideros, even using black and white aerial photographs. A texture analysis performed on a subset of the photographs was 90% accurate in distinguishing Albezia dominated forests from the native dominated forests. A change detection analysis for the two periods showed a 32% increase in Albezia cover for this small subset of photos. The second research activity involved an examination of rates of forest succession in rainforests with distinctive `edge effects' versus rainforests without distinctive edges. This analysis was performed using black and white aerial photos from 1965, color aerial photographs from 1992, and color satellite imagery from 1995 for the Big Island of Hawaii. Results indicate that rates of primary succession in forests with significant edges are enhanced by as much as 40% when compared to forests without distinctive edges. The rate appears to be influenced by the shape of the lava flow as well. The more circular the flow, the more succession is enhanced by the edge effect. Evidence to date supports the hypothesis that the edge formation is nutrient and microclimate induced.
Impact: Developing an effective way to identify and map invasive tree species over large spatial scales will contribute to the development of forest management programs aimed at the eradication of these threats to native forests in Hawaii. Documenting rates of primary succession in these forests is likely to provide insight into long-term montane rainforest dynamics in the

Hawaiian Islands. Both exercises are likely to result in information which could be used for restoration of these threatened habitats.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Seedling Demography in the Sierran Mixed Conifer Forest: Determinants of Success Under a Novel Disturbance Regime
Description: The proposed research will evaluate predictions from the current theory of nonequilibrium forest dynamics and obtain the necessary information to assess the near-term future of the Sierran mixed conifer forest. The specific objective associated with these tasks are: 1) Calculate robust estimates for the survival and growth rates of juvenile trees; 2) Track the inter and intra-season survival schedule of spring germinants; 3) Determine the 'effective' reproductive output of adult trees; 4) Develop measurement based, statistical models of fine-scale heterogeneity in light availability and soil water availability; 5) Measure the species replacement probabilities; 6) Parameterize a measurement based, statistical model that predicts the performance of juvenile trees as a function of species, local density, light availability, and water availability. GSY=1. To date, this research has quantified three important trends occurring in the mixed conifer forests of the Sierra Nevada: 1) The mortality rate of adult trees in the mature, second-growth forest are two to three times higher than the rates observed for adult trees in an old-growth forest; 2) The two pine species (Pinus ponderosa and Pinus lambertiana) present in the canopy are failing to regenerate; 3) Projections for P. lambertiana (sugar pine) indicate that this economically valuable and ecologically important species is declining. Although old-growth forests share compositional and structural similarities with mature second-growth forests (80+ years since disturbance), the dynamics of the two forests differ. Overall canopy-tree mortality in the old-growth forest was 0.5%/yr. Abies concolor (white fir) had the highest rate at 0.7%/ yr. Sugar pine mortality was 0.4%/yr. In contrast, comparable white fir trees in the second-growth forest died at a rate of 1.5%/yr while sugar pine mortality exceeded 6%/yr for codominant trees. Last year we completed the fifth regeneration census in two intensively studied stands at Blodgett Research Forest in Georgetown, California. During those five years, no P. ponderosa germinant survived the first year. In contrast, the effective reproductive rate for white fir (effective reproduction is defined as the density of seedlings that survive the first year) averaged 828 seedlings/ha/yr (std = 1,622 seedlings/ha/yr). Effective reproduction for sugar pine was ten times lower, on average, than for white fir (85 seedlings/ha/yr). Throughout the Sierran mixed conifer forests, sugar pine populations are threatened by the combined effects of an exotic pathogen, Cronartium ribicola (white pine blister rust), and a novel disturbance regime, fire suppression. Thus the potential exists for a shift from a forest historically characterized by shared dominance among five conifer species to one with a clear hierarchy of importance. To evaluate the likelihood of this shift, we compared the demography of sugar pine to white fir, a co-dominant tree species immune to the pathogen and intolerant of fire. We constructed size-classified matrix models and then applied elasticity analysis to determine what vital rates were the most important components of change. During the last 30 years, survival of canopy-sized white fir averaged 0.985/yr with little variation (std = 0.005). Fecundity over the last 5 years averaged 154 germinants/canopy tree/year with a huge range (std = 266). Projected population growth rate for white fir was 1.007, indicative of a slowly growing population. In contrast, sugar pine was projected to decline with a growth rate of 0.985. Adult survival, particularly in the codominant size class, was much lower for sugar pine than white fir (0.939). Sugar pine fecundity averaged less than 10 germinants/tree/year. Changes in the sugar pine population were

extraordinarily sensitive to the survival rate of canopy trees (elasticity = 0.856). The white fir population was also sensitive to adult survival (elasticity = 0.506) but understory tree survival was another important factor (elasticity = 0.371).
Impact: This research is producing credible, quantitative insights regarding the long-term (next 30 years) impact of exotic pests and management decisions on California's Sierran conifer forests. The pine component in Sierran conifer forest is the most valuable in terms of timber. The lack of natural regeneration represents a serious ecological and economic concern.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.19 Invasive Species
Title: Yellow Starthistle Management
Description: Yellow starthistle is the most conspicuous of the noxious weeds that are a serious concern on rangelands and forestlands of California. This introduced species significantly reduces biodiversity, recreational opportunities, forage production and the value of habitat for wildlife. UC Cooperative Extension has conducted cutting edge research on various strategies to control yellow starthistle, including burning, chemical control, grazing, mowing, pulling and biological control. CE has worked with the Noxious Weed Management Groups around the state and through educational programs to teach landowners and land managers how to control yellow starthistle.
Impact: Research and educational efforts have had a significant effect on the control of yellow starthistle. In collaboration with local Weed Management Groups, these efforts have resulted in treatment of 100,000's of acres of yellow starthistle-infested range and forest land. This has significantly reduced the overall population of yellow starthistle in the state, improving forage production, increasing biodiversity and benefitting wildlife habitat and recreational opportunities.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.22 Niche Market
Title: Economic Analysis of the World Wine and Grape Economy
Description: Objectives: 1. Investigate the factors affecting the demand for wine, wine grapes, table grapes, raisins, and grape concentrate. 2. Analyze the behavior of grape growers and wineries with respect to new investment decisions: which varieties are planted, types of trellising systems used, areas in which planting occurs. 3. Analyze the behavior of grape prices in relation to supply, demand, inventory and expectations, and foreign trade developments. The U.S. is a major player in the world wine market being fourth largest behind France, Italy and Spain. Ninety percent of U.S. wine is produced in California. The world wine and grape economy is currently experiencing fundamental change. Analysis will be undertaken of the impact on growers, wineries, location and extent of planting, and growth of imports and exports. This information will be combined with previously developed material into a more comprehensive model to analyze the worldwide wine and grape economy outlook.
Impact: The impact of the contracts research was quite strong. A substantial number of grower and winery personnel attended the workshop and there are periodic requests for the publications in addition to the original distributions. Growers and wineries are intensely interested in contracts and contracts are playing an increasing role as the wine industry matures and grows. Synopses of the papers have appeared in several grower publications. The impact of CUSFTA research is useful as a documentation of the benefits of free trade. The grape price determination

should be of benefit to analysts of wine and grape industry. The research relating to industry outlook and organization should have a wide audience in view of the interest in wine and globalization of business in general. Research was undertaken four areas. First, the PI along with his colleagues conducted a survey of contract usage by California's grape growers. Very little is known about agricultural contracts in general and the grape economy in particular. The information gained related to extent of contracts, types, length, price determination, bonuses/penalties, disagreement resolution, and tenure. These results were presented at the Winegrape Outlook Workshop sponsored by the Ag Issues Center. The results were disseminated in various publications. Second, research was completed on the impact of the Canadian U.S. Free Trade Agreement on U.S. wine exports to Canada. The analysis showed that as a result of the agreement both volume and value of wine exports by the U.S. to Canada increased substantially. This increase occurred mainly because of the lessening of non-tariff trade barriers. Third, research on grape price determination was completed and submitted for publication. Results show that traditional models of supply and demand are not adequate for explaining price movements. This failure is due to the presence of contracts which are in force over several years and set prices which are to some extent independent of short-run market supply. Also, the presence of contracts was shown to diminish the impact of other market forces. Research conducted in 2002 resulted in the paper - 'Fragmentation in the California Wine Industry'. This paper was a combination of outlook information and analysis of the changes taking place in the wine industry. These changes are globalization and fragmentation. Large wineries are getting larger as they acquire more middle sized ones who are having difficulty competing. Economies of production and marketing are the main forces driving this movement. Small wineries are finding a niche through agro-tourism and sales at the winery.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.23 Organic Agriculture
Title: Economic Issues Affecting the U.S. Fruit and Vegetable System
Description: (1) To assess the evolution of Supply-Chain Management in the fruit and vegetable sector, identifying strategic organizational and marketing implications for firms and specific commodity subsectors. (2) To analyze the relative competitiveness of fruit and vegetable subsectors, either regionally, nationally, and/or globally, using new and established analytical paradigms which incorporate theories from business schools and other fields.
Case studies of federal marketing order programs for Calif. almonds and kiwifruit, and Oregon-Washington winter pears on market-ing 'organic' almonds, kiwifruit, and winter pears were prepared. Data for each study was provided by the marketing order administrative committees and cooperating organic handlers. Secondary data was used where appropriate. Organic acreage and production for market year 2001-2002 were estimated for each commodity. There were 2,959 acres of organic almonds with production of just over 3 million pounds. They accounted for only 0.56% of total Calif. almond acreage and 0.35% of total production. There were 297 acres of organic kiiwifruit, which accounted for 6.47% of California kiwifruit acreage and 6.06% of production. About 1,000 acres of organic winter pears made up 3.8% of Oregon-Washington winter pear acreage and 2.75% of production. The average per acre yields were lower for each organic commodity than comperable conventional commodity. Handlers for all three commodities view the typical organic consumer as having above average education, income, concern about health, and environmental awareness. Each expressed their customer's concerns for a quality product. One kiwifruit handler described the market evolution for organic kiwifruit as beginning with customers who were most concerned about farming practices. As consumers

became familar with organic kiwifruit, they came to appreciate the taste and were not too concerned with appearance. But now, his customers want fruit that not only tastes good but that is free from blemishes. One handler markets only his U.S. No. 1 organic kiwifruit as organic; Fruits below the No. 1 grade are sold as conventional kiwi-fruit. Handlers commented on marketing order provisions, including minimum quality standards, research, supply control, and advertising and promotion. Organic handlers tended to favor minimum quality standards for organic products. Several commented that quality conscious organic consumers are probably not interested in product that does not meet the minimum standards. The majority of organic almond and winter pear handlers had positive comments regarding production and marketing research projects funded by these two marketing orders. The reserve provisions of the almond marketing order (the only one of the three orders with supply control provisions) had very limited support from organic almond handlers. The majority of the assessments for the almond and winter pear marketing orders fund generic advertising and promotion programs. The California Kiwifruit Commission, which works jointly with the kiwifruit marketing order, also funds generic advertising and promotion for kiwifruit. Most of the organic handlers for almonds, kiwifruit and winter pears who offered comments, believe the market for organic product is separate from the conventional commodity. They believe the organic product they market is clearly superior to the conventional product. Thus, though the marketing order advertising and promotion may have increased demand for the conventional commodity, the majority of organic handlers believe the impact on organic products is indirect and limited, at best.
Impact: Comparative acreage and production data for these three organic crops has not been previously available. Organic customers' increasing emphasis on quality and the sale of organic products in conventional markets has important implications for organic producers. Marketing considerations will become much more important as organic production expands.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AL, CA, DE, FL, GA, ID, KY, LA, ME, MI, MS, NC, NJ, NYC, OK, PA, TN, WA, NFAPP, USDA/ARS

Theme: 1.23 Organic Agriculture
Title: Organic Apple Industry in California
Description: In the late 1980's and through most of the 1990's, California had about 15,000 acres in apples and ranked second only to Washington State. Due to strong market competition and low prices since that time, acreage has been on a steady decline--except in organic production. Many California growers wanted to take advantage of higher prices and brisk demand for organically produced apples. Unfortunately, they have had to contend with huge losses from diseases like apple scab and powdery mildew as well as insects such as codling moth and aphids. In years with wet spring rains, apple scab caused a complete loss of blossoms and fruit. In some years, worm-infested apples caused by codling moths resulted in as much as 90% damage in untreated orchards. Aphids and powdery mildew were secondary pests, but under certain conditions could decimate production in orchards where conventional pesticides were not used. In 1990, several UC researchers across the state began to study an organic production system model for apples. They concentrated on use of new pheromone confusion technology for codling moth control. They also refined old systems for the use of various minerals, soaps, oils and resistant varieties for control of diseases and aphids that were limiting organic production. Many trials were conducted to evaluate the effectiveness of organically approved calcium materials for the control of bitter pit; for various types of mulches and cultivation to control weeds; for the use of biological control methods; and for meeting the crop's nutritional requirements with compost and cover crops. Scientific research was also conducted for the evaluation of new disease

resistant varieties and their economic potential in the organic market. After 10 years of work, the organic apple production system was well documented in the DANR publication # 3403 - Organic Apple Production Manual. Several short courses and field meetings were conducted throughout the state to present the results of the UC research to growers.
Impact: Growers now have a well-documented, successful organic apple production system based primarily on UC's years of research. They can grow apples organically using new disease-resistant varieties with good flavor and a high demand in the market. The organic pest control strategy has eliminated the use of all conventional pesticide materials. The fertility program using compost and cover crops can supply all the needs of an organic apple orchard at a relatively low cost. More growers have been able to remain in business with a specialty organic product during a period of worldwide overproduction of apples. They have been able to switch to an organic system without risking significant crop losses and with only a slightly higher cost of production. Organic apples still receive a premium in the market, with a price that is 2 to 3 time higher than conventional apples.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.23 Organic Agriculture
Title: Organic Controls for Walnut Husk Fly Developed
Description: In the Central Coast, walnut husk fly has been a major roadblock to converting conventional walnut orchards to organic production. (Gross returns are as much as 50% higher for organic walnuts.) Husk fly damage can approach 100% in unsprayed orchards but no effective organic controls have previously been available. Other pests such as walnut blight and codling moth already have adequate organic controls. Two new management tools for the control of walnut husk fly have been developed by a San Benito County farm advisor and a UC Berkeley Extension Specialist. Surround (kaolin) is a clay-based material that is sprayed on trees, turning them white. Besides providing walnut husk fly control, it may also reduce sunburn and induce earlier harvest. It is currently registered as an organic material. Spinosad is a microbial by-product that acts as an insecticide and has provided excellent walnut husk fly control when mixed with a bait. It has received organic registration for use on the husk fly in a fruit-fly bait, and organic registration as a separate insecticide is expected. Testing of organically-acceptable materials by UCCE began in the Central Coast in the mid-1990's in response to local industry requests. Tests showed that available insecticides and other control techniques such as mass-trapping were ineffective. In 2000, the first tests of spinosad were conducted in San Benito County. In 2001, expanded tests showed excellent control of husk fly when spinosad was combined with a bait. Further tests were conducted in 2002 in other locations. The researchers worked with Dow AgroSciences to pursue organic registration for spinosad. In 2001, the first tests utilizing Surround were conducted in San Benito County. An extensive test in 2002 showed efficacy if spray coverage was adequate. Surround is already registered as organically acceptable treatment. Results of both research projects were presented to the industry at local meetings and in the Walnut Research Reports published by the Walnut Marketing Board.
Impact: More walnut growers in California's Central Coast already have or are planning to convert to organic production because organic walnut husk fly controls developed by UCCE are available. Walnut growers in the Central Coast have a competitive advantage because of very high quality and less codling moth damage than many other growing regions in California. However, they suffer from lower yields and higher land and production costs compared to the Central Valley. Conversion to organic production helps to maintain a walnut industry in an area that has been increasingly converted to houses or row crops. Although walnut production

already is a relatively "clean" agricultural industry, reduced impacts on the environment such as less ground water contamination by nitrates and pesticides, reduced pesticide runoff to the Monterey Bay Marine Sanctuary, and increased farm worker safety also are potential benefits of conversion to organic production.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.25 Plant Genomics
Title: The Citrus Clonal Protection Program
Description: Objectives: 1) To provide the citrus industry and citrus researchers with a primary source of all important fruit and rootstock varieties maintained as protected Foundation Trees that are routinely tested for all known bud transmitted diseases and are evaluated for the presence of budsports, chimeras and other undesirable spontaneous genetic disorders. 2) To provide a safe mechanism for the introduction of citrus varieties from any citrus growing area of the world, for the purposes of research, variety improvement or for the direct propagation and use in California's commercial citrus industry. 3) To determine the etiologic agents of and to develop and evaluate new diagnostic techniques for the variety of bud transmissible diseases of citrus that include but are not limited to virus, viroid and prokaryote diseases. 4) To make the information about available varieties generated by this project available to researchers and citrus growers through the CCPP website: www.ccpp.ucr.edu In June of 2002 the CCPP completed the VI Index on 15 new citrus varieties This is a test for all the known bud transmitted diseases affecting citrus. These new varieties will be released from quarantine and placed in the CCPP Foundation Plantings for evaluation and possible future release for commercial and research purposes. The varieties included two blood oranges, two sweet limes, one lemon, one sweet orange, one tangelo, one tangor, one kumquat and six mandarins. All of these varieties may be of commercial value and will require additional field evaluation. The CCPP now has 128 varieties of citrus still in quarantine. During the period covered by this report the CCPP received 31 new introductions that have begun the testing and cleanup process. Once again all of the citrus on the Lindcove Research and Extension Center (LREC) was tested for tristeza. All trees in the Foundation-Evaluation Block once again tested negative for the virus. The 30,000+ square foot addition to the CCPP LREC Screenhouse that houses the CCPP Protected Foundation Block was completed with an irrigation system and 100 of the most popular CCPP varieties were planted in the new screenhouse, directly in the ground, and are spaced so that budwood production will be similar to that of field grown trees. These trees are now growing well, and will allow the CCPP to begin discarding container grown trees of these varieties, thus freeing up some space to house new varieties in the protected environment. The CCPP will begin to repropagate the container grown varieties and rotate new young trees into the screenhouse. The small screenhouse that the CCPP had been using for a number of years was moved to the new site adjacent to our large screenhouse and now houses the source trees of the growth modifying Tsn-RNA's. This past fall, winter and spring we again evaluated fruit from our registered trees. The data from these evaluations were averaged into previous evaluation data and were posted on the CCPP Website (www.ccpp.ucr.edu). Once again this past year we were able to add a number of new images to the website and to improve on the quality of some previous images.
Impact: Continued availability of disease tested propagation material from the CCPP is essential for the variety of research projects conducted by the University and it is extremely important for the protection of California's citrus industry. Maintaining California in the forefront of high quality fruit production demands the newest varieties and the highest quality propagation material.

Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.25 Plant Genomics
Title: Defense-Response Genes: Roles in Insect Infestation and Pathogen Invasion
Description: There are two main goals of this project. This project will investigate the role(s) of the tomato leucine aminopeptidase (LAP-A) in the plant defense response. This wound-induced exopeptidase appears to have a regulatory role in the Solanaceous wound-response. The specific objectives are to determine (1) the impact of LAP-A down-regulation and over-expression in the plant defense response by monitoring a variety of JA-dependent and ?independent wound-response genes; (2)if LAP-A protein antagonizes insect growth and development; (3)the location of LAP-A in tomato cells. Second goal of this project will to further our understanding of the changes in plant gene expression in response to phloem-feeding insects. We propose to study two squash genes (SLW1 and SLW3) that are preferentially induced by silverleaf whitefly nymphs. In addition, novel genes induced in plant-whitefly interactions will be identified using the model plant Arabidopsis. The specific objectives are to (1)determine the enzymatic specificity of SLW1 and SLW3, which should enable us to determine likely roles of these enzymes in plant development or defense; (2)construct and evaluate SLW:GUS plants as reporters for signals generated during development, whitefly feeding and water-deficit stress; (3)use SLW3:GUS plants in a novel bioassay to identify elicitors in whitefly saliva; (4)identify elicitor-responsive DNA sequences in the SLW3 promoter; (5)determine impact of SLW1 and SLW3 ectopic expression on pests, pathogens and developmental disorders; (6)determine the magnitude of changes in Arabidopsis gene expression in response to whitefly feeding.
The mechanisms of LAP-A action was investigated by analyzing substitution mutations that altered residues important for coordinating zinc ions and catalysis. A model to explain the partial and unanticipated activity of the D347E mutant was proposed. The expression of LapA and pathogenesis related proteins genes in response to Phytophthora parasitica infection and elevated carbon dioxide levels was investigated. We have begun to unravel the role of aminopeptidases and transferases, which modify the N-terminus of proteins, in Arabidopsis growth, development and responses to abiotic and biotic stress. To understand changes in gene expression in response to phloem feeding insects, squash responses to the silverleaf and sweetpotato whiteflies were determined. SLW1 and SLW3 are genes that are preferentially induced systemically by the silverleaf whitefly. SLW1 encodes a M20b peptidase and SLW3 encodes a b-glucosidase. SLW1 is regulated by jasmonic acid, while SLW3 is modulated by an unknown defense signal. In a collaborative project with Dr. Elizabeth Bray, we identified an effective method for isolating RNA from chili pepper plants.
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 us to develop 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: 1.25 Plant Genomics
Title: Evaluating Competitive Traits in Rice Cultivars and Potential Improvements in Weed Control

Description: Our objectives are 1) to determine the utility of competitive cultivars in significantly reducing weeds and weed seed production in water-seeded rice and 2) to identify traits for breeders that will improve the competitive ability of rice. To accomplish our goals, we propose a combination of field experiments linked with simulation modeling. The field experiments will allow us to assess phenotypical differences, including root growth, among cultivars adapted to grow under continuously flooded temperate conditions. The field experiments will also provide data for the modification, parameterization and validation of a simulation model, based on DSRICE, to include a root competition sector.
Research on competitive cultivars progressed on two fronts which have been carried on simultaneously. Experimental tests of vigor in rice and its translation into traits associated with competitive suppression of weeds were carried out in field plantings over both years. We used a variety of rice cultivars, from old tall varieties to modern short-statured ones in association with watergrass, Echinochloa spp. We showed that the properties of rice growth did not require an obligate tradeoff between grain production and vegetative biomass. Some modern short cultivars were at least as competitive as taller ones. The data from both years were characterized by large variation, which has illustrated that competitive impacts are based on multivariate interactions, i.e., no single trait was highly associated with competitive suppression over a wide range of circumstances. The other approach was based on smaller mechanistic experiments using a variety of ecophysiological and numerical measurements. Less comprehensive in design but more directed towards particular hypotheses, these have proven to be more productive and ultimately more promising, although not yet finished. We have confirmed that competition for light remains important, but the major discovery associated with this grant has been the emerging importance of rhizosphere interactions, especially early in the establishment of the stand. Early growth is vital to competitive impact, and such tools as delayed fertilization and deeper water are useful in manipulating the competitive advantage of rice. Furthermore, we have evidence for the importance of certain interactions, such as light times nitrogen, which cause both weeds and rice to react to by changing biomass allocation and resource procurement priorities. This research has confirmed the multivariate model and the importance of plasticity in plant growth. In the near future, we have learned that we must more fully investigate the importance of root-shoot interactions in early growth to understand the process of competitive displacement in crop stands. In turn, that has underlined the importance of a simulation model that can utilize and guide a maze of research that this work has opened.
Impact: The process of breeding competitive cultivars has turned out to be far more complex than we thought it would be. Far from solving the problem and turning over a list of traits to the rice breeders, we have discovered that the core problems of root-shoot interactions and phenotypic plasticity have hardly been investigated.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.25 Plant Genomics
Title: Genetics, Breeding, and Evaluation of Citrus Fruits
Description: Objectives: 1) Continue breeding and evaluation of hybrids and possible mutants in order to select new citrus cultivars for California. 2)Manage, further characterize, and establish direction for the UCR Citrus Variety Collection and Citrus Evaluation Blocks and utilize these collections to provide performance data for selected citrus cultivars; develop methods to identify citrus cultivars; provide extension activities to disseminate information on citrus and citrus relatives to the citrus industry and the public. 3) Create genetic maps of citrus scion breeding populations that can be used to develop marker-aided selection approaches and

isolate genes that influence various traits. 4) Develop improved citrus cultivars by transformation with genes derived from citrus or other species. 5) Analyze the organization and expression of the citrus genome. Evaluation of yield and fruit quality of Gold Nugget (released in 1999) and several other mandarins continued. Three new seedless, late season mandarin cultivars, Shasta Gold-TM (TDE2), Tahoe Gold-TM (TDE3), and Yosemite Gold-TM (TDE4) were released. Low-seeded forms of Fairchild, Nova, Daisy and several other mandarins were identified by selection among trees propagated from irradiated budwood. These selections are being propagated for wider testing to evaluate stability, seediness, productivity when isolated from other cultivars, and other horticultural traits. Hybridization to develop new low-seeded triploid mandarin and low-acid grapefruit types continued. Simple sequence repeat (SSR) markers were used to study genetic diversity in over 400 accessions from the University of California, Riverside Citrus Variety Collection. Development and scoring of SSR markers is complete and data analysis is in progress. Alleles of several SSR markers were cloned and sequenced to determine whether a stepwise or infinite allele model is more appropriate for analysis of this dataset. About 20 new SSR markers were developed from citrus genomic DNA libraries enriched for simple sequence repeats. Additional seedling populations were screened with inter-simple sequence repeat markers to identify genotypes with high priority for inclusion in germplasm collections. These markers were useful for identifying apomictic seedlings that are genetically identical to each other. Only a single seedling of each nucellar type will be retained for the citrus germplasm collection.
Impact: Development of new citrus cultivars can provide growers with additional market opportunities and consumers with better tasting, more attractive, low-seeded fruit. Development of cultivars with improved pest and disease resistance can reduce production costs and reduce the need for use environmentally damaging chemicals.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.25 Plant Genomics
Title: Mechanism of Resistance to Root-Knot Nematodes in Tomato
Description: Objectives: 1. To characterize the mutants (rme2, rme3, rme4 and rme5) 2. To map and clone Rme1 3. To study the gene induction in the Mi-1-mediated resistance pathway to both nematodes and aphid using microarray technology. We continue our work towards understanding how the tomato gene MI-1 confers resistance against 3 species of root-knot nematodes(MELOIDOGYNE SPP.) and to the potato aphid (MACROSIPHUM EUPHORBIAE). We have identified a new member in the Mi-mediated pathway to both organisms. In addition, we have fine-mapped a novel root-knot nematode resistance gene to the short arm of chromosome 6 of tomato. While the MI-1 mediated resistance is heat-sensitive (breaks down above 28 C), the resistance mediated by the novel gene is heat stable (at 32 C).
Impact: Nematodes are serious pest of tomato. Identifying and characterizing novel sources of resistance is crucial for the tomato industry. Understanding how resistant gene work will enable us to engineer durable resistance.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.25 Plant Genomics
Title: Molecular Genetic Improvement of Fruit Quality
Description: 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 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 and 3) develop strategies to access a broader range of intellectual properties for applications to horticultural crops. 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 has identified genetic sources of elevated antioxidant levels and ascorbate levels from a wild relative of tomato, Lycopersicon pennellii, and localized those traits to specific chromosomal locations. This research is now seeking to identify what genes are encoded at these chromosomal loci and to further evaluate the potential to introgress these traits into tomato for enhanced human nutrition. Research has also evaluated the impact of simultaneously suppressing the expression of an expansin and a polygalacturonase gene on fruit texture, using transgenic plants. The results of these experiments indicate that eliminating the activities encoded by these two genes in ripening fruit has a positive impact on both fresh and processing tomatoes. A non-transgenic approach to deploy traits that improve fruit quality has been initiated by preliminary research to produce a deletion mutant population of tomato using fast neutron mutagenesis. Tomato seeds were irradiated with several doses of fast neutron irradiation and examined for reduced germination as a meant to assess mutation efficacy. During the next year, tomato populations will be grown and subjected to molecular analysis for the detection of deletion mutations. A project to establish an agricultural biotechnology intellectual property clearinghouse for the public sector has been initiated. This project is collaborative with 12 major universities and public sector research institutions and is using a survey system to aggregate information on public sector intellectual property and its licensing status. This information will be deployed as an integrated database available for searching by the public sector members and by potential licensees. The goal of the clearinghouse is to make intellectual property in agricultural biotechnology more widely available for both commercial and humanitarian uses.
Impact: Information on genetic determinants of fruit quality will assist breeding programs to enhance consumer quality. The development of non-transgenic approaches to deploy novel traits will provide the means to deliver genome-based traits to breeding programs, particularly in specialty crops, which are currently unable to utilize transgenic traits.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.25 Plant Genomics
Title: Positional Cloning and Analysis of the Citrus Tristeza Virus Resistance Gene
Description: The overall objective of this project is to use positional cloning methods to isolate a dominant gene (Ctv) that causes resistance to citrus tristeza virus (CTV) in its source, Poncirus trifoliata and in Citrus x Poncirus hybrids and backcrosses. The gene will then be transformed into CTV susceptible citrus cultivars to produce virus-resistant plants. The gene has been localized to a 300 kb region covered by four BAC clones. Specific objectives during the next two years are: 1) to genotype additional progeny and identify new markers closer to Ctv so as to further delimit the region that must contain Ctv; 2) to complete the sequencing of the contig; 3) to continue to identify candidate genes and transform them into CTV-susceptible citrus genotypes and; 4) to initiate tests for resistance of transformed plants. In order to further refine the location of Ctv, we studied markers in 430 progeny from several crosses, and found only

three with potentially informative recombination events near the resistance gene. Analysis of the CTV resistance of these progeny is in progress. We also developed new SSR markers in the CTV region and used these to delimit Ctv to a 173 kb region. Four BAC clones covering a 282 kb region surrounding the Ctv gene were sequenced to 7.8X coverage and the sequence was assembled and annotated. This region was predicted to contain 22 genes, including seven CC-NBS-LRR class disease resistance genes. Six other predicted genes have homology to other plant genes. The region also included 61 simple sequence repeats (SSRs), 8 retrotransposons and 2 transposons. Nine candidate genes, including four R genes are located in the region defined by marker mapping as containing Ctv. The putative amino acid sequences of the seven R genes found in this region have 69-84% identity, and are more closely related to each other than to other R genes in sequence databases. Two are apparently pseudogenes, and we have demonstrated expression of three of them by RT-PCR. Six other genes from the 282 kb region were confirmed by either isolation of corresponding cDNA clones or Northern hybridization. Northern blot analysis of six genes in leaf and bark tissue of CTV resistant and susceptible genotypes did not reveal differences in expression. Sequences of the partial coding regions of the resistant and susceptible alleles of several R genes were identical, indicating that if these genes correspond to Ctv, the alleles must differ in expression or in regions not yet sequenced. For two other R genes, the resistant and susceptible alleles differ in sequence, but additional analysis is needed to determine whether any of these differences affect function. Identification of Ctv will require transformation of the candidate gene into a susceptible cultivar, and a demonstration that such plants are resistant to CTV. Toward this end, we produced more than 30 grapefruit plants transformed with 24-56 kb inserts from BAC clones in the Ctv region. Transformants are being propagated and some plants will be ready for virus resistance testing in 2003. Constructs with smaller inserts containing one or two genes from the target region have also been developed and transformed into grapefruit stem segments. Many apparently transformed (GUS-positive) shoots have been identified and are being propagated for additional testing. Overall, these transformation experiments will test all genes in the region defined by markers as containing Ctv.

Impact: We have made substantial progress toward identification and isolation of a gene that confers resistance to citrus tristeza virus, a potentially severe viral disease of citrus. We sequenced the region containing this gene, identified candidate genes, and began experiments to prove which gene confers virus resistance. Final isolation of this gene will permit development of transgenic citrus varieties that are resistant to this disease.

Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm

Title: The Characterization and Exploitation of Molecular Diversity in Plants

Description: Objectives: 1) Continue the characterization of molecular diversity in selected crop plants; 2) Develop microsatellite markers for mapping and analysis of the avocado genome; 3) Use molecular markers to address practical issues in avocado management and improvement. Research in our laboratory continues to have three main foci: (1) analyses of molecular genetic diversity within wild and cultivated barley; (2) investigations of the joint evolution of flavonoid genes and floral color phenotype in morning glory genus (Ipomoea); and (3) the development of molecular markers for avocado improvement. With respect to topic 1 we have characterized DNA sequence diversity at six genetic loci in addition to our previous work with the triplicate adh loci. The data reveal surprisingly high rates of intragenic recombination, low levels of linkage disequilibrium and relatively high migration rates across the geographic range of wild

barley (Morrell et al., in preparation). Our work on topic 2 has focused on an analysis of gene expression patterns among various Ipomoea species for flavonoid biosynthesis genes. The ultimate goal is to identify the genes that are responsible for shifts in floral color among different species of Ipomoea. We have characterized expression differences among eight Ipomoea species for four genetic loci (Clegg and Durbin, 2003; Durbin et al., 2003). The results implicate regulatory gene evolution as the primary cause of adaptive shifts in floral color patterns. With respect to topic 3, we have developed more than 80 good microsatellite markers for use in avocado improvement. These markers are being applied to QTL mapping of important traits in experimental populations of avocado.
Impact: The analysis of nucleotide sequence diversity within barley is important in understanding crop plant origins and in the design of germplasm conservation programs. Our work on floral phenotypic evolution is aimed at connecting phenotypic and molecular levels of evolution. Our work on avocado genetic markers should lead to accelerated rates of improvement of this fruit crop species.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Chilling Tolerance in Wild and Cultivated Tomatoes
Description: We will develop near-isogenic lines (NILs) of tomato that differ for allelic combinations at the quantitative trait locus (QTL) on Chromosome 9 associated with shoot wilting under chilling and that on Chromosome 7 associated with recovery from shoot wilting under chilling. We shall conduct additional screening of the BC1 population to affirm a QTL associated with root NH4+ absorption and develop appropriate NIL. These NILs should serve like temperature-sensitive mutants in identifying key components of plant NH4+ and H2O transport and, thus, advance the study of these vital processes. We will test the following hypotheses: *Chilling tolerance of tomato depends in part on the chilling tolerance of NH4+ absorption and turgor maintenance. *Chilling causes a dramatic reduction of the root hydraulic conductance. Immediate recovery of shoot turgor results from stomatal closure, but the recovery of hydraulic conductance requires many hours. *Diminished water transport to the shoot at chilling temperatures affects long-distance solute transport in the xylem that, in turn, contributes to a severe inhibition of shoot growth. *Tomato NH4+ absorption is independent of water movement. This research will bring together unique genetic material and novel instrumentation to address fundamental issues in stress tolerance and transport physiology, as well as improve the chilling tolerance of crop plants. The shoots of cultivated tomato (Lycopersicon esculentum) wilt if their roots are exposed to chilling temperatures of around 5 degree C. Under the same treatment, a chilling-tolerant congener (L. hirsutum) maintains shoot turgor. This trait, when mapped in an interspecific backcross (BC1) population of 196 plants, was associated with quantitative trait loci (QTLs) on seven chromosomes. Plants (BC1S1) with the L. hirsutum allele at the QTL on chromosome 9 grew faster after a chilling episode, suggesting that this QTL confers overall chilling tolerance. We have established the physiological basis for this response. Root hydraulic conductance in both species declines severely as root temperatures fall. Despite diminished water flow from the roots, cultivated tomato keeps its stomata open and transpires unabated until its leaves lose so much water that they become flaccid and suffer permanent damage. By contrast, L. hirsutum closes its stomata as water flow from the roots diminishes, and its leaf water potential remains relatively constant during a chilling episode. Grafts between the shoots of one genotype and the roots of another demonstrate that this response has distinct shoot and root components.

Impact: This project involves a collaborative effort among biologists with expertise in molecular genetic mapping, marker-assisted selection, quantitative genetics, root physiology, water relations, and biomechanics. Our results will provide insights about the chilling tolerance and water relations of crop plants and their wild relatives.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Citrus Program Protects Health of State's Trees
Description: California citrus growers often want to import foreign citrus varieties to develop new product lines and extend growing seasons. To protect the state citrus industry from devastating diseases, all foreign budwood entering California must go through an official inspection service, which will quarantine, test, and, if necessary, cleanse the citrus tissues to ensure that they contain no pathogens. Also to protect the industry, the state requires that nurseries and commercial growers propagate new trees either from their own state-registered trees or from budwood increase blocks grown from buds from a registered source.
The Citrus Clonal Protection Program at the University of California, Riverside has operated since 1958 to import citrus varieties and to maintain a collection of true-to-type, disease-free registered trees that serve as the primary source of budwood for the state's nurseries and commercial growers. The program holds one of only two federal permits in the western United States for the importation of foreign budwood, and it assisted the second agency, the USDA National Clonal Germplasm Repository for Citrus & Dates, also located in Riverside, to obtain its permit in 2002.
Impact: California, with a $800-million-a-year citrus industry, has the lowest disease incidence and the highest fruit quality of any citrus-producing area of the world. While a large part of the credit belongs to the state Department of Food and Agriculture for enforcement of regulations, the Citrus Clonal Protection Program also has served a significant role in ensuring that the state industry has a reliable disease-free source of budwood. It maintains more than 1,000 trees at the UC Lindcove Research & Extension Center as budwood sources, and it routinely quarantines and cleans diseased foreign budwood. During the past five years alone, the CCPP has released 69 new varieties--including the popular Cara Cara navel and several Clementine tangerine varieties--and sold more than 110,000 buds.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Citrus Variety Collection
Description: The citrus industry in California is a three-quarter-billion-dollar industry, placing citrus in the top 10 of California crops. Oranges, lemons and grapefruit are also individually among the top 30 of California export crops. To sustain this level of productivity and competitiveness, UC breeders and researchers and the citrus industry must have access to collections of citrus genetic resources. The UC Riverside Citrus Variety Collection (CVC), established in 1909, is one of the most extensive collections of citrus diversity in the world. This living collection encompasses two trees of each of the approximately 900 different types of citrus and related types within 28 genera of the subfamily Aurantiodeae in the Rutaceae family. Approximately 640 of the types are in the sub-genus Citrus, which contains the citrus varieties commonly consumed. These include sweet oranges, sour oranges, mandarins or tangerines, lemons, limes, grapefruits, pummelos and citrons. The collection's diversity is manifested

visually with fruits of unusual shapes, sizes and colors growing on trees of varying heights, forms and foliage characteristics. Fruit vary considerably in the chemical compounds of the rind and flesh, producing differences in nutriphytochemicals, taste, texture and aroma. Underlying all of this visible and tangible diversity is genetic diversity. Genes can be manipulated, combined and transferred to improve taste or disease and environmental tolerance, or to develop new food and horticultural crops.
Impact: The range of diversity within the collection creates a priceless resource for research. Currently, the collection serves approximately 40 research projects covering a range of topics including citrus breeding; the study of the biological activities of citrus limonoids as anticancer agents; characterization of the different types for commercially important traits such as disease resistance/susceptibility; and the isolation, mapping and transferring of specific genes. In addition, the USDA-ARS National Clonal Germplasm Repository for Citrus and Dates in Riverside uses the collection as its field site to fulfill its mission to acquire, preserve, distribute and evaluate genetic diversity. The CVC is the major source of observations documented on the National USDA GRIN database, available for the public on the Internet. Beyond the research mission, the Citrus Variety Collection serves as a resource for many extension activities. Industry representatives visit the collection to evaluate potential commercial varieties. The collection itself serves as a source of citrus for numerous fruit displays; for teaching at UCR and local schools; and for the Riverside Orange Blossom Festival, which has provided samples to approximately 30,000 people annually for the past eight years.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Combining Chilling Tolerance at Emergence without Heat Tolerance at Flowering
Description: Test whether it is possible to breed cowpea lines that have both chilling tolerance during emergence and heat tolerance during reproductive development, and whether genes that influence membrane function at one temperature extreme also influence membrane function at another temperature extreme. Warm-season annual crops such as cowpea, cotton and soybean can be damaged by both chilling temperatures during emergence and high night temperatures during reproductive development when grown in subtropical zones. We had hypothesized that chilling tolerance during emergence in cowpea is conferred by a dehydrin protein under dominant nuclear inheritance and an additive maternal effect associated with slower electrolyte leakage from seeds during imbibition of chilling water. By backcrossing we developed near-isogenic lines with and without the dehydrin in two maternal cytoplasms. We confirmed that presence of the dehydrin confers chilling tolerance during emergence under dominant nuclear inheritance. We purified the dehydrin and showed that allelic differences in the dehydrin structural gene map to the same position as the dehydrin protein presence/absence trait. However, nucleotide sequence differences in the coding region may not be responsible for trait expression since seed of both genotypes produced abundant dehydrin mRNA. The protein is translated from the mRNA of only one of the alleles. Control of translation may be determined by allelic differences in the 5' untranslated region that is upstream of the protein coding region. The slow electrolyte leakage from seed we had shown to be a maternal effect by using reciprocal hybrids was shown to have nuclear rather than cytoplasmic inheritance by using advanced generations. We bred cowpea lines that have both chilling tolerance during emergence and heat tolerance during reproductive development. Lines with reproductive-stage heat tolerance also had slower leaf-electrolyte-leakage under heat stress and thus greater membrane thermostability. We crossed a heat-sensitive cultivar that has rapid leaf-electrolyte-leakage with a line that has

reproductive-stage heat tolerance and slower leaf-electrolyte-leakage. The heat-tolerant line has similar genetic background in that it had been developed by two cycles of backcrossing to the heat-sensitive cultivar. After making the third backcross we divergently selected the progeny for either slow and fast leaf-electrolyte-leakage under heat stress or abundant and no pod set under hot field conditions developing four populations. The two sets of traits were closely related in that lines selected for slow leaf-electrolyte-leakage under heat stress also had high pod set under hot conditions, and lines selected for high pod set under hot conditions also had slow leaf-electrolyte-leakage under heat stress. Inheritance of leaf-electrolyte-leakage and associations with pod set and grain yield under hot conditions were determined. Indirect selection for heat tolerance during pod set using slow leaf-electrolyte-leakage under heat stress was shown to have similar low realized heritability as direct selection for heat tolerance during pod set (0.26). A procedure was developed for more efficient breeding of heat-resistant cowpeas consisting of screening for high pod set with plants grown under very hot field conditions in the summer and slow leaf-electrolyte-leakage under heat stress with plants grown under optimal temperatures in glasshouses during the off season.
Impact: We have developed more efficient procedures for breeding warm-season annual crops that have both chilling tolerance during emergence and heat tolerance during reproductive development. Cultivars bred using these procedures would have higher and more stable productivity in subtropical zones.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Control of Cellular Processes During Embryogenesis and Postgerminative Growth in Higher Plants
Description: The major goal of this project is to understand the cellular processes that underlie events that occur during embryogenesis and postgerminative development. To this end, I propose the following. First, I will analyze embryo lethal mutations of Arabidopsis that define genes required for embryogenesis. I will isolate the genes and determine the function of the gene products during embryogenesis. Second, I will study the regulation of genes encoding isocitrate lyase and malate synthase to understand regulatory processes that operate during postgerminative growth. Third, I will identify genes required for peroxisome assembly. During embryogenesis, the single-celled zygote undergoes a series of differentiation events that establishes the plant body and allows the mature embryo to enter into a state of metabolic and developmental quiescence until conditions are favorable for germination. Much is becoming known about the events that occur during embryo development, but little is known of the molecular mechanisms involved. A major goal of my experiment station project is to define the mechanisms that regulate embryo development in higher plants. During this reporting period, we have focused on analyzing genes involved in embryo development in the model plant Arabidopsis thaliana. In one project, we are studying LEAFY COTYLEDON1, a HAP3 subunit of the CCAAT binding transcription factor, that plays a critical role in controlling embryo development. LEC1 is required for many aspects of embryo development, and ectopic expression of the gene is sufficient to induce embryo development in vegetative cells. By analyzing the function of mutated versions of the LEC1 gene, we have shown that it encodes a novel class of HAP3 subunit. Specifically, we have identified amino acid residues that are necessary for LEC1 to function in embryogenesis. These studies provide insight into the mechanisms that allow cells to become competent to undergo embryo development in plants.

Impact: Improving crops by manipulating embryo and seed development is of obvious relevance to the mission of the Agricultural Experiment Station. Seeds are an economically important part of crops and seed yield has important implications for crop productivity. Identification and analysis of genes required for embryo and seed development will provide useful tools for the design of strategies to improve crop plants.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Develop Cowpea Cultivars for Semiarid Zones & Improved Understanding of Plant Resistance to Stresses
Description: Breed cowpea cultivars for California that can be grown without requiring pesticides (except for herbicides), and have higher yield potential under short- and long-season conditions, heat tolerance at flowering, and chilling tolerance at emergence.
Cowpea cultivar California Blackeye No. 27 (CB27) was bred for use in California. CB27 was approved for release by the California Crop Improvement Association in May 1999, registered in Crop Science, May-June issue 2000 (Reg. No. CV-167, PI 608035) and given plant variety protection, title V (Certificate No. 200000183) in October 16, 2000. CB27 is a semidwarf cowpea cultivar and produces greater grain yields than standard-height lines at narrow row spacing in soil conditions that promote moderate to vigorous early plant growth. CB27 has heat tolerance during reproductive development and produces greater grain yields than current cultivars grown in California when weather is hot at flowering. CB27 has greater resistance to root-knot nematodes and Fusarium wilt than current California cultivars. Cowpea cultivar Ein El Gazal was bred for use in the Sahelian zone of Africa. Ein El Gazal was registered in Crop Science, September-October issue 2002 (Reg. No. CV-199, PI 619432). Ein El Gazal is extremely early and adapted to drought. In the Sahel in Senegal, it has produced 1091 kg/ha of grain in a short growing season of 55 days with only 181 mm of rain, sandy soil that was dry at the beginning of the season, and high evaporative demands. In seven annual trials in the Sahel in Sudan with average rainfall of only 285 mm, Ein El Gazal produced an average grain yield of 596 kg/ha while the best local landrace only produced 215 kg/ha. We established that the traits we are incorporating to enhance heat tolerance during reproductive development also cause dwarfing and increase harvest index. Our empirical studies and theoretical analyses indicated that the reproductive-stage heat-tolerance traits also could enhance cowpea yield responses to future increases in atmospheric carbon dioxide concentration. We demonstrated by backcross genetic studies that a specific dehydrin protein in the seed of cowpea enhances chilling tolerance during emergence. We purified the protein and cloned and mapped the structural gene responsible for its production. We established that only 3 out of 61 US cowpea cultivars have this dehydrin protein in their seed. This indicates that the chilling tolerance of many US cultivars could be enhanced by incorporating the gene responsible for producing this dehydrin in their seed, and we have developed efficient breeding procedures for doing this. UC is pursing a utility patent (Case No. 1999-381-1) based on the concept that this specific protein confers chilling tolerance during emergence. We have contributed to the development of a genetic-linkage map for cowpea that combines AFLP, RFLP, RAPD, biochemical markers and disease and pest resistance traits. This map provides an opportunity for developing indirect DNA-marker-assisted selection procedures to enhance the efficiency of cowpea breeding. We have discovered a cowpea source of broad-based resistance to root-knot nematodes that is even stronger than that in CB27. We have discovered that certain cowpea accessions have strong adult-plant resistance to the biotypes of cowpea aphid occurring in California.

Impact: Cowpea cultivar CB27 should have value to US growers and home gardeners when Certified seed becomes available to them. The strong resistance to cowpea aphid we discovered will be valuable to US growers by reducing their need to apply pesticides, once it has been incorporated into cultivars. As of 2001, cowpea cultivar Ein El Gazal had been adopted by about 500,000 farmers in the Sahelian zone of the Sudan.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Katanin Function in Chromosome Segregation
Description: Our objective is to determine whether the activity of katanin is required for a component of anaphase chromosome movement during mitosis. Completion of this objective will allow us to determine whether katanin is an appropriate target for new anti-cancer drugs and new fungicides. The goal of this project is to determine whether the microtubule-severing protein, katanin, contributes to anaphase chromosome movements by disassembling microtubules in the pole of the mitotic spindle. After finding relatively mild effects on chromosome segregation due to katanin inhibition in cultured primate cells, we have focused on katanin inhibition in the nematode, Caenorhabditis elegans. We have monitored meiotic chromosome segregation in oocytes of worms homozygous for loss of function mutations in MEI-1, the C. elegans ortholog of katanin. We have found that anaphase chromosome segregation is completely blocked in the meiotic spindles of MEI-1 mutants. In addition, the translocation of the meiosis I spindle to the oocyte cortex is completely blocked in MEI-1 mutants. These phenotypes are specific because elimination of two other conserved microtubule regulators did not block anaphase or spindle translocation. We are currently interested in determining whether the difference between cultured primate cells and C. elegans oocytes reflects a differential requirement for katanin between species or between mitotic vs. meiotic spindles. Our research is also focused on understanding the mechanistic reasons for failures in anaphase chromosome segregation and spindle translocation in MEI-1 mutants.
Impact: Our experiments will determine katanin's precise role in mitosis and meiosis in both vertebrates and nematodes. The results of these experiments will determine whether katanin is an appropriate target for anti-cancer or anti-nematode drug development.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Metabolic Regulation of Gene Expression During Cereal Seedling Development
Description: Starch breakdown provides the sugar needed to support the germination and growth of the cereal seedling. While the enzyme, beta-Glucanase, initiates the breakdown of the endosperm cell walls, alpha-amylase is the primary enzyme responsible for initiating the breakdown of insoluble starch granules to the disaccharide, maltose. Cereal grains typically have little or no alpha-amylase in the mature seed, so alpha-amylase must be produced de novo during germination and seedling development. In addition to their roles in plant nutrition, sugars play important roles in regulating water relations, gene expression and enzyme activity, stress response. Thus, by helping to control the sugar content of the seed, alpha-amylase can have far-reaching effects on plant growth and development. Working at the molecular level we have characterized the rice alpha-amylase and beta-glucanase gene families. Phytohormones and metabolites regulate expression of these genes. We have recently shown that alpha-amylase gene expression can also be affected by the oxygen level. Under anoxic germination conditions, rice

seeds show pronounced differential expression of the members of the alpha-amylase gene family. The gene RAmy3D, which is only transiently expressed during aerobic germination, is up regulated under anoxic conditions. We believe the unique ability of rice to germination anaerobically may be due to the up-regulation of this particular isozyme of alpha-amylase. Over the past decade, we have investigated the role of sugar metabolites on early seed development. Early seedling development is associated with the massive breakdown of stored starch by enzymes such as alpha amylase and beta-glucanase. A model for how sugars control early seed gene expression is described by the Metabolite Signal Hypothesis. The most notable feature of the Metabolite Signal Hypothesis is the repression of alpha-amylase gene expression by mono and disaccharides such glucose, fructose, maltose and sucrose. In recent years, we have exploited the concept of metabolic regulation of alpha-amylase gene expression to develop a plant cell gene expression system that permits the over-production of foreign proteins in rice cell culture. Cultured rice cells (including micro-calli) have been used to produce a variety of medically important human proteins such as human alpha-1-antitrypsin, human lysozyme and human lactoferrin. Expression and secretion was achieved by placing the genes for these human proteins under the control of the rice alpha-amylase, 3D promoter and signal peptide. These gene/promoter constructs were introduced into rice tissue via particle bombardment. After selecting for transformed rice calli, cell cultures were established. Removing sucrose from the culture medium induces expression of these gene/promoter fusions. Upon characterization, all proteins were found to be processed and posttranslationally modified and fully functional. These accomplishments now make it possible to use plant cell fermentation as a production system for scarce and expensive pharmaceutical proteins. We have now extended our studies to include the molecular events surrounding early seed development. We are particularly interested in molecular mechanisms controlling the switch between cell division and cell expansion. In most seeds, cell expansion is accompanied by extensive DNA endoreduplication of the cellular genome. We believe a small 43 amino acid peptide, expressed early in seed embryogenesis, is responsible for the switch from cell division to cell enlargement.
Impact: A better understanding of the molecular events controlling plant growth will provide the information needed to develop superior crop varieties. These crops will provide healthier and more nutritious foods to the consumer and can also be used to manufacture human therapeutic proteins and metabolites. This research will have a significant societal impact by promoting global food security and improving the quality of life.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Potato Cultivar Selection, Evaluation and Development
Description: Objectives: 1. Introduce or develop russet, white, red chipping, and specialty potato cultivars of improved adaptability and quality. 2. Evaluate and demonstrate, under the varying California environments, the characteristics of the many new cultivars and advanced selections being developed or tested in the U.S. 3. Determine relative resitance/susceptibility of named cultivars and advanced selections to common biotic and abiotic diseases. 4. Assess cultural requirements of advanced selections and new cultivars. 5. Conduct a seed potato increase program, as necessary. In 2002, UC conducted selection and evaluation trials on long whites, russets, chippers, reds, yellow flesh, and specialty potato types. Collaborative projects included the Western Regional Trials for russets, reds and specialty, and chippers; Southwest Regional Trials (Colorado, Texas, and California), national Snack Food Association chip trial, California Department of Food and Agriculture Fertilizer Research and Education Program, and

the California Potato Research Advisory Board (potato industry) trials. In addition to standard production, harvest and postharvest quality assessment on new and advanced clones, cultural adaptation of new cultivars was emphasized. The emphases were nitrogen rate and in-row spacing of more than 20 advanced selections and new varieties, at three locations. Response to nitrogen rate appears to be most heavily influenced by soil type. Plant tissue analyses are only moderately useful in predicting nitrogen needs. Potato varieties do differ in nitrogen needs and response to additional nitrogen. This was the third year of this study; one more year of field data, laboratory analyses, and data analyses must be completed before conclusions can be made. Extensive trials were conducted in Kern County, Tulelake/Klamath Basin, and the Stockton Delta. More emphases was placed on specialty variety production and postharvest handling of "new", "salad", and specialty market types. Best performing clones and new cultivars included AC93026-9RU, TC1675-1RU, A90586-11RU, Stampede Russet, A91576-2RU, A94074-1RU, AC89536-5RU, NDC5372-1RU, AO96747-1R, CO93037-6R, NDTX4271-5R, NDTX4304-1R,A961002-1R, AO96747-2R/Y, A94377-6R/Y, Vivaldi, Satina, Ilona, NDA5507-3Y, CO94165-3P/P, NDTX4930-05W, MSF373-8W, B0766-3W, NY120W, NY112W, AF1424-7W, A91790-13W, and AF1775-2W. The number and acreage of new varieties that are being grown by California potato growers continues to increase. All of these have been introduced to California potato growers through the UC-CPRAB program, in cooperation with the Southwest Region and Western Region. These changes allow the California potato industry to maintain their market share with higher quality, higher value varieties. .Interest in specialty varieties, combined with alternative/specialty marketing continues to increase.
Impact: California potato industry does not compete well in the conventional high volume / low price marketing systems. It remains viable because it produces high quality fresh product year around. The national statistics verify that California ranks 10th or 11th in acreage of potatoes but 3d in farm-gate income. Most of the production is devoted to varieties introduced and developed in this potato variety program.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Salinity and Environmental Stress Resistance in Turfgrass and Landscape Plants for Recycled Water Irrigation and Phytoremediation
Description: Objectives: 1. Further improvement of buffalograss environmental stress characteristics for low maintenance turfgrass. 2. Research on California native grass species and landscape plant species for recycled water irrigation management. 3. Study mechanisms of bioremediation using plants for soil and water quality improvement. A buffalograss (BUCHLOE DACTYLOIDEDS) cultivar "UCD-95" was developed from mass selection. Superior turf quality is displayed over the entire growing season. Field trials tested salt tolerance of 38 landscape plants to determine their suitability for reclaimed water irrigation. A salt tolerance reference list was developed by this study. Four selenium (Se) nonaccumulator plant species including a forage grass species, tall fescue (FECTUCA ARUNDINACEA Schreb.), a forage legume species, alfalfa (MEDICAGO SATIVA L.), a wetland species, rush (JUNCUS TENUIS Wild.), and a dry-land alkaline soil saltgrass (DISTICHKIS SPICATA L.) were grown in soil contaminated by agricultural drainage sediment having elevated levels of Se and sulfur. The soil S concentration was several hundred times higher than the soil Se concentration, but Se accumulation by the plants and Se dissipation from the soil were not impaired by the high level of soil sulfur concentration. Four cool-season turfgrass species and four warm-season turfgrasses were analyzed for phenolic acids and allelopathy. Substantial quantitative and qualitative

differences were detected among the turfgrass species. They are potentially useful traits for turfgrass breeding and management.
Impact: The UCD-95 buffalograss is a drought resistant turfgrass cultivar that maintains high turf density under low maintenance conditions and thus is a valuable contribution to the turfgrass industry. The work on Se accumulation by the aquatic plants and Se dissipation from the soil by plant colonization provides additional information in management and phytoremediation of Se contaminated land. The research on allelopathy and recycled water irrigation has generated valuable references for landscape management.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: Stone Fruit Diseases: Etiology, Pathogenicity Mechanisms and Host Resistance
Description: Objectives: 1)To identify several of the most promising cling peach selections that possess the desired characteristics of brown rot disease resistance and horticultural traits for subsequent multiplication and distribution in test orchards. 2)To analyze these selections for additional value-added qualities, with emphasis on phenolics, polyphenoloxidase activity, carotenoids and fruit surface architecture. 3)To determine mechanisms by which redox active compounds regulate the display of selected depolymerases that the pathogen, Monilinia fructicola, may use for penetration and/or nutrient acquisition, and to identify genes that are selectively regulated by changes in the redox environment of the fungus. We have continued evaluations of peach genotypes for resistance to brown rot disease caused by Monilinia fructicola, using similar approaches reported in the previous year. 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, was estimated by spectral analysis of light transmittance of the fruit surface. Consistent with results from previous years, fruit from the various peach genotypes displayed significant differences in disease resistance to the brown rot fungus, with a significant number of the genotypes showing high levels of resistance. During the 2002 season, we evaluated over 250 genotypes, bringing the total number of genotypes that we have screened in the program during the past 8 seasons to over 1500. Our evaluations indicate that the disease resistance of some of the lines, which have been evaluated over several seasons, is stable. Basic studies on Monilinia pathogenicity mechanisms have continued, with focus on redox regulation of potential pathogenicity factors. We are collaborating with the laboratory of Dr. Dov Prusky of the Volcani Institute in Israel to examine the contributions of redox climate and other fruit factors for their effects on Monilinia and other post-harvest fungal pathogens. One such factor, the Monilinia cutinase MFCUT1, has been studied in some detail. This enzyme was expressed at high levels as a His-tagged fusion protein in Pichia pastoris, and purified to homogeneity in a single-step by Ni2+-nitrilotriacetic acid affinity chromatography. Analysis of variant MFCUT1 mutants in which the novel serine and histidine residues were replaced by site-directed mutagenesis indicated that these residues had an important effect on enzyme activity. The presence in the growth medium of antioxidants, such as caffeic acid, glutathione and lipoic acid, suppressed mRNA accumulation and enzyme activity of this cutinase. We are currently cloning the flanking DNA of the Mfcut1 gene by inverse PCR in order to 1) knockout the endogenous gene by gene replacement to functionally test this gene's role in pathogenesis and 2) construct a promoter-reporter gene fusion to more facilely test this gene's regulation in response to numerous redox active compounds and during pathogenesis. In order to genetically manipulate M. fructicola, we have developed a transformation system utilizing Agrobacterium tumefaciens to transfer and

integrate DNA into the fungus' genome. In addition to the functional characterization of Mfcut1, we intend to utilize this efficient transformation system to generate tagged mutants of M. fructicola affected in pathogenicity and extracellular redox modulation.
Impact: These findings are advancing our ongoing efforts to select a range of promising peach genotypes for further development within the stone fruit breeding programs, with the goal of developing cultivars with improved fruit chemistry and resistance to brown rot disease. Findings elucidating the mechanisms of pathogenesis and quiescence of the causal fungus will facilitate design of improved disease management strategies. The results of this research also could lead to novel strategies to develop disease resistant crops.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.26 Plant Germplasm
Title: UCR Develops New Citrus Varieties
Description: The citrus industry generates about $800 million a year in California and $2.3 billion a year nationwide. Conducting research to benefit this major industry can take many facets, including the breeding of new or improved varieties. Traditional citrus varieties are becoming less popular as consumer prefer easy-to-peel citrus, much of it imported. Developing new varieties helps California growers remain competitive. The University of California, Riverside is one of the few universities in the world to support an active citrus breeding program, and private companies have not engaged in citrus breeding. A UCR Professor of Genetics has continued the work of earlier UCR scientists to bring new citrus varieties to growers. UCR has developed many new varieties since beginning its breeding and genetics program in the 1910s. Some of the more recognizable varieties developed here include the Oroblanco and Melogold grapefruits and several tangerines such as the Gold Nugget. This breeding work has relied extensively on the citrus germplasm maintained as part of the Citrus Variety Collection at UC Riverside. (See related UC Delivers story.) This collection has about 900 different citrus and citrus-related varieties available to aid research.
Impact: In September 2002, three new mandarins--or tangerines--were released commercially, with licensed growers permitted to buy budwood. Shasta Gold (TM) hybrid mandarin, Tahoe Gold (TM) hybrid mandarin, and Yosemite Gold (TM) hybrid mandarin were all developed by crossing a Temple by Dancy hybrid with Encore, another UCR-developed mandarin. A common feature of the three new varieties is that they are largely seedless, with trees averaging less than one seed per fruit. They tend to be large for tangerines, have a sweet taste and a deep-orange rind, and offer different peak maturity periods, ranging from February through May. Few seedless mandarin varieties are available during this time of year, so the recently released ones offer growers new market opportunities.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: ANR Scientists Develop New Pistachio Varieties
Description: The cultivar 'Kerman' is planted on more than 95% of current pistachio acreage. While Kerman has been an extremely successful variety, growers would benefit from a variety that produces a higher proportion of split nuts. Also, although the U.S. pistachio industry prides itself on producing large, unstained nuts, a new selection with even whiter and larger nuts would give the U.S. a further market advantage. In addition, the almost exclusive planting of a single cloned variety makes the pistachio industry genetically susceptible to new plant diseases.

Development of this new selection began in the late 1980's when existing pistachio germplasms were crossed by a U.C. Davis researcher, and Kern County Farm Advisor in a project funded by the California Pistachio Commission. The resulting seeds were planted in a seedling test plot. A pistachio farm advisor in Kern County, became actively involved in the project in 1995. As the trees grew, measurements were made of precocity, flowering and harvest dates, cluster type, nut size, split percentage, nut staining and other characteristics. Ten promising genotypes were selected, grafted on to rootstocks and planted in randomized and replicated test plots in 1997. During the fifth year of growth in 2002, a single cultivar emerged with the potential of being a replacement for Kerman, or at least a viable option. This selection has been named 'West Wind'. Testing will continue for a few additional years.
Impact: The pistachio cultivar 'Kerman' has been so successful over the past 30 years that it has been almost exclusively planted by U.S. growers. As a result of ANR development and testing, a contender named 'West Wind' has emerged with the potential of being a viable alternative to Kerman. West Wind matures at the same time as Kerman and appears to have as much as a 10% better nut-split percentage, while producing equal or better yields of larger-sized nuts with less shell stain.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: C Budget, Sap, Sugars, Root Anatomy: O3 Effects in Contrasting Phloem Loaders
Description: The proposed research will explore basic questions about the integration of whole plant carbon budgets, the role and mechanism of phloem transport, and specific questions regarding plant responses to ozone. These studies will also be applicable to plant response to other natural and anthropogenic stressors. This study further explores a novel paradigm for ozone impact on carbon allocation in plants, through source control of fluxes rather than of assimilation. It will determine the role of altered root morphology and anatomy in mediating ozone induced changes in root and plant hydraulic conductance. It will characterize the impact of ozone on transport of stachyose and sucrose in the phloem sap, the rate of transport of total carbohydrates to developing roots, and their concentrations in source, transport and sink tissues. The impact of ozone on root respiration in both species will be determined to characterize the role of the carbon budget in altered root development. The effect of ozone exposure on the ratio of sucrose to stachyose will be interpreted in terms of the involvement of apoplastic and symplastic sugar transport and phloem loading. Sampling of sugars in the phloem with the use of aphids, and comparison of carbohydrate profiles in the source and sink tissues, will distinguish ozone impacts on the species of sugar loaded into the phloem, from effects on interconversions during transport or in the sink tissue. The studies to be performed may deemphasize the role of chloroplast function in mediating ozone damage to plants. Ozone is the most damaging air pollutant to crops and vegetation. Plants of Pima cotton and muskmelon were cultivated in open top exposure chambers at Kearney Agricultural Center. Ozone inhibits photosynthesis and export of sugars from leaves to roots and fruit. Measurements of photosynthetic gas exchange and root respiration provided novel information that root respiration increased even though sugar production in leaves decreased. This may indicate transport of toxic byproducts of ozone exposure, suggesting future experiments are required in this area. Ozone altered the shape, size and internal anatomy of the root system of both cotton and melon, reducing water transport capacity in the roots. Morphological analysis of root systems of plants treated with ozone suggest that there is no change in the distribution of root growth among roots of different size classes, but

that all classes are reduced proportionally. These data explain how the reductions in root hydraulic capacity develop in plants exposed to ozone.
Impact: Ozone is increasing in rural areas where much of the nation's food is produced. These results integrate at the whole plant level the effects of ozone, identifying root properties as key components of ozone damage. This is leading to management and plant breeding strategies that are better focused to improve crop resistance to ozone, and will allow better prediction and model development of ozone impacts on crop yield and on carbon sequestration below ground. Increased knowledge of the range of ozone effects and their role in yield suppression in crops is guiding development of air quality regulations at state and national levels.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: Collaboration Develops Improved Avocado Maturity Test
Description: Since 1983, the Avocado Inspection Program of the California Department of Food and Agriculture has measured the percent of dry matter content of avocados to determine fruit maturity. The maturity testing process used for the past nine years--the opposing eighths method--was time-consuming and potentially dangerous. It involved the use of sharp blades and required the use of food processor that had to be thoroughly cleaned between each test. Given the steps involved, Inspection Program personnel had to receive significant training to conduct tests.
An Extension Subtropical Horticulturalist from the Kearney Agricultural Center collaborated with personnel from the Avocado Inspection Program and a grower from the Del Rey Avocado Co. in Fallbrook in the development and two-year evaluation of a new sampling process, the equator coring method. A plugging tool invented by the collaborators removes a 20- to 30-gram core from the widest circumference of the fruit. A two-year evaluation of 1,386 fruit samples that entailed 1,027 official tests concluded that the equator coring technique produced almost identical analyses of dry matter content as the opposing eighths method. However, the coring method took only about five minutes to prepare samples for weighing and drying as opposed to the 18 minutes commonly needed for the opposing eighths method. The Hofshi Coring Machine also eases the sampling process and eliminates the need for personnel to place their fingers near sharp blades. After reviewing the statistical data from the two-year evaluation, the Avocado Inspection Committee recommended the adoption of the equator coring technique for all maturity testing. The new regulation took effect September 28, 2002.
Impact: State inspectors expect to reduce the time and costs associated with maturity testing. As significantly, they also anticipate less injuries for workers. Growers, marketers, and researchers also will benefit from this improved method when sampling avocados to analyze fruit nutrients or maturity. This new method is under review in New Zealand by HortResearch in Auckland to streamline maturity testing for avocados. Researchers in both Australia and Chile also have expressed interest in using the Hofshi coring machine as a research tool for avocados and potentially mangos.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: Developing Plant-Based Irrigation Strategies to Improve Irrigation Efficiency in Orchards
Description: Objectives: 1. Refine the use of plant-based water relations measurements, particularly midday stem water potential (SWP), as a practical irrigation management tool for orchards. 2. Determine the effects of water stress on tree horticultural productivity and fruit

quality. 3. Recommend deficit irrigation strategies that allow significant savings of irrigation water while maintaining or improving horticultural productivity. Plant-based monitoring for moisture stress, using midday SWP, was conducted across a wide range of both traditional agricultural crops (prune, almond, walnut, peach and grape) and non-traditional, but ecologically important species (oaks). A substantial emphasis was placed on the study of grapevine water relations, particularly to describe the relation of stem water potential (SWP) to leaf water potential (LWP) under field conditions. The analysis of this data is not yet completed, but indicates that SWP is a more sensitive index of water deprivation that LWP, as found in other crops. Unlike other crops however, midday vapor pressure deficit (VPD) was not a reliable predictor of midday SWP in grapevines, so further work may be needed to develop the practical use of SWP for irrigation scheduling in grapevines. Many walnut growers believe that the growth and productivity of walnut trees are particularly sensitive to inadequate irrigation, and as a result, many growers over-irrigate this crop. An irrigation study, funded by the California walnut board, was initiated in 2002 to test for the effects of three levels of irrigation on walnut growth and yield. Data analysis from the first year of this experiment is not yet completed, but early season growth measurements indicated that reductions in irrigation were effective in reducing vegetative growth with no apparent reduction in nut growth. Peach fruit growth is also considered highly sensitive to inadequate irrigation, and a pilot study was conducted to monitorSWP under low-volume and flood irrigation regimes, and to relate SWP to soil moisture measurements. In this study, peach fruit size was strongly correlated to SWP, but analysis of the soil moisture data is not yet complete.
Impact: Midday SWP is becoming a standard method to quantify water stress in trees and vines, and is allowing for more efficient use of water resources under conditions where growers can reduce irrigation without substantial reductions in SWP.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: Forms of Carbonic Anhydrase Linked to Photosynthetic Oxygen Evolution
Description: The chemical mechanisms that allow chloroplasts to evolve molecular oxygen, and thus begin the complex process of photosynthesis, remain a mystery. We know that oxygen is evolved from the splitting of water molecules and that the apparatus for carrying out this feat is located in a chlorophyll-protein complex, photosystem II, within chloroplast thylakoid membranes. Certain cofactors are required, among them manganese and calcium cations and chloride and bicarbonate anions. The project is to focus on one of these ions, bicarbonate, as a possible chemical intermediate in oxygen evolution. It has been proposed by several investigators (Metzner(25), Kreutz(24), Zeinalov(28), Stemler(26)) that bicarbonate, HCO3-, formed by the hydration of CO2 in solution (CO2 + H2O 'HCO3- + H+) could serve as the form by which water enters the oxygen-evolving reaction. As bicarbonate is decomposed to yield molecular oxygen, another product of the reaction, CO2 is also liberated. The CO2 must then be rehydrated to again form bicarbonate in a cyclic process. One prediction of this theory is that photosystem II and the oxygen-evolving apparatus itself must be able to catalytically hydrate CO2. Otherwise, this reaction would be extremely rate-limiting. The catalytic hydration of CO2 in solution is normally the function of the enzyme carbonic anhydrase (CA). We have discovered, in support of the idea that bicarbonate may be a chemical intermediate in oxygen evolution, that thylakoid membranes actually contain two sources of CA activity. One source appears to be a 33 kDa protein located in the lumenal space between thylakoid membranes. A second source is closely associated with the oxygen-evolving mechanism within the membrane.

The lumenal protein can be removed by washing the membranes with concentrated CaCl2 solution. It has been proposed, based on a similar enzyme found in Chlamydomonas reinhardtii that it functions to supply CO2 to the carbon-fixing enzyme, rubisco. The physiological function of the second source of thylakoid CA activity that remains tightly bound to the photosynthetic membranes, is also in question. We believe, however, that this source is most likely the one that supplies bicarbonate to the oxygen-evolving mechanism. The specific objectives of the planned work are several: 1. To characterize separately and in detail the two sources of thylakoid membrane carbonic anhydrase activity. For the lumenal source, we intend to obtain the base sequence for the gene as a first step in genetic manipulation. For the intrinsic carbonic anhydrase activity, we will attempt to localize the activity to some substructure of photosystem II. For each, we will determine pH optimum, ionic strength optimum, response to specific inhibitors and other biochemical parameters. Once we can control the activity of each CA source separately, we will begin to ask what physiologic role each plays in the chloroplast. 2. To test the hypothesis that bicarbonate is a chemical intermediate in oxygen evolution. The first steps in photosynthesis result in the decomposition of water and the release of molecular oxygen. Cofactors for this process include manganese, calcium, chloride and bicarbonate. The exact roles played by these ions remain highly speculative despite much effort over many years. We continue to study the role of bicarbonate ions and the enzyme that produces it, carbonic anhydrase (CA), in the mechanism of oxygen evolution. We discovered in the past that there are two sources of CA activity closely associated with photosystem II and the oxygen-evolving machinery. In the past year we have further characterized these sources of CA activity. We have obtained additional evidence that one CA is the 33 kDa extrinsic protein on PSII. This CA is unique in requiring manganese for activity. Another source of CA activity is more firmly attached to the membrane and requires calcium. The concentration dependence of the tightly-bound CA for calcium is the same as for oxygen evolution. When extrinsic proteins are removed from PSII, oxygen evolution becomes dependent on very high concentrations of chloride. This is also true for the tightly-bound CA activity. The strong correlation in the need for similar concentrations of calcium and chloride between oxygen evolution and tightly-bound CA allows the suggestion that these two cofactors may indirectly stimulate oxygen evolution by maintaining the supply of bicarbonate from tightly-bound CA. Such roles for calcium and chloride have never before been proposed. The 33 kDa activity is blocked by acetazolamide and ethoxzolamide. Both compounds are classical inhibitors of CA. The tightly bound CA form, in contrast, is immune to these inhibitors. In the absence of the 33 kDa protein, oxygen evolution is likewise immune to CA inhibitors. However, in the presence of the 33 kDa protein, oxygen evolution is reduced by CA inhibitors. These results imply, for the first time, that the 33 kDa protein has a strong regulatory role in oxygen evolution. We have also found that the two forms of CA also have different enzymatic functions. The tightly bound CA appears to catalyze only the hydration reaction, converting carbon dioxide to bicarbonate. The 33 kDa form does only the reverse, dehydration reaction. This means, that by varying the substrate and conditions, the two enzymes can be assayed independently, even when both forms of CA are present in the PSII complex. It also implies that the two enzymes have very different roles in oxygen evolution, despite their close proximity. We propose that the tightly-bound CA supplies bicarbonate to the oxygen-evolving mechanism and that the bicarbonate may act as the immediate source of evolved oxygen rather than water directly. This hypothesis has been in the literature for some time, but had little supporting evidence. The foregoing results suggest that it is time to reevaluate this possible model for oxygen evolution. We are now in the process of testing this idea further. The role of the 33 kDa CA activity is much less obvious and therefore more intriguing. More detailed characterization, now in progress, may provide the necessary clues.

Impact: Photosynthesis is responsible for the food we consume and the air we breathe. It is critical to understand all aspects of this process to ensure continued human and environmental well being. The work discussed provides insight into the initial chemical steps of photosynthesis, the least understood aspect of the process. Knowledge of how nature accomplishes this feat is the first step in engineering systems for converting light energy into stable chemical forms.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: Freeze Damage and Protection of Horticultural Species
Description: Identify factors that influence cold acclimation and winter survival.
We are investigating aspects of flower differentiation in olive and almond. Recent work has focused on within tree variation in the timing of floral transition and floral differentiation. Within-tree variation was previously shown to be much greater than the literature on the subject would predict. We showed that lateral floral bud number and leaf area are positively correlated on individual almond spurs, and that among spurs, floral initiation and differentiation is earlier in buds with greater leaf area. Investigations are underway to determine the extent to which these events are correlated with carbohydrates at the spur level. We are also investigating how timing of floral initiation and differentiation relates to time of bloom for individual flowers. A second focus involves adapting California table olive cultivars for olive oil production. Table olives are harvested in September, well before risk of freeze damage to the crop. Oil production increases through March but quality declines and the risk of freeze damage increases. Our research is directed to determining optimum yield timing consistent with high oil quality. We are adapting the standard European experimental-scale analysis system to California production parameters
Impact: Results will provide the ability to predict timing of floral initiation in buds in almond, the timing of floral development events may predict bloom phenology and provide useful insights into avoiding frost damage during bloom. Our results will better inform orchard managers on the precise phenology, and enhance production efficiency. Our work on olive oil production will provide the fundamental data for this emerging California industry.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA-B, CA-D, CO, FL, GA, IN, KS, MD, MN, SD, WA, WI, WVA

Theme: 1.28 Plant Production Efficiency
Title: Improving the Productivity of Crops Growing under Abiotic Stress
Description: Objectives: I. Investigate the effects of abiotic stresses on nitrogen metabolism. A.1) Determine the number of arginine vs. pyrimidine pathway-specific carbamoylphosphate synthetase (CPSase) enzymes encoded in a family of alfalfa CPSase genes and 2) quantify their expression in drought-tolerant and sensitive alfalfa cell lines during osmotic stress. B.1) Establish traits for selecting salt-tolerant avocado rootstocks by quantifying changes in endogenous concentrations of inorganic nutrients, especially K, organic metabolites, including soluble N compounds and sugars, and plant growth regulators (PGRs) during salinity stress. 2) Test the hypothesis that avocado rootstocks that accumulate putrescine are salt-sensitive, whereas rootstocks that maintain spermidine and spermine synthesis are salt-tolerant. 3) Test the hypothesis that expression of a high-affinity potassium uptake system homologous to that of Arabidopsis is related to salt tolerance of avocado rootstocks. II. Study the regulation of flowering, fruit set, and fruit development in citrus, avocado, and pistachio. Apply the results to the problem of alternate bearing in each crop. A. 1) Quantify `Washington' navel orange floral gene expression (homologs of Arabidopsis TERMINAL FLOWER, LEAFY, and APETALA 1)

in response to low temperature (promotive) or to application of gibberellin (GA3) prior to irreversible commitment to flowering (inhibitory). 2) Use floral gene expression to identify fruit produced compounds that inhibit flowering following an on-year and 3) compounds that can be used commercially to manipulate navel orange flowering and yield. B. 1) Study the role of PGRs in ovary sink strength, i.e. their effect on phloem unloading enzymes of developing fruit of leafy and leafless inflorescences of the `Washington' navel orange. 2) Based on results obtained, determine if properly timed foliar applications of PGRs increase fruit set and size by increasing the activity of fruit phloem unloading enzymes. C. 1) Quantify the number of determinate vs. indeterminate floral shoots produced by sylleptic vs. proleptic shoots of the `Hass' avocado and determine the role of carbohydrate, nitrogen and PGRs in regulating sylleptic vs. proleptic shoot production. 2) Determine whether high nitrogen fertilization or NH4+, in contrast to NO3- increases root cytokinin synthesis and translocation and alters the ratio of sylleptic to proleptic shoots by altering the auxin to cytokinin ratio of the parent shoot. D. 1) Study the role that endogenous PGRs play in retention and development of `Hass' avocado fruit. 2) Based on the results, determine if properly timed foliar applications of PGRs increase yield and fruit size. E. 1) Study the role of fruit-produced PGRs vs. competition for available nitrogen in alternate bearing of `Kerman' pistachio. 2) Based on the results, correct alternate bearing with foliar applications of PGRs and/or foliar applied N. III. Study the role of essential mineral nutrient elements in plant metabolism and physiology. A. 1) Determine the role of K, P and Ca in albedo breakdown of `Valencia' and `Washington' navel oranges. Urea (37 or 74 g N/tree) sprayed on Clementine mandarin (CITRUS RETICULATA Blanco) trees at prebloom (December-January) significantly increased total yield, fruit size, and yield of early-harvested and total export grade fruit per tree compared to control trees; results with the higher N rate were significantly better than with the lower N rate. Properly timing soil application of ammonium nitrate (75 or 150 g N/tree) to key stages in Clementine mandarin tree phenology significantly increase total and export yields compared to control trees. Foliar-applied urea is a cost-effective N-fertilization strategy that increases Clementine mandarin yield and fruit size and reduces nitrate groundwater pollution. Application of potassium phosphite (0-28-26; 6 mL/10 L per tree) at green flower-bud stage and again at June drop to the canopy of Clementine mandarin significantly increased total and export yields per tree and potassium phosphite applied at color break increased early fruit maturity and leaf P and K concentrations compared to control trees. Crease, a citrus rind blemish, occurs on the flavedo when underlying albedo cells separate (albedo breakdown) causing the flavedo cells to sink. In California, peel thickness (flavedo plus albedo) at harvest was the factor most consistently related to crease in both navel and `Valencia' oranges (CITRUS SINENSIS L. Osbeck). Relationships among severity of crease, leaf and peel nutrient concentrations, peel thickness and temperature were quantified for two years in 16 orchards located from southern to central California. Maximum peel thickness plus peel potassium concentration at maximum peel thickness explained 65% of the variation in crease at harvest. By October, peel thickness alone explained 60% of the crease data at harvest. Average maximum and minimum temperatures in February prior to flowering were positively correlated with crease and explained 91% and 96% of the crease observed at harvest, respectively. Rough lemon (CITRUS LIMON L. Burm. f.) and Carrizo citrange (C. SINENSIS L. Osbeck x PONCIRUS TRIFOLIATA L. Raf.) rootstocks grown in K-sufficient and K-deficient nutrient solutions for 240 days accumulated ammonia during early K-deficiency stress that was preferentially assimilated into proline. Arginine synthesized de novo was the major compound for storage of excess nitrogen after 210 days of K deprivation of rough lemon and for the entire period of K-deficiency stress of Carrizo citrange. Putrescine accumulation was delayed until halfway through the stress and was insignificant. Growth of rough lemon, but not Carrizo citrange, was severely limited in the absence K. Rough

lemon should be considered a K-dependent rootstock. Homologues of the ARABIDOPSIS THALIANA floral regulatory genes TERMINAL FLOWER, LEAFY, and APETALA1 were isolated from C. SINENSIS L. Osbeck, cloned and sequenced. C. SINENSIS genes share 74%, 68%, and 66% amino acid identity with their ARABIDOPSIS counterparts, respectively.
Impact: By properly timing foliar-applied urea or potassium phosphite, growers can increase yield, size and quality of Clementine mandarin fruit (CITRUS RETICULATA) or harvest fruit early when prices are high. Growers can increase yield, size and quality of Clementine mandarin fruit by applying soil N at key stages in tree phenology. The research results provide Clementine mandarin growers with cost-effective management tools that increase yield parameters and income. Knowledge that rough lemon (C. LIMON) is K-dependent alerts growers to manage leaf K nutrition of cultivars on this rootstock rather than soil K. Reduced peel K concentration prior to maximum peel thickness is a major factor contributing to crease of sweet oranges (C. SINENSIS) and loss of grower income.
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: 1) Work to maintain productivity in dense plantings. 2) Assess possibilities of using regulated deficit irrigation and/or nitrogen manipulation to attempt to control vegetative growth. 3) Investigate the role of role of irrigation and canopy management in disease and insect resistance. Objective 1- There were again no significant effects of the high limb pruning treatment on midday canopy light interception on any individual day during the season in 2002. However, when the average seasonal canopy light interception was calculated, there was a small but significant increase for the high limb pruning treatment in 2002. This suggests that the pruning treatments may have stimulated a slight increase in canopy development, perhaps due to a slight decrease in crop load in the high limb pruning treatment in 2002. The appearance of the high limb pruned trees is substantially different than that of the trees that have not been pruned after two years of treatment imposition. The overall canopy height is considerably lower and the average height at which the nut crop is borne appears to have moved down about 6-10 feet in the high limb pruned trees. This suggests that high limb pruning in this manner may be useful for canopy management in high density Tulare plantings as they mature. There were no significant treatment effects on yield. First year results were encouraging in that yields were not negatively impacted by the high limb pruning treatment. The plan is to continue the pruning treatments for the 3 years it is anticipated will be required to lower canopy height without impacting yield. Objective 2- The objectives of this aspect of the project are to quantify the dynamics of spur renewal, fruitfulness and longevity and to determine how these are influenced by nitrogen and irrigation. Tags were placed on 2400 spurs which will be monitored throughout the anticipated 6 years of the study to quantify the impacts of treatments on spur longevity. In 2002, all three deficit treatments had significantly lower midday canopy light interception than the control throughout the season. Unlike in 2001, stem water potentials were able to be maintained at target levels throughout the 2002 season. All three deficit treatments had a negative impact on yield but the low water, high nitrogen treatment did not yield significantly less per unit canopy light interception. Improvements in spur quality as measured by leaf specific area occurred in inner canopy locations in the deficit treatment suggesting potential future differences in flowering and nut retention is possible in these locations. Objective 3- Codling moth is the key pest in walnut orchards and requires successive intervention through the season to suppress damage levels at harvest. This work was initiated to look at the relationship between leaf water potential and nut

susceptibility to provide growers with an opportunity to maximize the natural resistance of nuts to codling moth damage through irrigation management. The work was overlaid on another walnut irrigation project that was initiated this year but due to an untimely grower spray just before the desired sampling date at one of two locations, data was only collected at one site. Preliminary results indicate that codling moth susceptibility was again lower on nuts from deficit irrigated trees.
Impact: The results of this project are promising. If deficit water management can be used as a tool for managing dense plantings while decreasing the susceptibility of these orchards to pests, the reliance on fossil fuels for orchard practices such as irrigating, pruning tower operation and spraying operations can be reduced as could pesticide usage. These practices would provide benefits to growers (decreased costs of production and reduced pesticide exposure) and to consumers (products with the lower pesticide residues they desire).
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: Nitrogen Utilization Efficiency in Deciduous Fruit Trees
Description: Objectives: 1. Characterize the magnitude and temporal patterns of nitrogen use by commercially-grown, selected deciduous tree fruit species not previously studied. 2. Design foliar nitrogen application management strategies for selected crop species to reduce the impact of fertilization on groundwater quality and integrate foliar nitrogen applications with other management practices to facilitate grower adoption. 3. Refine nitrogen plant diagnostic indices to better reflect overfertilization. 4. Assess the human/social variables that impact grower decision-making and adoption of environmentally-sensitive fertilizer management practices.
Data collected from a three-year experiment to reassess the validity of currently-accepted potassium (K) critical values and the effects of insufficient soil K availability on yield determinants in almond are being summarized for publication. During that study, however, it became apparent that there are distinct sub populations of almond spurs which differ from other spur sub-populations in leaf K concentration, leaf area per spur, fruit number per spur, and spur survival over the winter. The timing of floral initiation and flower number per spur are influenced by fruit number and leaf area per spur. About 90% of the almond crop is borne on spurs, and yield stability is dependent upon maintaining a balance between spur renewal and spur mortality.
Impact: The awareness of distinct spur sub-populations (varying in fruit load and leaf area per spur) may stimulate us to rethink the validity of the currently-used diagnostic protocols to assess tree nutrient status. The sampling and nutrient analysis of leaves from non-fruiting spurs in July to assess nutrient status may be ignoring more vulnerable segments of the spur population within the tree canopy.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: Olive Oil Industry in California
Description: The US consumes 50 million gallons of olive oil (7% of the world's production) per year, but produces only 300,000 gallons of this high-value commodity. Consumptive demand has increased by 88% just in the last few years and California would have to plant 350,000 acres of oil olives in order to offset imports. Many producers see olive oil as a opportunity to diversify their current mix of agricultural crops and enter into a market that has been dominated by low-

quality, refined foreign oils. Gourmet chefs and consumers interested in fine food products are very interested in buying fresh, locally produced olive oil. Considerable interest in this alternative crop from local producers requires information on varieties, cultural practices, pest management, processing methods and quality assessment. Over the last 10 years UCCE farm advisors and specialists have coordinated three olive oil production short courses, five olive oil sensory evaluation short courses and three educational grower tours to Europe (Spain, Italy, and Greece). They helped start the California Olive Oil Council, developed the first International Olive Oil Council taste panel recognized outside the Mediterranean region, collected industry statistics on production and developed a cost study to help assess the crop's investment potential. A great deal of research has been conducted on high density planting systems, pruning levels, mechanical harvest, variety evaluation, deficit irrigation, plant nutrition, disease management and olive fruit fly control.
Impact: California's small-scale gourmet olive oil industry is producing excellent quality olive oil that is being recognized worldwide. Due to production methods championed by UC, the establishment of grading standards by UC and assistance with processing methods taught by UC advisors, the industry is positioned to grow a significant amount of its own olive oil and to offset a large portion of the $1 billion in annual olive oil imports from Europe.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: Orchard Operations - Pruning to Induce Early Bearing in Orchards
Description: Of the 58,000 acres of fruit trees in Tulare County, more than 47,000 acres are fresh-shipping peaches, plums and nectarines. These orchards are commonly replaced every 8 to 12 years as the varieties become obsolete. Industry observers suggest that this figure has recently fallen to 7 to 9 years of productive orchard life. Because of this short potential market life, it is extremely important for peach and nectarine orchards to reach full production as quickly as possible. Our research results from four sets of trials and demonstrations have shown that two methods can help to induce early production. For peaches and nectarines, reduced pruning during the first three growing seasons is practical and effective. For plums, which also can benefit from earlier production, reduced pruning combined with small metal anchors and twine to tie limbs into a specific orientation are more suitable. We worked closely with about six influential growers noted for their growing expertise and strategically located throughout the growing area. Demonstration blocks were set up in their orchards to compare these systems side by side with current pruning system. Trees were brought into bearing two to three years sooner than with conventional pruning techniques. In all cases the growers became enthusiastic supporters of the reduced pruning method. The concept also has been disseminated through the trade press and other media.
Impact: A verbal survey of growers in the Tulare County area indicates that this technology is now being used by more than 45 growers on a full-scale basis on more than 3,000 acres of trees. Many other local growers are trying the concept on at least a portion of their orchards. Additionally, many growers in other parts of California are using these techniques. Assuming that orchard life before varietal obsolescence is roughly 10-12 years, these techniques have increased productive orchard life by at least 10 to 25%, thereby placing money directly in the growers' pockets.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: Practical UC Course on Specialty Crops Production
Description: Over the last few years numerous specialty crops have become of great interest to small-scale growers. About 800 producers in Sonoma and Marin Counties have planted approximately 2,500 acres in specialty vegetables, berries, mandarins, cut flowers, chestnuts, Christmas trees and specialty tree fruits. Every year, hundreds of these and other small-scale land owners are looking for information on crop production methods. They usually need basic information on types of alternative crops, specific varieties, land evaluation, collecting and analyzing soil samples, farming equipment, irrigation, pest control, postharvest handling and direct marketing. It is very difficult to get a significant amount of information on such an array of topics to them, especially on a one-on-one basis during a farm visit. Since 1987, an 18-week course on specialty crop production has been taught by UCCE annually through Santa Rosa Junior College. This course involves three hours of lecture per week plus time in the field to get hands-on training in seeding and transplanting vegetables, pruning berries and fruit trees, measuring irrigation system efficiency and tasting various types of specialty fruit crops. The students range from young people with an interest in agriculture to existing landowners looking for alternative ideas. They are shown demonstration plots and working farms with most of the locally grown crops. The demonstration plots on chestnuts, mandarins, apples, oil olives and berries are used to show the students what those crops taste like, and also to demonstrate how they are planted, spaced, irrigated, pruned, harvested, packaged and sold.
Impact: About 400 growers have taken the course and many of them are now successful producers. Specific information on berry varieties has helped the local berry growers stay in business by growing plants that tolerate our winter rains and produce early, flavorful, large-sized fruit. Marketing information has opened up new markets for farmers with specifics on how to set up a farmer's market booth, start a subscription farm, or appropriately package their produce for the wholesale market. The course has saved growers thousands of dollars by teaching them how to eliminate unnecessary pest control sprays and by demonstrating practical methods of vegetable bed planting with mechanical weed control. The course has established a good working relationship between the UC advisor and farmers who have taken it. There is also a network of past students to help new students.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.28 Plant Production Efficiency
Title: Reflective Films Improve Fruit Color and Marketability
Description: In buying fresh fruit, consumers look for color even though red skin is strictly cosmetic and does not indicate that fruit is more mature or of better quality. Red color is enhanced in cool climates and is greatly reduced in warm or hot growing areas like those in the San Joaquin Valley. For fruit grown in these warm locations, better color improves both marketability and price. To improve color on a variety of crops, research initiated by Harry Andris in Fresno County led to the development of a plastic reflective film that bounces sunlight normally absorbed by soil back into the tree canopy and onto the ripening fruit. This added light triggers a photochemical reaction, forcing pigment precursors to convert from green or yellow to red. This dramatically improves red color and also increases fruit size, since more photosynthesis is taking place in normally shaded areas of the tree.
Impact: Within four years of its introduction to Fuji apple growers in Fresno County this technique received worldwide acceptance. Reflective films are currently manufactured and used

worldwide. Their use has improved the eye appeal and marketability of many crops and has completely replaced expensive hand pulling of leaves around individual fruits to promote color.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.31 Risk Management
Title: Commodity Forecasts: Methods, Applications, and Implications for Risk Management
Description: Accurate forecasts of various commodity prices and quantities are of vital importance to the agricultural sector. This project will review existing forecasting procedures for selected representative crops and assess their accuracy. It will also investigate alternatives for improving forecasting accuracy.
Impact: The evaluation of forecasting methods has had a direct impact on the procedures of the California Agricultural Statistics Service, which forecasts more than 100 California agricultural crops. New methods for forecasting prices in interrelated regional markets have been proposed, and issues in the settlement of risk-shedding futures contracts have been identified, with important practical implications. Empirical work assessing market promotion activities has shown the duration of certain types of effects to be far longer than previously believed, a conclusion of great importance to USDA marketing efforts abroad. At a more abstract level, the regulated, deregulated, re-regulated, and re-deregulated microcosm of cable television was used to examine the effects of government policy uncertainty, a major issue in agricultural programs. There are numerous issues surrounding the production and marketing of agricultural commodities, ranging from forecasting the crop to measuring the effects of government regulation and sales promotions to shedding risk via financial markets. Work under this project ranged from improving crop forecasts to analyzing alternative nonlinear demand model specifications to assessing the effects of repeated government policy changes to examining the conditions under which future contracts are settled (see prior progress reports for more specific details).
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 1.32 Small Farm Viability
Title: Assistance to Southeast Asian Strawberry Growers
Description: In the early 1990s, several Southeast Asian immigrants began planting strawberries in Sacramento County. They had very limited experience in farming, particularly with pest management, and they frequently lost entire crops to pests. They needed information, as did other Southeast Asian growers who joined them. There are currently about 40 Southeast Asian growers in Sacramento County. In 1996, a UCCE horticulture advisor began working closely with the growers, conducting research and holding one or two meetings per year. We received a grant to provide each grower with a hand lens, an Integrated Pest Management manual and other useful information. He also encouraged the TV program "California Heartland" to film a segment on strawberry farming in Sacramento County, which they did in 2002. Several newspaper and magazine articles were written featuring these growers.
Impact: Through these efforts, these growers are using safer and more effective production and pest management practices, and have received media attention to attract more customers. Growers are now able to identify and control key pests such as spider mites and worms. They frequently use UCCE as a resource for production questions.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 1.32 Small Farm Viability
Title: Small Farm "Incubator Project" Helps Fresno County Farmers
Description: Small farms and those with limited resources number well over 1,400 in Fresno County. The county's great diversity in ethnic makeup of small farmers makes for a unique and challenging opportunity to extend information. Many Hmong farmers also have difficulty understanding English. A Small Farms Advisor helped develop a 20-acre incubator farm where participants farm one to three acres and receive technical training during a two-year program. The programs are presented in various languages, including Hmong and Lao. The Center also serves as a one-stop-shop where farmers can attend computer classes, get information about loans and recordkeeping or find out in the resource library about all of UC's programs. Cooperative Extension provides technical assistance for the farm production.
The project is a collaboration between UCCE, Hmong American Community, American Farmland Trust and CV Small Business Development Center. Other participants include USDA-RMA, FSA, RD.
Impact: During 2002, more than 100 minority small farmers attended workshops at the Small Farm Incubator Project site in Fresno. Six, including three Hmong, two Lao and one African American, are participating in the two-year training and are farming between one and three acres. They also attend monthly workshops at the site, learning about IPM, soils, irrigation, fertilizers, marketing, postharvest, recordkeeping, budgets and finances.
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.

According to estimates from the Centers for Disease Control, approximately 75 million Americans last year suffered from some type of food-borne illness with an estimated 300,000 serious illnesses and 5000 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; there is a positive interaction between farm employment and immigration that increases rural poverty and welfare demands; it is possible to improve crop forecasts and to analyze alternative nonlinear demand model specifications and to develop a user-friendly model of hamburger cooking to ensure a safe product with desirable levels of textural quality; and magnetic resonance imaging can be used to measure spatial distribution of moisture in foods during storage.

Sixteen local extension programs were delivered in this area. In addition, two statewide collaborative workgroups composed of both AES and CE academics planned and conducted research and extension projects. California academics published 67 peer-reviewed articles to address Goal 2 last year.

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 2002-2003 Allocated Resources

Extension Federal Funds (Smith Lever	Extension State Match	Research Federal Funds	Research State Match
$22,532	$1,530,077 [8.09 FTE]	$160,507	$4,684,165 [20.53 FTE]

Theme: 2.01 Food Accessability and Affordability
Title: Private Strategies, Public Policies and Food System Performance
Description: Objective: To analyze the impacts of changes in strategies, technologies, consumer behavior, and policies on the economic performance of the food system.
Impact: Analysis of market structure and market power in the meat and other agricultural industries provides a crucial input into regulatory and policy analysis. Analysis of the determinants of technological growth in agriculture informs policy makers as to the specific impacts of physical and intellectual infrastructure and can help in setting public spending priorities. The U.S. Department of Agriculture has regulatory over the red meat industries under the Packers and Stockyards Act and will benefit from research on the sector's performance. Both federal and state legislation to affect market structure and competition in the agricultural sector are receiving serious consideration, and analysis of technology and competition in these industries provides valuable input into these deliberations. The analysis of seed pricing demonstrates that the relevant market for analyzing market power is in production input systems, not the market for individual innovations, as assumed in previous analyses. The evaluation of state-level environmental regulations shows that the economic impact of such rules may be large. The field-level methodology developed in this analysis may be applied to any other buffer zone regulations adopted for environmental or health purposes. Research has proceeded along four defined avenues; (a) technology and productivity, including their causes and effects, in both food processing and primary agricultural industries; (b) technological structure, efficiency, and contracting in the meat industries; (c) conceptual and empirical evaluation of processor, retailer, and input supplier market power in agricultural industries, and the linkages between market structure, regulation, and biotechnology; and (d) evaluation of costs to agricultural producers of compliance with state and federal environmental and health regulations. Findings under (a) suggest that technological change embodied in high-tech, human, and research capital has had substantive effects on cost savings in food processing industries. Trade, technical change and outsourcing have also had impacts on input composition, including capital and labor composition toward more high-tech capital and skilled labor. Expansions in the highway system have had important cost-saving impacts for the U.S. agricultural sector. The cost impacts of reducing risk from pesticide use are also significant and vary substantively by region. Research under (b) has found negligible measured market power in the U.S. meat packing industries, using both aggregate and micro data, and employing both cost-based methodologies and more traditional industrial organization models. This conclusion, in conjunction with significant utilization economies (lower costs with increased throughput), implies that economic pressure is toward higher demand and prices for cattle. However, procurement contracts that specify a base price in terms of a yet-to-be-determined spot price can reduce cattle prices when the same processors compete in both the contract and cash markets. Evaluation of transactions-level data for cattle procurement in the Texas Panhandle revealed that cattle were often not procured by the packer with the highest valuation for the cattle. Furthermore, the incidence of switching among buyers by feedlots was significantly less than would be expected under competitive procurement. Under

(c), research investigated the potential of agricultural biotechnology firms to exercise market power when pricing their innovations, in turn affecting the magnitude and distribution of resulting welfare gains. Analysis of producers' returns to planting patented seed innovations suggests that such innovations do not increase the market power of biotechnology firms. Work for fresh produce commodities found strong evidence of retailer buyer power for CA iceberg lettuce, but evidence on buyer power was mixed for fresh tomatoes from either FL or CA. Retailers exercised some market power as sellers of produce commodities to consumers, but pricing was restrained relative to what was possible, based on estimated elasticities of demand. No evidence of collusive behavior among retailers was found. Under (d) compliance with environmental and health regulations may significantly affect producer profits. Research on the effect of state-level methyl bromide use regulations on the California strawberry indicates that losses to producers could be as large as 25% of total revenues.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA, IA, IN, NE.

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Theme: 2.02 Food Handling
Title: Effect of Surfactants on Hydrophobic Solute Delivery in Biocompatible Systems
Description: Objectives: 1. Measure the solubilization kinetics of hydrophobic solutes from an oil (alkane or lipid) phase into an aqueous phase. Use convection and viscosity studies to probe the influence of interfacial transport barriers. Investigate the influence of solute hydrophobicity (i.e. water solubility), surfactant type, and aqueous properties on interfacial transport kinetics. 2. Develop a technique for forming monodisperse emulsions to be used in solubilization studies (Mason and Bibette, 1997; Mabille et al., 2000). 3. Extend model solubilization studies to allow prediction of surfactant effects on flavor and nutrient release. 4. Determine microemulsion formation in oil/water mixtures containing lecithin (phospholipids) and alpha-lactalbumin. Oil will consist of alkanes, triglycerides or fatty acid esters. Explore influence of temperature, overall concentration of surfactant/protein, and surfactant-to-protein ratios. Quantify the extent of solubilization within the microemulsion and size and structure of microemulsion droplets. 5. Determine microemulsion formation in oil/water mixtures containing monoglycerides, diglycerides and phosphate esters of mono- and diglycerides in combination with alpha-lactalbumin. Explore influence of temperature, overall concentration of surfactant/protein, and surfactant-to-protein ratios. Quantify the extent of solubilization within the microemulsion and size and structure of microemulsion droplets. We have worked in the first year of this project to advance our understanding of solute delivery in emulsions and microemulsions. Our key findings are: 1. We have compared experimentally measured solubilization kinetics in oil-in-water emulsions in the presence of surfactant micelles with various mechanistic theories predicting these rates. Models based on interfacially limited transport at the droplet surface or reaction-enhanced aqueous diffusion are both possible descriptions of this transport process. 2. Rates of hydrophobic solute transport in microemulsions contain contributions from both microemulsion droplet diffusion and solute transport within water, with the latter contribution increasing for more water-soluble materials. These measurements were obtained using holographic interferometry. 3. By adding 0.7wt percent of the protein alpha-lactalbumin to an equivolume mixture of isooctane and brine and the food-approved surfactant AOT (2.6 wt percent), the phase behavior of the microemulsion becomes strongly dependent on pH. The system forms water-in-oil droplets at high pH, both water-in-oil and oil-in-water droplets at intermediate pH, and forms an aqueous liquid crystalline phase at low pH. The AOT surfactant-oil-water mixture in the absence of protein would have no pH dependence. 4. alpha-Lactalbumin added in amounts less

than 0.1 wt percent to equivolume mixtures of cyclohexane and water shows little interaction with the zwitterionic surfactant phosphatidylcholine.
Impact: Microemulsions have food, pharmaceutical, and cosmetic applications for solute delivery, but use is hampered by the limited number of biocompatible surfactants which form them. We have shown that alpha-lactalbumin greatly enhances the formation of microemulsions. Our increased understanding of solute delivery in emulsions will enable better control of release of flavors, drugs and nutrients.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 2.02 Food Handling
Title: Physicochemical Aspects of the Role of Water in Foods
Description: Objectives: To study the physical chemistry of water in food preservation processes; To probe the mechanisms of ice nucleation, propagation and ripening, and determine at a molecular level the role of the matrix within which the ice grows; To develop technologies that utilize this mechanistic knowledge; To quantify the cross links which are a consequence of aggregative processes during water removal from a matrix; To develop simple procedures to predict the losses in functionality accompanying the aggregation. The ultimate goal is to understand the interactions between water and its immediate environment within food systems in order to better control and direct the changes which take place, mediated by water, water crystallization, and water removal, during food processing. To assess the consequences of power load management in cold stores, we have been investigating the influence of temperature fluctuations on the rates of change of quality related factors during frozen storage. Of primary importance to the rate of change is the average storage temperature. The lower the temperature, the slower the change. For moisture migration, the size of the fluctuation also has an accelerating effect. The larger the fluctuation, the greater the acceleration. The significance of this is greater at higher average temperatures. Results for chemical change are similar, but the acceleration caused by large fluctuations only has significance at the higher average temperatures, and in sensitive products. The conclusion is that if the average storage temperature is at or below the recommended 0oF there is no detrimental effect of typical load management schemes. Continuing our study of consistency loss in tomato products, the effect of cell wall composition on the loss of swelling potential accompanying partial dehydration has been studies using a tomato material in which enzyme activities have been modified by genetic manipulation. The patterns of swelling correlate with the changing patterns of enzyme activity. Changes in wall composition are still being analyzed. The screening test for consistency loss potential for tomato varieties continues to be evaluated. Results to date show some promise.
Impact: Demonstrating that the temperature fluctuations accompanying power load management have no significant deleterious effect on frozen product quality allows industry to use these cost saving procedures with confidence. The results also confirm the importance of conforming to recommended guidelines for average storage temperature.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 2.06 Food Safety
Title: Characterization and Control of Moisture Redistribution in Food During Storage and Processing
Description: Objectives: 1. Measure changes in the internal distribution of moisture in food products during storage/processing. 2. Develop mathematical models to predict moisture

redistribution in foods during storage/processing. 3. Develop magnetic resonance imaging techniques and procedures for measuring moisture and moisture migration in food products during storage and processing. Moisture migration within foods affects their quality, safety and consumer acceptability. Little knowledge exists on internal redistribution of moisture in foods. This project uses magnetic resonance imaging to measure spatial distribution of moisture in foods during storage. The moisture migration inside of foods will be measured and the impact of this migration on quality, safety and acceptability of these foods will be quantified.
Impact: The changes in the moisture distribution during storage of a filled cake model system have been initiated. The filling has a high moisture content relative to the cake. Magnetic resonance imaging parameters, spin-lattice and spin-spin relaxation times, have been measured. Moisture relaxation rates in oranges change significantly after freezing, 20-30 percent. This change can be used to determine the regions in oranges that have been frozen and hence are subject to drying-out during storage. These results are useful for understanding moisture redistribution in food during storage. The knowledge can be used to alter formulation, processing, storage or use of product.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 2.06 Food Safety
Title: Consumer Food Safety and Food Irradiation Education
Description: Objectives: 1. Decrease foodborne illness by increasing consumer knowledge and acceptance of foods processed by irradiation. 2. Prepare state public health officials, professional dietitians, and other health professionals to respond to consumer questions about food irradiation. (Outreach) 3. Increase consumer knowledge of the safety, quality and wholesome of irradiated foods. (Outreach) 4. Assess effectiveness of consumer educational program. (Research) 5. Determine consumer satisfaction with irradiated products. (Research) 6. Conduct an economic analysis of market response to irradiated food offered in the test markets in California and Kansas. (Research) Consumer knowledge of irradiation will be increased through informing health professionals and delivering an educational program directly to consumers in the community.
Impact: Collaborators delivered programs in their states to extension personnel, Department of Health officials, and others. Many participated in media interviews. Purdue University completed their educational video and shared it with all participating states. In addition, the video was presented at the FDA/USDA sponsored Food Safety Educators Conference in September. A curriculum was developed and will be placed on the Purdue web page. A curriculum was also developed in Nebraska where consumer response to irradiated ground beef in grocery stores is being tested. Pennsylvania developed 2 low literacy brochures, a tabletop display and several fact sheets on irradiation. Minnesota has incorporated food irradiation as a component in a food safety program for food service managers. Minnesota is also working with other health educators to explore introducing irradiated hamburger into school food service. A consumer survey in Kansas found more people developed a positive attitude toward irradiation when information was received from a government rather than industry source. A second study found consumers could not taste a difference between irradiated and non-irradiated ground beef patties. Groups receiving information on irradiation were significantly more accepting of the technology while groups not receiving information were uninformed and skeptical. Irradiated foods are now available in select markets in four of the participating states. Scientists in each state have been able to address consumer and media questions, thus enhancing public understanding of this

technology. The market is growing, with irradiated ground beef representing 10-15 percent of fresh ground beef sales in supermarkets offering the product.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 2.06 Food Safety
Title: New Approaches to Improve Quality and Safety in Cooking of Hamburger Patties
Description: Objectives: 1. Determine changes in physical and thermal properties, such as thermal conductivity, specific heat, and density of hamburger patties as influenced by initial composition of hamburger meat, initial temperature, cooking temperature, and applied pressure. 2. Develop predictive mathematical models to describe heat transfer in hamburger patties including dimensional changes, pathogen destruction, and textural modifications during cooking. 3. Using optimization methods, develop new and improved cooking processes for hamburger patties that ensure a safe product with desirable levels of textural quality.
Impact: A user-friendly model of hamburger cooking, developed during this study, was demonstrated at professional meetings. In response to requests received, copies of the model were made available to practitioners in the food industry. The model is now being used by equipment manufacturers in designing new clamshell grills and by food processors in developing specifications for frozen patties. The overall goal of this research was to develop a mechanistic approach to determine heat and mass transfer during cooking of a hamburger patty for improving the quality and safety of cooked patties. This goal was accomplished by addressing the following objectives, i) determining changes in physical and thermal properties of hamburger patties during cooking, ii) developing a predictive mathematical model to describe heat transfer in hamburger patties, and iii) predicting changes in microbial population during cooking of hamburger patties. When a frozen hamburger patty is placed on a heated grill plate, the heat is transferred from the grill surface into the patty. The cooking process starts and, as heat penetrates the patty, the frozen fat and ice melt. Near the patty surface, the temperature exceeds 100 degrees C, water evaporates and by a combination of dehydration and browning reactions, the formation of a crust takes place. Water and fat are released from the patty, affecting mainly the heat transfer resistance between the hamburger and the hot plate. A solid-liquid interface (during melting) and a liquid-vapor interface (during evaporation) can be assumed when a frozen hamburger is heated by contact. Thus, the problem can be studied as a multi-phase, moving boundary one. A mathematical description of the moving boundary problem was formulated. For this model, which is based on the physical mechanisms of heat transfer, the hamburger patty is described by its physical and thermal properties. These properties were obtained experimentally. The volume of hamburger meat decreased significantly with the increase of heating temperature and holding time. The total volume reduction reached 30.5 percent when temperature was 75 degrees C and holding time was 20 minutes. The water loss was more than 30 percent and fat loss was more than 40 percent when the temperature was 75 degrees C. The rates of water and fat losses decreased when the temperature increased to above 70 degrees C. The thermal conductivity of hamburger meat at the temperature range of 5 to 70 degrees C varied in the range of 0.35 - 0.41 W/m degrees C. A two-dimensional mathematical model involving moving boundaries for predicting the heat transfer in meat patties heated in a clam shell grill was developed and solved by a numerical method. The model was validated experimentally by cooking hamburgers at different plate temperatures. Although the mass transfer was not considered, a good agreement between the experimental and theoretical values was obtained. An increase in the plate temperature reduced the time for reaching 71 degrees C at the midpoint. The required center temperature was reached in 124 s when 204 degrees C bottom and 221 degrees C top plate

temperatures and a gap thickness of 0.011 m were used. A variable heat transfer coefficient between the heating plate and hamburger patty was experimentally obtained. The predictive model was found useful in predicting temperature anywhere inside a patty for different gap thickness of the clamshell grill, plate temperatures, and fat content of the hamburger patty.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 2.06 Food Safety
Title: Postharvest Physiology of Fruits
Description: Objectives: 1. To evaluate postharvest requirements of new fruit varieties. 2. To develop sustainable alternatives to chemical control of physiological disorders, diseases, and pests.
Impact: Optimizing the use of 1-MCP for fruit storage and studying the effects of temperature and ethylene on pear fruit quality contribute to a reduction in economic losses by farmers and fruit marketers and improve the quality of fruit available in the market. The availability of higher quality fruit will increase consumption and have health benefits for society.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA, DC, GA, MA, MD, MI, NC, NYC, NYG, OR, PA, WA, USDA/ARS, CANADA

Theme: 2.06 Food Safety
Title: Postharvest Quality and Safety in Fresh-Cut Vegetables and Fruits
Description: Objectives: 1. 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. Crop production and postharvest management systems must be designed and implemented with sensory quality, nutritive quality, and safety to consumers as equal priorities. The microbial quality of pre and postharvest water plays a major role in the safety of fresh cut product. Several approaches will evaluate microbial food safety risks and will seek to provide a better understanding of novel options to prevent and control human pathogens on these non-cooked foods.
Impact: Economic considerations and wastewater discharge regulations make water recirculation a common practice in the industry. Few practices have the capacity of water recirculation to increase the potential risk of food-borne illness by readily distributing a point source contaminant (one lot, one bin, or even one plant) to non-contaminated produce. Disinfection of water is a critical step to minimize the potential transmission of pathogens from a water source to produce, among produce within a lot, and between lots over time. Water-borne microorganisms whether postharvest plant pathogens or agents of human illness can be rapidly acquired and taken up on plant surfaces. Natural plant surface contours, natural openings, harvest and trimming wounds, and cut surfaces during processing can serve as points of entry for microbes. Within these protected sites, microbes are largely unaffected by common postharvest water treatments such as chlorine, chlorine dioxide, ozone, peroxide, peroxyacetic acid, UV-irradiation and other approved treatments. It is essential, therefore, that the water used for washing, cooling, transporting, postharvest drenches, process handling be maintained in a condition suitable for the application. Accurate monitoring and recording of disinfection procedures is an important component of a sound postharvest quality and safety program during product cooling and processing. Progress to Date: Significant progress has been made in characterizing the applicability of redox potential as a single value measurement of the microbial quality of water in cooling and fresh-cut handling applications. Studies were conducted to

support the preliminary development of water disinfection strategies that utilizes Oxidation Reduction Potential (ORP in mV) as the determinant criteria for manual treatment or automated injection of a sanitizing agent, such as sodium hypochlorite (NaOCl). ORP values of >650 mV suppressed the accumulation of microbial population densities in recirculating reservoir water at a level at least 1000-fold, or 3 log cycles, lower than a nonchlorinated system with an essentially comparable daily commodity flow. The impact of turbidity, conductivity, and specific commodity leachates during fresh -cut processing are being evaluated. The relationship between ORP and free chlorine under diverse conditions are being determined. In addition, ORP and antimicrobial relationships are being developed for chlorine dioxide, ozone, peroxide, and peroxyacetic acid with Salmonella, Listeria, E.coli, various plant pathogenic bacteria and fungi, and environmental microbes in irrigation and process water. This information and research is helping to define parameters for design and implementation of Good Agricultural Practices and future research needs to improve microbial food safety programs. A survey of five commercial packing and minimal processing operations confirmed that ORP was a valid process control criteria for monitoring and documenting the bacteriological status of the agricultural water being treated with hypochlorite and chlorine dioxide formulations. This relationship was less suitable for ozone and peroxide-based oxidants. Field based research and commercial demonstration trials on management and reduction of water-borne contamination that contacts fresh produce is critically needed to guide the industry in developing effective programs in food quality and safety. This research has had a positive effect in building awareness of the need to develop and implement process and commodity-specific Good Agricultural Practices for microbial food safety. Implementation of improved practices and better documentation and record-keeping are leading to standardizing protocols for water disinfection. New findings and recommendations are being broadly disseminated in trade journal publications, workshops, extension bulletins, and electronically.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AL, AR, CA, FL, GA, IL, IA, LA, MD, MI, NYC, OK, PA, TN, USDA/ARS

Theme: 2.09 Foodborne Pathogen Protection
Title: Physiological and Biochemical Responses of Fruits to Controlled Atmospheres
Description: Objective: To investigate the mode of action of oxygen and carbon dioxide on postharvest physiology and compositional changes of fruits in relation to their quality maintenance and postharvest life. Postharvest-life of fresh fruits based on flavor is shorter than that determined by appearance and textural quality. The purpose of this project is to identify the optimum atmospheric composition to maintain flavor and nutritional quality of fresh fruits.
Impact: We evaluated the efficacy of atmospheric modification in controlling decay and maintaining quality of "Wonderful" pomegranates kept at 5, 7.5 or 10C during the first season using air, 2 kPa O2, air + 10 kPa CO2, and 2 kPa O2 + 10 kPa CO2. During the second season we tested the following atmospheres at 5 and 7.5C air, 5 kPa O2, air + 10 kPa CO2, air + 10 kPa C O2 + 15 kPa CO2, 5 kPa CO2 + 10 kPa CO2, 5 kPa O2 + 15 kPa O2 . We found that it is possible to store pomegranates at 7.5C in 5 kPa O2 + 15 kPa CO2 for up to 5 months, provided that the level of latent fungal infections at the time of harvest is low and that pomegranates are sorted carefully after harvest to store only fruits that are free from defects and decay. CO2-enriched atmospheres resulted in higher concentrations of acetaldehyde, ethanol, and ethyl acetate, especially after 4 and 5 months of storage. Accumulation of these volatiles was greater at 7.5C than at 5C, but in both cases the highest concentrations were below the threshold values for detection of off-flavors. Production of ethanol increased sharply in grapes kept in 45 kPa CO2, 0.25 kPa O2, and their combination, and remained relatively constant after transfer to air. In

contrast, rate of acetaldehyde production in grapes kept in the same atmospheres remained relatively low during the 12 day exposure, but increased several fold after transfer to air. The superatmospheric O2 atmosphere (80 kPa O2) did not induce ethanolic fermentation in grapes compared to the air control. Activities of pyruvate decarboxylase a (PDC) and alcohol dehydrogenase (ADH) increased in grapes kept in 45 kPa O2 and the combination of 0.25 kPa O2 + 45 kPa CO2, but not in the 0.25 kPa O2 atmosphere. Northern blot analysis revealed that all 3 ADH genes (adh1, adh2, and adh3) were expressed in grapes kept in all treatments throughout the 15-day storage period with adh2 being the predominant gene. These biochemical and molecular data suggest that it is likely that the regulation of adh gene expression may be through post-transcriptional or post-translational control. Also, adh may exist in either homo- or heterodimeric forms in order to be active at particular times under particular atmospheres. The rapidly expanding pomegranate industry in California is using the results of our research in controlled atmosphere storage of pomegranates (5% O2 + 15% CO2 at 7.5C and 90-95% relative humidity) to extend their marketing period. Some of the banana marketing companies are using the results of our research in delaying ripening of partially- ripe bananas by keeping them in 2-4% O2 + 8-12% CO2 at 14C and 90-95% relative humidity (modified atmosphere packaging).
Funding Source: Hatch 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. Twenty-five percent of California's children live below poverty level, 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. Breast feeding practices of Southeast Asians, childhood obesity and anemia prevention are a few of the areas being worked on that will impact the health and nutritional status of Californians. Specifically, our work has provided an understanding of the effects of environmental toxicants on health; increased our understanding of the biological basis of obesity; investigated the farm policy impacts on food production and consumption, nutritional intakes, and producer and consumer welfare; developed and tested strategies to diagnose, prevent and correct deficiencies in iron and zinc; found that the conversion of carbohydrate to fat (triglyceride) by the liver is a determinant factor for the lipid profile and that fish oil improves the lipid profile by reducing hepatic conversion of carbohydrate into fat in both lean and obese human subjects; developed a machine system to process tubs of grapes allowing evaluation of a system for hand picking grapes without having to manually lift and carry them to a larger container; completed studies on the effect of zinc supplementation on young children's growth, the effects of varied levels of zinc fortification on the acceptability of wheat products, and absorption of zinc from wheat products fortified with either zinc oxide or zinc sulfate; found that food insecurity is positively related, and specifically for this sample of Latino women in California, those who were food insecure were more likely to be overweight than those who were food secure; assessed the prevalence, causes and consequences of vitamin B-12 deficiency in

Latino elderly (>65 years) in the Sacramento, CA region; found that a greater emphasis must be made to educate women about the need for optimal iron intake during pregnancy and that appreciation of the health significance and causes of iron deficiency and iron deficiency anemia by members of the medical community is needed; and found that incorporating dietary fiber into foods and meals is beneficial for enhancing the satiety associate with low fat foods and blunting the insulin response to meals. A food such as almonds, which has been avoided because of its fat content, was shown to contribute to lowering cardiovascular risk when incorporated appropriately into the diet.

Thirty-eight local extension programs were delivered in this area. In addition, four statewide collaborative workgroups composed of both AES and CE academics planned and conducted research and extension projects. In addition, UC ANR has one Statewide Special 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 101 peer-reviewed articles and 13 extension publications to address Goal 3 and one patent was issued that addressed Goal 3.

UC-DANR's Human Resources Programs Covering:

- **Human Health and Nutrition**

Research and Extension Performance Goals:

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

FY 2002-2003 Allocated Resources

Extension Federal Funds (Smith Lever	Extension State Match	Research Federal Funds	Research State Match
$515,221	$4,146,331 [28.82 FTE]	$318,343	$3,621,868 [15.28 FTE]

Theme: 3.02 Human Health
Title: California Agricultural Ergonomic Intervention Project
Description: Objectives: To describe and prioritize landmark ergonomic risk factors and hazards for musculoskeletal injuries in the agricultural industries; apply biomechanical, metabolic, and postural stress analyses to prioritized hazards; evaluate previously validated task and tool modifications; develop task and tool modifications for high-risk tasks identified by detailed ergonomic analysis to eliminate or significantly reduce hazards; conduct cooperative task and tool intervention trials; evaluate intervention trials and communicate project findings to industry and other agricultural industry groups. Labor intensive agriculture is known to be more hazardous than general industry with respect to musculoskeletal injuries, and Washington State reports that between 1990 and 1997, 27 percent of all workers' compensation claims and 46 percent of the cost of all claims resulted from non-traumatic musculoskeletal disorders. It appears that removing most of the lifting tasks from manual grape harvest improves crew productivity, and probably also reduces ergonomic hazard levels.

Impact: Hand harvest work in wine grape vineyards is physically demanding and exposes workers to a variety of ergonomics risk factors. Analysis of these exposures together with data on reported work-related injuries points to risk of back injury as a priority for preventive effort. Among back injury risk factors identified, lifting and carrying tubs of cut grapes (weighing up to 80 lbs) during harvest is a priority concern. The use of smaller picking tubs to lighten loads lifted and carried to below 50 lbs (from 57 to 46 lbs average) was shown to result in five-fold reduction in workers' post-season MSD pain and symptom scores (p less than .001) without significant negative effect on productivity. Over 2000 smaller tubs were used this picking season, indicating rapid adoption of past research. This season, a machine system processed over 10,000 tubs of grapes allowing evaluation of a system for hand picking grapes without having to manually lift and carry them to a larger container. Worker acceptance was excellent, and commercial companies are currently designing a similar machine.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Control of Neural Crest Cell Emigration
Description: The objective of this research is to determine the mechanism by which the neural crest cells detach from the neural epithelium. We hypothesize: 1) that neural crest cells detach from the neural epithelium as a result of asymmetric mitoses and 2) that this process is regulated by Wnt signaling. The neural crest is a population of cells that detaches from the dorsal portion of the neural epithelium by a process known as an epithelial to mesenchymal transformation (EMT). I have purposed in the current grant to test the idea that the EMT is a result of an asymmetric mitosis that generates one cell that leaves the neural tube (the neural crest cell) and another cell that remains behind in the epithelium tethered by way of adherens junctions. I proposed first, to directly visualize this process using confocal microscopy and second, to test the idea that Wnt signaling controls whether a cell division will be symmetric or asymmetric. In the current year of the Hatch grant we have looked in detail at the role of Wnt signaling in the development of the neural crest. We can over express Wnts and see an increase in the number of neural crest cells, whereas when we inhibit Wnt signaling we see a decrease in the number of crest and a loss of the pigment cell lineage. We have also looked at the effect of Wnt signaling on the expression and function of the transcription factor, slug. We have shown that slug expression triggers the EMT by causing a loss of cell polarity in the neural epithelium and an increase in cell division. We are currently assessing whether these cell division are symmetric or asymmetric.
Impact: Understanding the EMT will not only elucidate the molecular and cellular mechanism for a fundamental developmental process that is often affected in numerous children with birth defects, but may also give us clues about the same cellular process that goes awry in many pathological diseases such as cancer.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Degradation of Agricultural and Natural Toxins Present in Livestock Feed and Forage
Description: Characterize enzymes in the alpha/beta hydrolase fold family of detoxifying enzymes in livestock species to avoid xenobiotic interaction leading to toxicity. Objective II. Develop rapid biosensors for the detection of pesticides, mycotoxins, bioterrorism agents and other foreign compounds in feed and forage.

This project covers the use of accelerator mass spectrometry (AMS), xenobiotic metabolism in mammals, and biosensors for pesticide detection. We continue to pioneer the use of AMS in biology. Work is progressing on the use of AMS for human metabolism of the pyrethroid permethrin. Our studies of mammalian epoxide hydrolases have taken us toward the discovery of a new branch of the arachidonate cascade and a new class of chemicals that promises to reduce high blood pressure, vascular inflammation, coronary artery disease and end target damage from diseases like diabetes. We have found that the N-terminal domain of the epoxide hydrolase is a lipid phosphatase suggesting the presence of a new regulatory kinase/phosphatase pair. We have developed a new class of surrogate substrates for the study of the esterases that degrade pyrethroid insecticides. We continue to develop rapid immunoassays for a variety of pesticides. An assay for paraquat is being used in the largest human exposure study ever run with this pesticide. We are using optical transducers to enhance the sensitivity and speed of immunoassays for monitoring human and environmental exposure to pesticides.
Impact: Safe use of permethrin to control the important vector, sand fly, will be critical to any military action in the Middle East. Thus the work on human metabolism and exposure is critical. Epoxide hydrolase inhibitors are being examined by several pharmaceutical companies for the possible treatment of human disease. Immunoassays developed at UCD are in wide use for monitoring a variety of materials from pesticides through mycotoxins and genetically modified organisms.
Funding Source: Animal Health and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Effects of Fish Oil on Hepatic Lipid and Carbohdrate Metabolism in Healthy Human Subjects
Description: Proposal # 199900651 The overall aim of this proposal is to investigate the mechanism by which (n-3) fatty acids affect hepatic carbohydrate and fat metabolism in healthy subjects. The interplay between glucose production, de novo lipogenesis, and VLDL-TG production will be the main focus. The hypothesis that (n-3) fatty acids reduce de novo lipogenesis and TG levels will be tested, and the regulatory role of de novo lipogenesis on glucose homeostasis will be investigated. Specifically, we hypothesize that the during high gluconeogenic substrate fluxes to the liver (carbohydrate rich diet containing fructose) the rate of gluconeogenesis is regulated by diversion of gluconeogenic precursors into de novo lipogenesis. This process, hepatic autoregulation, which prevents sharp rises in glucose production, will lead to increases in de novo lipogenesis and possibly hypertriglyceridemia. We hypothesize that when (n-3) fatty acids are ingested in presence of a high hepatic gluconeogenic precursor flux the increase in gluconeogenesis and hepatic glycogen fluxes will be proportional to the decrease in lipogenic fluxes. To test this hypothesis, the relationship between the flux of precursors and the rates of gluconeogenesis and de novo lipogenesis will be compared in healthy subjects eating a carbohydrate rich diet containing fructose. The specific aims are to determine if an increased availability of gluconeogenic-lipogenic substrates leads to hypertriglyceridemia and if inhibition of de novo lipogenesis leads to a decrease in VLDL-TG production and consequently to an increase in the rate of gluconeogenesis, hepatic glycogen and possibly glucose production. Overnight fasted healthy subjects will be studied before and after a 5-hour infusion of fructose, a lipogenic and hypertriglyceridemic carbohydrate. The interplay between de novo lipogenesis and gluconeogenesis will be determined by comparing the effect after fish oil supplement versus placebo (3 weeks at home and 1 week as inpatient with a controlled high carbohydrate diet). The following experiments will be performed: b) The rate of glucose production, gluconeogenesis

and de novo lipogenesis will be measured in post-absorptive healthy subjects before (basal state) and after a 5-hr infusion of fructose. c) The measurements will be made once after four weeks of daily supplement with placebo and repeated after four weeks of daily supplement with (n-3) fatty acids. These studies will determine the importance of de novo lipogenesis in the synthesis of VLDL-triglyceride and its potential role in glucose homeostasis. Furthermore, our proposal will clarify the mechanism leading to lower triglyceride level and potential higher hepatic glycogen stores after a diet containing (n-3) fatty acid in healthy human subjects. Thirty years ago, Bang and colleagues observed that Eskimos rarely developed cardiovascular disease, even though their diets were high in fat and cholesterol. Large scale studies confirmed that the frequency of cardiovascular disease was much lower in Eskimos who consumed their traditional foods when compared to populations consuming Western diets. This difference was not explained by the quantity of dietary fat (similar in the Eskimo and Westerners) but the source of fat (fish versus land animal and plant, respectively). These observations sparked extensive investigations, which determined that the beneficial effects could be attributed to the fish oil. It is now recognized that fish oil has a wide range of biological effect on blood fat, platelets, blood clotting, blood pressure and others, with the potential to protect against the risk of cardiovascular disease. More specifically a particular blood fat called triglyceride which is associated with cardiovascular disease can be reduced by 20 to 40%. At present although fish oil has a recognized effect on lowering triglyceride levels it is not known how this effect operates and the consequence of this effect on liver glucose metabolism. We propose that: 1) The reduction of triglyceride by fish oil is due to a reduction of the conversion of carbohydrate to fat in the liver. 2) Fish oil may increase glucose synthesis and production by the liver. To find out whether this proposal is true, we will measure the synthesis of fat and glucose in healthy subjects when they are receiving either fish oil or a placebo in their diet.
Impact: Hypertriglyceridemia is an independent risk factor for cardiovascular disease. Fish oil supplementation reduces normal to high triglyceride levels in human subjects. In this study we determined that one mechanism leading to the lowering effect of fish oil on triglyceride level is reduced conversion of carbohydrate to triglyceride by the liver. This was observed in lean healthy subjects and obese with high insulin and triglyceride levels. Fish oil also promoted significantly more fat oxidation in lean healthy subjects, but this effect was not observed with the obese subjects with high insulin levels. Finally, a major finding was the critical role of the conversion of carbohydrate to triglyceride by the liver in raising the blood triglyceride levels. Thus high carbohydrate diet and simple sugars lead to a higher conversion of carbohydrate to triglyceride and this contributes to high triglyceride levels. Conversely, fish oil reduces the rate of this conversion with lowering of blood triglyceride levels. These results suggest that the conversion of carbohydrate to fat (triglyceride) by the liver is a determinant factor for the lipid profile and that fish oil improves the lipid profile by reducing hepatic conversion of carbohydrate into fat. This is true for both lean and obese human subjects.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Identification of Genes Causing Obesity or Diabetes in Response to High Fat Diets
Description: Identification of specific genes that influence response of humans and domesticated animals to high fat diets will provide novel tools useful for many purposes. These genes may be targets for drug therapy. The genes may identify pathways where others genes are targets for drug therapy. Obesity and diabetes genes may be used to identify specific individual causes for obesity or diabetes, that is, why is this person or animal obese or diabetic. At the most

basic level, knowledge of obesity and diabetes genes will provide a better understanding of the mechanisms by which body fat and diabetes are regulated. Finally, identification of genes mediating diet response can also be used to test diets - that is, which diets activate pathways that will lead to obesity or diabetes. This information could be useful in formulating dietary recommendations. Identification of candidate genes: This year we identified the hemochromatosis gene as an obesity gene by quantitative PCR of adipose tissue mRNA from lean and obese mice. Progress on Aim 2 - testing the roles of candidate genes. We have now shown that the lipin-3 gene is not responsible for obesity in the BSB mouse model. BSB mice are produced by the backcross of (C57BL/6J x Mus spretus) F1 x C57BL/6J. These mice exhibit a range of obesity from 1 to 50% percent of body weight as fat. We have shown that a region on chromosome 2 contains a gene responsible for some of the obesity in this model. We constructed two congenic strains containing spretus donor chromosomal alleles on a B6 background for the chromosome 2 obesity locus. Both congenic strains contained the spretus alleles for lipin-3, but only one had a significant obesity phenotype when compared to the B6 background strain. Thus, lipin-3 is NOT responsible to the chromosome 2 obesity. However, we continued to test the role of another chromosome 2 obesity candidate gene, the lipopolysaccharide binding protein (LBP). We demonstrated that LBP is overexpressed in the adipose tissue of obese mice last year. This year we examined obesity phenotypes in LBP knockout mice. We have now shown that LBP knockout mice are statistically significantly leaner than the wild type background strain mice. Thus, we have confirmed that LBP is an obesity candidate gene.
Impact: This work identifies genes that might cause obesity and also provides evidence that one of them, LBP is a differentially expressed obesity causing gene. LBP is particularly interesting because it also influences inflammation and response to endotoxin. These results may lead to better understanding and treatment of a chronic problem and its co-morbidities.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Innate Immune Systems of Long-Lived Invertebrates
Description: Characterize the functions of the immune effector moelcules alpha sub 2-macroglobulin and limulin in lobster and horseshoe crab. The innate immune system recognizes generic pattern molecules on the surfaces of invading microbes and attacks these as part of immune defenses. One of the important targets is lipopolysaccharide (LPS, endotoxin), which is the toxic molecule of Gram-negative bacteria. Although generally considered a product solely of Gram-negative bacteria and cyanobacteria, a LPS-like homologue has recently been described from a eukaryote, the green alga Chlorella. This year I developed a novel immunostaining procedure to detect LPS in cells that involves the binding of the LPS-binding protein, LALF, which is isolated from the immunocytes of the horseshoe crab. LALF is then visualized with an anti-LALF antibody. I see strong staining of the outer membrane of Gram-negative bacteria (positive control), and similarly strong staining of the surface of the green alga, Chlorella, a eukaryote. This is the first demonstration that a LPS-like molecule is present at the surface of any eukaryote and is strong evidence that LPS is not restricted to the Gram-negative bacteria, but is found in addition in certain eukaryotes. During the coming year, I plan to apply this method to look for LPS in higher plants. The genome project for Arabadopsis has shown that that species has all of the enzymes required for biosynthesis of lipid A, the signature component of LPS.
Impact: LPS is of major medical importance. Approximately 100,000 Americans die every year of Gram-negative sepsis, essentially from acute LPS poisoning. It has its own scholarly society

and its own dedicated journal. Demonstration that plants have LPS is of major interest and importance. It will be of interest to discover its localization in higher plants and its function.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Mammalian Circadian Rhythms
Description: Although the general objectives of the project are quite broad, the immediate objectives focus upon two specific projects: 1) the effect of environmental parameters such as the light-dark cycle and ambient gravitational field on the homeostatic and circadian regulation of sleep, body temperature and performance; 2) the effect of gender on the responses to the various environmental stimuli. This research program has made significant progress in examination of the mechanisms underlying the response of the circadian timing system (CTS) of primates to altered gravity. We have also instituted studies of sleep in a primate model for human sleep. The forced desynchrony protocol has been, for the first time, applied to determining how the CTS responds to altered gravity. Using chronic centrifugation at low G levels, we have compared the endogenous periodicity of the CTS at two G levels with normal earth gravity. Preliminary analysis showed that the period of the body's clock is longer with increased G level. Further, the amplitude of the body temperature rhythm is depressed by increased G load. Sleep was also affected by increased G. Fragmentation of sleep was seen after acclimation to 2G. Increased deep (slow-wave) sleep was also seen. We have also initiated studies of the ability of the CTS to entrain to altered day length with both solar and simulated martian lighting spectra. Determining how the CTS can adapt to altered day length will be crucial to extending the ability of humans to function in isolation from the normal 24-h day. This has implications for both isolated terrestrial environments (polar, submarine) and extra-terrestrial environments such as space craft and contained habitats. These and subsequent studies will contribute to known problems with sleep and circadian timing associated with space flight and provide a groundwork for maintenance of satisfactory health and performance for planetary exploration.
Impact: Our studies relate directly to human welfare and agricultural production. Circadian rhythms in human physiology and performance are critical to health. Identifying underlying regulatory mechanisms of the circadian clock, and their relationship to the environment could lead to treatments that promote health and well being. Similarly, the circadian system is critical to agricultural stock growth, reproduction and health. Understanding the role of the environment in this system can have a direct benefit to agriculture.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Mechanisms of Action of Insecticides
Description: Identify the action mechanisms of selected insecticides, several new and established insecticides/acaricides and study the basis of their differential toxicities against mammalian, insect and acarine large proteins. Previously we reported a novel phenomenon that some organochlorine compounds mainly act through activation of c-Neu tyrosine kinase without being strong agonists for the estrogen receptor. In this study we tested the possibility of developing an assay system to identify estrogenic compounds acting through this c-Neu-mediated mechanism. We describe herein an assay that utilized foci formation of MCF7 cells as an endpoint, antibody 9G6 to neutralize the c-Neu-mediated pathway and 4-hydroxytamoxifen to block the ER. Aroclors 1242 and 1248, 2,2',3,5',6-pentachlorobiphenyl (PCB 95),

2,2'dichlorobiphenyl (PCB), cis- and trans- permethrins, and chlorothalonil were found to render estrogenic effects through this c-Neu-mediated mechanism, while alpha and beta endosulfans appeared to act through a pathway independent of the c-Neu-mediated one. Pentachloronitrobenzene was found to be capable of antagonizing the 17Beta-estradiol effect, which has never been reported previously.
Impact: The above finding indicates that those pesticides promote carcinogenic transformation of human breast cells, and thereby support the hypothesis generated by epidemiological evidence that the presence of those long lasting residues in human bodies may be linked to rising incidence of breast cancer.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Metabolic Effects of a High Fructose Diet in Women: Role of Leptin
Description: Objectives: To investigate whether the consumption of high dietary fructose, as opposed to dietary glucose, results in increased weight gain, adiposity, decreased energy expenditure, and increased appetite in moderately overweight post-menopausal women, a population susceptible to adult onset obesity and type-2 diabetes. To examine the relationships between 24-hour circulating insulin, glucose, and leptin concentrations, and muscle and adipose uncoupling proteins in women consuming high fructose versus high glucose diets. To investigate whether consumption of dietary fructose as opposed to dietary glucose results in changes of insulin sensitivity, serum lipids, and blood pressure, which could over a long period of time lead to the onset of co-morbidities associated with obesity, specifically insulin resistance, hyperlipidemia, and hypertension. A renewal proposal was submitted 10-1-02 to the USDA CREES to continue this this study. Eleven subjects (seven on the high fructose diet (HFr) and four on the high glucose diet (HGl)) completed the 14-week protocol. Body Weight and Adiposity: Body weight and adiposity were not affected by the 10 week HGl or HFr diets compared to the eucaloric high complex carbohydrate (HCC) baseline diet. Glucose: Plasma glucose excursions (AUC) were lower after the HFr meals than after the high HCC baseline meals ($p < 0.001$). Insulin sensitivity: Insulin sensitivity as assessed by fast sample intravenous glucose tolerance test (FSIVGTT) was not significantly different for the two groups. However, the baseline FSIVGTT trials in the first cohort of subjects studied did not yield reliable data, and only five sets of trials from the HFr group and two from the HGl group were valid and analyzed. HOMA, an insulin resistance parameter, was calculated using fasting values for plasma insulin and glucose. Insulin resistance in the glucose group tended to decrease over 10 weeks as estimated by HOMA-IR (i.e., insulin sensitivity was improved). In the fructose group, however insulin resistance as assessed by HOMA increased marginally at 2 wks, but not at 10 wks. Hunger and Appetite: There were no significant differences in the AUC for any of the appetite variables measured, most likely because this study was a eucaloric, weight maintenance protocol.
Impact: This study shows that fructose does not stimulate insulin secretion or increase leptin production. Insulin and leptin are important regulators of energy homeostasis and body adiposity. Our data also indicates that fructose increases postprandial triglycerides and apolipoprotein B. These finding suggests that fructose could contribute to obesity and obesity-associated cardiovascular disease.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Molecular Genetics of Human Cell Response to Environmental Carcinogens
Description: Substantial public concern exists over potential exposure to environmental toxins in the State of California. Genotoxic risk, including the potential for carcinogenesis and birth defects, invokes particularly strong concerns. Much of the concern focuses on agricultural chemicals present as residues in produce and in ground water. In addition exposure to background radiation, primarily from radon gas in residential settings, may be the causative agent in up to 10% of all lung cancers and 30% of lung cancers in non-smokers. The need to understand the risks that these agents pose to human health is clear. 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. Substantial public concern exists over potential exposure to environmental toxins in the State of California. 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.
Impact: 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. Most studies, including our own previous work, suggest that homologous recombination generally involves only a localized event known as a gene conversion, without associated exchange or cross-over between the arms of the interacting chromosomes. However, in analysis of spontaneous, benzo(a)pyrene diolepoxide (BPDE), or radiation-induced conversion in human lymphoblasts, we observed cross-overs in approximately 15% of the cases. This result identifies an unexpected disparity between the anticipated fraction of recombinational exchanges associated with a cross-over, and those that are actually selected in a chromosomal mutation assay. Furthermore, these cross-overs were associated with complex local outcomes, involving multiple and discontinuous occurrences of conversion. Finally, the conversion tracts associated with cross-over were sometimes quite long, extending more than 1 million bases. These 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. 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: State and Grant
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Novel Technology for Stabilization of Biological Cells in the Dry State
Description: Objectives: (1) To optimize a method for introducing trehalose into cells; (2) to obtain evidence concerning the mechanism for high temperature introduction of trehalose; (3) to scale-up the process for platelets to a full unit size; (4) to test safety and efficacy of freeze-dried

platelets in animal models; (5) to establish the mechanism by which trehalose stabilizes the dry cells; (6) to develop new means for introducing trehalose into cells, using molecular techniques.
Impact: This project is aimed at achieving stabilization of living cells in the dry state. In the past year we have: (1) developed methods for long term storage of human blood platelets freeze-dried in the presence of the sugar trehalose, with a shelf life of two years at room temperature; (2) scaled up the platelet product to full unit volumes, which makes the process clinically relevant; (3) applied some of the same technology to red blood cells, with a view towards long term preservation; (4) established that the rehydrated platelets are full functional and circulate normally. Human blood platelets have a lifetime in blood banks of five days, after which they are discarded. We have extended the lifetime to at least two years, in a form that is applicable clinically to humans. The same technology is being transferred to domestic species, where we expect to find applications in valued domestic animals such as horses and dogs.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Nutrient Induced Mucosal Differentiation by Neuro-Gut Regulatory Peptides
Description: (1) Determine whether the Y1_ and Y2 receptors co-expressed on the same cells in the intestine and does NPY/PYY act through these receptors to regulate CD63 transcripts. (2) Determine whether NPY and PYY regulation of CD63 and other intestinal specific proteins is a function dependent on the extracellular matrix and cellular migration. (3) Determine whether NPY/PYYU effect on cell differentiation and cell migration is through a mechanism involving intestinal CD63. Peptide YY (PYY) is a peptide synthesized in the mucosa of the gastrointestinal (GI) tract. In response to dietary fatty acids PYY is released into the circulation as a hormone that inhibits pancreatic digestive enzyme secretion and gastrointestinal motility. We have discovered that at similar concentrations of this peptide that elicits these responses in whole animals, PYY can regulate intestinal mucosal cell differentiation in GI cells in culture. The receptors for PYY are also shared by neuropeptide Y (NPY), which is a peptide found in central and peripheral nerves. We have demonstrated that NPY can also regulate intestinal epithelial cell differentiation. We have performed studies that indicate that both the action of PYY and NPY occurs by regulating the expression of cytoskeletal proteins and/or proteins that interact with the basement membrane extracellular matrix that are involved in cell adhesion and migration. We demonstrated that NPY and PYY induce actin reorganization in a manner specific to each peptide, and both peptides induce the expression of the differentiation dependent protein markers. This action could occur through a combination of several Y receptors that we cloned from the intestinal cell lines. Messenger RNA subtractive hybridization and microarray analysis of intestinal cells treated with PYY has allowed us to identify responsive genes that code for proteins associated with the extracellular matrix-cytoskeletal interface such as CD63, annexin, and the actin binding protein anillin. Both NPY and PYY induce the expression of the tetraspanin CD63 in intestinal epithelial cells. Cells transfected with antisense cDNA to CD63 failed to differentiate. Thus we have been investigating the mechanism that PYY/NPY could regulate cell differentiation through pathways that intersect with the mode of action of CD63. During the past year we have discovered that one such pathway involves the increase in expression and activity of metalloprotinases that are synthesized in intestinal epithelial cells that coexpress CD63. We are currently investigating if tetraspanin regulation of metalloprotinase activity is a mechanism where by NPY/PYY can induce extracellular matrix remodeling necessary for cell migration and differentiation. Understanding the mode of action of these proteins will help establish, for the first time, a mechanism whereby neuro-gut regulatory

peptides can effect mucosal cell differentiation and provide a link where luminal and neural signals can induce adaptation to environmental factors such as diet and stress.
Impact: The current research may provide insight into the role of nutrients in differentiation, and cell adhesion and migration in the small intestine. Results from these studies could help in the treatment of patients with short bowel syndrome and other intestinal disorders.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Physiological Activities of Chemicals in Natural Plants
Description: Objectives: To isolate and identify physiologically active principles of plants such as barley leaves and Aloe leaves in human and animals. To determine the mechanisms of their physiological activities. Volatile components, isolated from 3 species of eucalyptus leaves (Eucalyptus polyanthemos Schauer, Eucalyptus globulus Labill, and Eucalyptus perriniana) and their major volatile components were examined in two different assays for antioxidant activity. The inhibitory effect of the extract and its components toward aldehyde/carboxylic acid conversion was measured for 30 days. Their inhibitory effects toward malonaldehyde formation from lipid oxidized by Fenton's reagent were also measured. The eucalyptus volatile extract (E polyanthemos) inhibited the oxidation of hexanal completely for 30 days at a level of 200 mg/mL and 500 mg/mL. It also inhibited malonealdehyde (MA) formation from cod liver oil by 86% at the 160 mg/mL level. Thymol, 1,8-cineole, benzyl alcohol, and terpinen-4-ol identified in the extract of E polyanthemos inhibited the hexanal oxidation by 100%, 96%, 82%, and 75%, respectively, at the 500 mg/mL level for 30 days. In the lipid/MA assay, thymol, benzyl alcohol, terpinen-4-ol, and 1,8-cineole inhibited MA formation by 80%, 63%, 58%, and 26%, respectively, at the level of 160 mg/mL. Thymol exhibited potent antioxidant activity comparable to that of the known natural antioxidant, a-tocopherol.
Impact: Aroma chemicals identified in this study can be utilized to prevent oxidative damages associated with cancer, arteriosclerosis, diabetes, and immune-deficiencies.
Funding Source: Animal Health and State
Scope of Impact: State Specific

Theme: 3.02 Human Health
Title: Telomere Array Organization and Telomerase Function in Chicken.
Description: The overall objective of the proposed research is to investigate the organization, function and stability of the chicken genome through expanded studies of telomere biology. The specific objectives of the research are to (1) determine the contribution of telomere-driven recombination in enhancing genetic variation in the chicken genome and (2) establish the molecular and cellular features of alternate telomere regulatory factors that impact genome stability in vivo. Specific aims of the grant are to: 1. Determine the nature of telomere recombination in meiotic and mitotic lineages for the purpose of investigating the contribution of telomere-driven recombination in enhancing genetic variation in the chicken; 2. Establish molecular aspects of alternate in vivo genetic mechanisms governing telomere stability in somatic and germ tissues; and 3. Investigate immortalization potential of chicken primary cells in vitro by chTERT transfection. Grant funding was available January 2002. A new graduate student entered the program September 2002 and her thesis project focuses on Aim 1. During the last three months the student learned all of the techniques needed to conduct the research. In December '02 initial experiments to screen all individuals for telomere array profiles were initiated. On the basis of the screening, parents will be selected for matings to study inheritance

of the ultra-long telomeres. A research technician has initiated experiments related to Aim 2. A 3rd year Ph.D. student is conducting experiments related to Aim 3.
Impact: The impact of this research will be to understand and improve our knowledge of mechanisms regulating genome stability in poultry and avian cells. Poultry are a vital part of the U.S. agricultural economy and this research will improve our knowledge of appropriate usages for poultry cells for human vaccine production and therapeutics through biotechnology applications.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 3.03 Human Nutrition
Title: 1% Milk Promotion Increases Sales 43.8%
Description: Milk is an important food for children and adults, providing calcium, Vitamin D and protein as well as helping to prevent osteoporosis. Compared to whole milk, low fat (1%) milk provides all these benefits and also significantly reduces the amount of saturated fat in the diet (8 grams of fat in a cup of whole milk, 2.5 grams in a cup of 1% milk). In children and adults alike, reducing fat in the diet can help prevent overweight and obesity, heart disease, cancer, stroke and type 2 diabetes. This is particularly true in Hispanic population groups, since data indicate Hispanics consume more high-fat milk than non-Hispanics. A recent (2002 and ongoing) community-based social marketing campaign targeting low income Hispanic women with a "1% Milk ...Healthy & Delicious" message was developed by UCCE and other members of the Central Valley LEAN Coalition. Implementation of the campaign involved an array of community partnerships:

- Schools in the targeted zip codes allowed parent education classes with taste tests, a Loteria Bingo game, posters and brochure distribution to all parents.
- Posters and brochures were distributed at local health clinics and doctors' offices.
- WIC, the Fresno County Health Department and Head Start distributed brochures and posters and strengthened their own 1% milk message.
- Local supermarkets displayed posters and shelf-talkers and sponsored taste tests.
- 30- and 60-second Spanish and English TV and radio commercials were developed and run on local stations, and both English and Spanish local newspapers printed articles supporting 1% milk.

All of these activities saturated the environment and reinforced the 1% milk message.
Impact: Pre- and post-campaign milk sales data collected from local supermarkets in the targeted zipcodes demonstrated a 43.8% increase in 1% milk sales during the first four-month campaign. Pre- and post-campaign exit surveys done at the supermarkets with Hispanic women confirmed that behavior had changed...barriers of knowledge about the nutritional advantage of 1% milk had been overcome by the information provided in classes and in the brochures; barriers of taste had been overcome by taste tests allowing people to discover that they liked 1% milk; barriers of habit had been overcome by point-of-sale reminders to purchase 1% milk. Over a life-time, this single behavior change will have a significant impact on the health and well-being of children and adults in California.
Funding Source: Smith-Lever 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 Popluations at High Risk of Deficiency

Description: Objectives: 1. To assess the bioavailability of vitamin A from selected plant sources in Bangladeshi volunteers, using the paired deuterated retinol dilution technique; and to assess the validity of a simplified technique to estimate vitamin A bioavailability, using plasma isotopic ratios of retinol within 1-3 weeks of initiating consumption of a single major source of the vitamin. 2. To assess the efficacy of local plant or animal sources of vitamin A or vitamin A-fortified rice in the treatment of maternal night blindness during pregnancy in Nepalese women. 3. To assess in adult volunteers the absorption of zinc from wheat products fortified with either zinc sulfate or zinc oxide. 4. To assess in Peruvian children at risk of zinc deficiency the net absorption of zinc and iron from wheat products fortified with iron and different levels of zinc.
Impact: During the past year several studies were completed on: a) the effect of zinc supplementation on young children's growth, b) the effects of varied levels of zinc fortification on the acceptability of wheat products, and c) absorption of zinc from wheat products fortified with either zinc oxide or zinc sulfate. In a meta-analysis of 33 trials conducted in pre-pubertal children, we found that zinc supplementation produced highly significant, positive responses in height and weight increments, with effect sizes of 0.350 and 0.309 SD, respectively, and a large increase in serum zinc concentration, with an effect size of 0.820 SD. Growth responses were greater in children with low initial weight-for-age Z-scores, and in those aged >6 mo with low initial height-for-age. In a study of the sensory acceptability of products made from fortified wheat flour, volunteer subjects rated their degree of liking (DOL) for flavor and texture of bread and noodles fortified with 30 mg of iron as FeSO4/kg flour and either 60 or 100 mg of zinc/kg flour, as either ZnSO4 or ZnO. All products were generally well liked and there were no differences among breads and only minor among noodles by type of fortification. In a study of zinc absorption from wheat products fortified with either ZnSO4 or ZnO, healthy adult male volunteers received either low-phytate bread meals or higher-phytate porridge meals once weekly on two occasions. The meals were fortified with one of the two zinc salts (60 mg elemental zinc/kg wheat flour) during week 1 and the other during week 2, in random order. Zinc absorption was assessed using an isotopic tracer and whole-body counting. Zinc absorption from bread was significantly greater than from porridge (13.8% versus 6.4%, respectively), presumably due to the effect of phytate. Controlling for the type of diet, there were no statistically significant differences in the mean zinc absorption from meals fortified with ZnSO4 compared with those that were fortified with ZnO. In addition to the foregoing, zinc-related studies, the data collection phases were completed for one study in Bangladesh adult volunteers of vitamin A bioavailability from carotenoid-containing foods and for another study of the treatment of maternal nightblindness during pregnancy, using locally available, vitamin A-containing foods in rural Nepal. The final results of the latter two studies are still pending. Results of the zinc-related studies indicate that zinc supplementation increases the linear growth and weight gain of children with stunting and/or underweight. Interventions to improve children's zinc nutriture should be considered in populations at risk of zinc deficiency. The population mean serum zinc concentration is a useful indicator of successful delivery and absorption of zinc supplements in children. Zinc fortification is an alternative method for improving population zinc status. Our studies indicate that zinc-fortified wheat products will be well accepted. Either ZnSO4 or ZnO can be used to fortify wheat products consumed by presumably healthy persons.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.03 Human Nutrition
Title: Etiology of Iron Deficiency and Iron Deficiency Anemia Among Children Aged 12-36 Months
Description: Recruitment will take place in person at selected WIC clinics located in selected California counties. Children aged 12-36 months will be recruited from a pool of children visiting selected clinics. Bilingual interviewers (English and Spanish) will meet with the mother of the eligible child and briefly describe the study and ask mother if they would like to participate. If a respondent indicates that he/she would like to participate, interviewers will read them the consent form, have them sign it, and give them a copy. Subjects will also be given the 'Experimental Subject's Bill of Rights' at this time. The parent or guardian of the subject will receive $20.00 after the completion of the interview and blood draws. Blood samples will be processed at the clinic and transported to the Clinical Nutrition Research Unit housed at the UC Davis campus for subsequent analyses. The definition of iron deficiency will be based on 4 laboratory tests of iron status: 1) free erythrocyte protoporphyrin, 2) transferrin saturation, 3) serum ferritin, similar to the approach taken in NHANES III (20), and 4) transferrin receptors. To be considered iron deficient, an individual must have an abnormal value for 2 or more indicators. Iron deficiency anemia will be defined as having iron deficiency and a low hemoglobin value (10). A questionnaire has been developed to collect demographic information, data on acute illness at the time of study or in the previous 2 weeks, maternal iron status, and dietary information including infant feeding history and timing of introduction of foods affecting iron nutriture and lifestyle.
Impact: The objectives of our study were to 1) to assess iron status in a representative sample of children from low-income families, aged 12-36 months, 2) to examine the association of several risk factors with iron status in this group of children. and 3) as a long term goal, the development of a comprehensive nutrition education program to reduce the risk of iron deficiency. Recruitment took place at the Contra Costa Public Health WIC Program in Richmond, Contra Costa County and the WIC clinic in Earlimart, Tulare County. To be included in the data analysis, the subject's mother must have completed the risk factor questionnaire and a venous blood draw obtained from the child. Blood samples used in the analysis included only those without evidence of hemolysis or elevated C-reactive protein. Data from Contra Costa County has been entered into the statistical program, SPSS and initial analysis has been conducted. Data from Tulare County is in the process of being entered into SPSS. In Contra Costa County, Hispanics comprised the highest proportion of subjects, followed by African Americans, Mixed Ethnicities, Asians, Native Americans and Non-Hispanic whites, and others. Approximately 34% of the sample had a family income less than $14,999. The prevalence of anemia in this sample was 12.8%, the prevalence of iron deficiency was 21.5% and the prevalence of iron deficiency anemia was 3.4% The prevalence of low iron stores (defined as serum ferritin concentrations less that or equal to 12 ug/l) was 30%). Iron deficiency was defined as serum ferritin concentrations less than or equal to 12 ug/l and transferrin saturation less than 16%. The percentage of iron sufficient and iron deficient subjects who utilized several food assistance programs was similar except for the use of Food Stamps; 24.8 % of the iron sufficient subjects utilized foods stamps compared to only 9.4% of the iron deficient subjects. Maternal anemia was associated with iron deficiency in the child as 38% of the mothers of children with iron deficiency were diagnosed with anemia during their pregnancy compared to 21% of the mothers of children who were iron sufficient. The majority of mothers, approximately 78%, in this sample had breast-fed their infants. There were no differences between groups with respect to breast-feeding. In contrast, current bottle feeding practices were associated with iron deficiency, with approximately 85% of the iron deficient children compared to 50% of the iron sufficient children currently using a

bottle. Similar, to what we observed with maternal anemia, 38% of the children with iron deficiency compared to 18% of the children who were iron sufficient had been previously diagnosed with anemia. In summary, results to date demonstrate a prevalence of anemia of 12.8%, iron deficiency of 21.5% and iron deficiency anemia of 3.4%. In addition, factors associated with iron deficiency included: 1) lack of participation in the food stamp program, 2) pre-term delivery, 3) maternal anemia, 4) prior diagnosis of anemia in the child, and 5) current bottle feeding practices. Efforts should be made to provide information to this target population regarding the potential positive health implications of participation in the food stamp program. A greater emphasis must be made to educate women about the need for optimal iron intake during their pregnancy. Appreciation of the health significance and causes of iron deficiency and iron deficiency anemia by members of the medical community is necessary. These data are being used in an education program provided by 4 California counties.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.03 Human Nutrition
Title: Food Production and Consumption, Nutrition, and Agricultural Policy
Description: The goal of this project is to conduct careful and comprehensive economic and econometric analyses that coherently combine economic theory with empirical practice to analyze domestic farm and food policies and proposed policy changes. As a result of this research, then, we hope to draw reasonable and logically consistent inferences based on the model estimates regarding the year-to-year and cumulative U.S. farm policy impacts on food production and consumption, nu-tritional intakes, and producer and consumer welfare. The primary objectives are: (1) to develop, estimate, and analyze models of food production and consumption; (2) to carry out analyses of the effects of farm policies on producers and consumers; and (3) to develop, estimate, and analyze models related to agricultural commodity programs in the United States, the effects on farm production and input use, and the impacts of significant changes in existing policies on the farm and other sectors of the U.S. economy.
Impact: Flexible, theoretically consistent, and econometrically stable models of consumer demand incorporating demographic data and the distribution of income were derived, estimated, and analyzed. Strict exogeneity of food expenditure in the demands for food is resoundingly rejected. Separability of foods from all other goods is rejected. The period between 1942-1946, which accounts for substantial structural shocks relative to the rest of the 20th century, was omitted as a result of specification tests for parameter stability and model specification errors. We analyzed the impacts of several common types of taxes on the production and storage decisions for products whose quality improves with age. All taxes assessed on storage reduce the quality of such goods. All forms of tax considered reduce the quantity produced. Volumetric retail taxes are found to increase the length of the storage period, and therefore the average quality of goods marketed. We analyzed the impact of subsidizing multiple peril crop insurance on the quantity of output, quality of marginal land in production, and total acreage under production. Increases in the subsidy rate are found to increase the extensive margin and the total supply of agricultural products, and negatively impact the environment. Once these commonly ignored empirical errors described above were taken into account, U.S. per capita food demand in the 20th century was found to be entirely consistent with economic theory, making this study the first among thousands to develop a statistically sound, theoretically consistent empirical model of consumer choice.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.03 Human Nutrition
Title: Improving iron/zinc nutrition
Description: Objectives: 1- Develop new methods applicable to the study of iron and zinc nutrition focusing in underprivileged populations. 2- Apply new methods to the evaluation of possible iron and zinc fortificants of foods for human populations. 3- Encourage the development of new plant varieties with desirable properties as sources of bioavailable iron and zinc, and evaluate them in different systems including humans. 4- Evaluate the efficacy and safety of different schemes and doses of iron supplementation and foster those that appear more effective and safe. 5- Study the mechanisms of iron absorption, regulation, utilization and safety in a rat experimental model with different iron status and receiving various iron supplementation schemes. This includes the functional characterization of early iron overload conditions. Iron and zinc deficiencies are highly prevalent and impair health and human development (individual and societal). Several strategies to diagnose, prevent and correct deficiencies are being developed and tested for efficacy and safety.
Impact: We have begun a series of studies exploring the bioavailability of different iron chelates using in-vitro dialysis techniques after simulation of gastric and intestinal digestion phases as well as using intestinal cell cultures and intestinal loop perfusions in rats. So far our results indicate that NaFeEDTA is the preferred iron chelate regarding iron absorption. We have conducted a study on daily iron supplements administered together or separate from zinc supplements in pregnant and lactating women, measuring both iron and zinc absorptions and metabolism by means of stable iron and zinc isotopes. This work is in collaboration with the WHNRC/USDA center at UC Davis. The objective of the study is to determine the effects of iron supplements on iron and zinc metabolism. We have finished the clinical phase of this study and are proceeding to complete all biochemical analyses. Our active collaboration with researchers from Molecular and Cell Biology has continued during 2002 in the study of iron-induced oxidative stress and oxidative damage following our human and animal experimental models of daily and intermittent iron supplementation. We have finished analyzing mitochondrial DNA breakages using real-time PCR and 8-oxo DG determinations by HPLC in DNA isolated from buffy-coat from the human studies we have performed comparing daily and weekly iron administration. Results: women receiving weekly iron as well as controls not receiving iron show the same degree of DNA breakage. Women receiving daily iron show very variable levels of DNA damage probably because of possible defects in sample storage and problems with DNA isolation. We will repeat a group of women on daily iron supplementation. We have continued our collaboration with Dr. E. Casanueva at the Instituto Nacional de Perinatologia in Mexico City on the relative effectiveness and safety of weekly and daily iron supplementation to pregnant women. The administration of 60 mg of iron daily to non-anemic women results in elevated hemoglobin levels associated with a higher prevalence low birth weights and premature deliveries. These undesirable effects are rare in women receiving weekly supplementation. We have repeated the study administering iron twice weekly. Results are similar as with weekly supplements. The infants of the mothers in this study are being followed for up to 6 months of age to determine their developmental characteristics. Lastly, we continue our collaboration with Drs. J.M. Ceriani, R. Schwarcz, C. Lomuto, G. Carroli and M.dC. Morasso in Argentina. We conducted a study on 3.738 deliveries to determine the practice of cord ligation. The average time for cord clamping is 25 seconds, but obstetric services that have read our publication on this matter have a significantly longer time of cord clamping benefiting the infants. We have continued to prove that daily iron supplementation as currently recommended is not innocuous, and that the intermittent administration of iron supplements is

safer and as effective as daily supplement administration. We have also continued to explore in depth iron-zinc supplementation in pregnancy and the choices of iron compounds for food fortification of populations. These studies may open new avenues for overcoming iron deficiency safely, including changing the practice of umbilical cord ligation for the benefit of infants' iron nutrition.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.03 Human Nutrition
Title: Prevalence and Consequences of Vitamin B-12 Deficiency in Elderly
Description: Our goals are to determine the prevalence, causes and consequences of Vitamin B-12 deficiency in 2000 Hispanic elderly in Sacramento, California. The association between Vitamin B-12 deficiency and dementia, cognitive function and hyperhomocysteinwmia will also be evaluated, as will the response of these outcomes to treatment with Vitamin B-12.
Impact: The objectives were to assess the prevalence, causes and consequences of vitamin B-12 deficiency in Latino elderly (>65 years) in the Sacramento region. A total of 1789 participants were enrolled. Of these participants, 6% had severe vitamin B-12 deficiency (Deficient, plasma B-12) The ability of beta-carotene to serve as a precursor of essential retinoids is highly variable among individual humans and largely unknown. So we devised a way to reliably assess the vitamin A value of orally administered beta-carotene relative to a co-administered reference dose of preformed vitamin A using a variety of isotope tracers. We found that 8.5 moles (16 g) of beta-carotene would provide a vitamin A quantity equivalent to 1 mole (1 g) of preformed vitamin A. We also found that the bioavailability of beta-carotene was 55 %. However, results from more subjects were needed to assess the general utility of our method. So we measured the intrinsic variability in the vitamin A activity of beta-carotene among healthy, well-fed adults living in a controlled environment. The mean bioavailability of beta-carotene in 12 subjects was about 5%, and the mean conversion ratio was 0.054 +/- 0.01 mol retinol to 1 mol beta-carotene. We concluded that the vitamin A activity of beta-carotene, even when measured under controlled conditions, can be surprisingly low and variable. Worldwide, blindness due to vitamin A deficiency especially in children is a major public health issue. While it can be ameliorated with vitamin A supplementation the margin between efficacy and safety is very narrow (the narrowest for all nutrients). Therefore, increased intakes of beta-carotene (that is not toxic and can serve as a precursor of vitamin A) has become popular and carotene rich plants have been engineered to increase human intake of this precursor source of vitamin A. The success of this approach will depend on ensuring plant carotene will yield sufficient vitamin A for human needs especially children; normally born with minimal vitamin A reserves.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 3.03 Human Nutrition
Title: The Relationship of Poverty, Food Security, and Food Assistance to Child Nutrition in Latinos
Description: The objectives of this research are to: 1) examine the validity of the 18-item Core Food Security Module (CSFM) in Latinos, particularly farm workers and immigrants; 2) examine factors related to participation in food assistance program and food insecurity in Latinos; 3) examine the relationship of seasonal fluctuation in food security to dietary variables; and 4) examine the relationship of food security to child growth.

Impact: During the past year, analysis continued with the dataset compiled in 2001 from the cross-sectional survey of 561 Latino households. Three manuscripts (# 2, 3, 4) were prepared and submitted to journals summarizing the data from this study. Another household food security survey was conducted in Mexico over the summer of 2002. In manuscript #2, we report data on the validity of using the 18-item food security supplement (FSS) in Latino households, residing in California. After controlling for confounding variables, greater food insecurity was significantly related to lower household food supplies of grains, dairy, meat, fruits, and vegetables. Food insecurity was not related to participation in the Food Stamp program and/or the Women, Infant, and Child Nutrition (WIC) program. However, WIC participation was associated with a greater variety of fruit in the household ($p < 0.04$). Manuscript #2 reports the data from four focus groups conducted among low-income Latino households. In addition to unemployment, farm workers identified lack of transportation and nutrition education as important factors contributing to food insecurity. Compared to the situation in Mexico, most people felt more food secure in the U.S., partly due to the availability of food assistance programs in this country. In manuscript #4, we examine the relationship between food insecurity and body weight in this population. Household food insecurity (previous three months) was related to mother's overweight ($p = 0.02$) but not to children's body mass index > 95th percentile ($p = 0.25$). Mother's past food insecurity was marginally related to her current overweight ($p = 0.08$) and to children's body mass index > 95th percentile ($p = 0.04$) but was not significant in the final models controlling for current food insecurity. Using logistic regression, the likelihood of being overweight was significantly greater for mothers who were food insecure without hunger (odds ratio 1.6, CI 1.0 2.5, $p = 0.04$) and food insecure with hunger (odds ratio 2.0, CI 1.1 3.9, $p = 0.04$) compared to those who were food secure. In addition, the likelihood of being obese was 2.1 times greater for mothers who were food insecure with hunger compared to those who were food secure. In a new study carried out in collaboration with the University of Guadalajara, we have collected food security data from 107 families living in rural Mexico. The purpose of this study was to conduct further validation of the 18-item food security instrument in a different population of Latinos. Although the magnitude of the problem is much greater in Mexico (20% severely food insecure in Mexico vs. 3% in California), the pattern of affirmative response to the 18-item food security supplement is similar in both populations. In addition, greater food insecurity in Mexico is correlated with lower household food supplies of animal source protein. In the next year, we will continue to analyze this dataset. Our research indicates that use of the 18-item food security instrument is valid among Latinos of Mexican descent. Our findings also suggest that food insecurity is positively related to overweight, and specifically for this sample of Latina women in California, those who were food insecure were more likely to be overweight than those who were food secure. We did not find food insecurity to be a risk factor for early childhood overweight among the preschoolers in this sample.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 3.03 Human Nutrition
Title: Role of n-3/n-6 Polyunsaturated Fatty Acids in Health Maintenance
Description: Objectives: 1) reduce the risk of cardiovascular disease and cancer
Impact: Accomplishments for this project include: In human subjects a medical food containing fish oil lowers plasma triglyceride (TG) concentration and reduces the concentration of TG-rich lipoproteins during the postprandial period. These results indicate that for individuals who consume the fatty acids in fish oil on a regular basis, their lipid response to a meal without the fish oil is modified to maintain a lower concentration of TG-rich particles containing apo B48

and B100. In human subjects who were asked to replace half of the fat in their diet by substituting foods with almonds or almond oil the LDL-cholesterol was significantly reduced by 4%. Incorporating almonds into the diet was also associated with a 14%reduction in TG concentration and elevation of HDL cholesterol. No differences in the response between almonds or almond oil were observed. These results indicate that almonds can be used in diets designed to reduce cardiovascular risk by lowering blood cholesterol levels. Supplementing the diet of women with soy protein isolate does result in a significant estrogenic or anti-estrogenic effect in post and pre menopausal women, respectively; however, a subpopulation of women may exist who are sensitive to the anti-estrogenic effects of soy. In men adding fiber from barley to a meal prolongs the elevation of cholecystokinin (CCK) compared to a low fiber meal. In addition consuming dry beans as a source of fiber, doubles the CCK response and increase the concentration of apo B48 during the postprandial period. We tested the hypotheses that increasing fiber or fat content a meal will increase CCK release and enhance subjective measures of satiety and that CCK response is correlated with satiety. Three isoenergetic meals-low fiber, low fat; high fiber, low fat; and low fiber, high fat-were tested in a randomized crossover design. In female subjects (n = 8), the meals higher in fiber or fat elicited greater CCK responses and feelings of satiety than did the low-fat, low-fiber meal. In male subjects (n = 7), the increase in CCK concentration did not differ between meals. However, the 2 low-fat meals elicited a greater feeling of satiety than the high-fat meal. In all subjects, CCK response was significantly correlated with subjective measures of satiety. The insulin response was significantly higher for the low-fiber, low-fat meal than for the other 2 meals, and the TG response was greatest for the high-fat, low-fiber meal. Alimentary plasma CCK response is associated with subjective measures of satiety. In female subjects, increasing either the fiber or fat content of a low-fat, low-fiber meal increases the feeling of satiety an effect mediated, in part, through CCK release. These results are important for development of recommendations to maintain health and lower risk for chronic disease. Incorporating dietary fiber into foods and meals is beneficial for enhancing the satiety associated with low fat foods and blunting the insulin response to meals. In addition a food such as almonds, which has been avoided because of its fat content, was shown to contribute to lowering cardiovascular risk when incorporated appropriately into the diet.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA, CO, IN, KS, MI, MN, MO, NE, NJ, TN, TX, WY.

Theme: 3.03 Human Nutrition
Title: Save Mart and 5 a Day Children's Poster Contest!
Description: Children who do not eat enough fruits and vegetables are at increased risk of developing chronic childhood and adult diseases like obesity, diabetes and ultimately heart disease and osteoporosis. Statewide research indicates that promoting fruit and vegetable consumption increases children's awareness and improves their eating habits. In addition, when parents provide fruits and vegetables at home and eat them themselves, children eat more of them. In partnership with Save Mart Supermarkets and the State of California Department of Health Services, UCCE Fresno County sponsored a poster contest in which children ages 5 to 11 drew their version of what "5 a Day" (five servings of fruits and vegetables) means to them. The result was community-wide promotion of fruit and vegetable consumption and its health benefits. UCCE's 5 a Day promotional materials were also displayed in Save Mart supermarkets to encourage more purchase at point of sale. In addition, all Save Mart supermarkets sponsor "Superfriends Tours" for school classes. These tours further reinforce the 5 a Day message and build on peer participation.

Impact: A total of 555 children drew their version of what 5 a Day means to them. The winner was enlarged for a highway billboard, so her poster has been seen by virtually every child and adult driving into Reedley. All of these activities increased awareness of a healthy diet, encouraging the consumption of 5 a Day both at school and at home.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 3.05 Medicinal Plants
Title: Research Leads to Elevated Vitamin C in Plants
Description: Vitamin C is an essential human nutrient promoting tissue, cardiovascular and immune functions; but as much as 30 percent of the U.S. population, especially the elderly and low-income, do not receive the current recommended daily allowance of 75-90 milligrams, an amount that some health officials suggest should be raised to 200 milligrams. Increasing the level of vitamin C in grains and other crops would provide a means to deliver more of the needed nutrient to the world population. A Professor of Biochemistry at the University of California, Riverside, and a researcher with the UC Agricultural Experiment Station, together with his research team, worked for five years to develop corn and tobacco (used as a model for green, leafy plants) with raised levels of vitamin C. Most plants rapidly lose the ascorbic acid, or vitamin C, they produce. The researcher and his team overcame this by causing the plants to overexpress a plant enzyme, dehydroascorbate reductase (DHAR), responsible for vitamin C recycling. They isolated DHAR cDNAs from wheat and introduced them into tobacco and corn using technology developed by the researcher.
Impact: As described in an article in the March 18, 2003, issue of the Proceedings of the National Academy of Sciences, the altered plants increased their DHAR activity by 11- to 100-fold. The amount of vitamin C in the leaves and kernels of the plants also increased two to four times. Grains are the major source of nutrition for the world's population, yet they do not contain high levels of vitamin C. The researcher’s research lays a foundation that can be used to increase the nutritive value of grains and other foods. This will enable people to obtain the recommended daily allowance of vitamin C more readily.
Funding Source: Hatch 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.

Significant progress was made 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 423 peer-reviewed articles and 15 extension publications in the areas covered by Goal 4. Over 429 local extension programs were delivered in this area. UC ANR funded 19 statewide collaborative workgroups composed 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 12 Statewide Special Programs that bring together AES and CE resources and personnel that addressed critical issues in the state that are included within National Goal 4.

FY 2002-2003 Allocated Resources

Extension Federal Funds (Smith Lever	Extension State Match	Research Federal Funds	Research State Match
$1,586,460	$19,592,582 [106.60 FTE]	$1,444,196	$35,549,313 [125.13 FTE]

Theme: 4.01 Agricultural Waste Management
Title: Alternative Uses of Rice Straw
Description: Because burning of rice straw impairs air quality, state legislation charged the Air Resources Board with finding alternative uses for 50% of the straw by 2002. It was estimated in 1999 that only 3% was being baled for such uses. The rest was incorporated back into the ground and flooded. Meanwhile, rice straw had a reputation as poor cattle feed and even as a cause of death in some instances. For that reason, little rice straw was being fed despite the mounting pressure to increase utilization of straw. A key finding of this UCCE project was the large variation in feed quality of rice straw. Research with rice growers in Sutter, Yuba and Butte counties identified production practices to improve straw quality. At the same time, efforts with cattle feeders in Siskiyiou county identified ways of feeding rice straw that are nutritionally adequate and safe for cattle. Thus, the UC work led to increased understanding of the needs of both rice growers and cattle feeders. Once those needs were identified, the CE advisors were able to develop quality criteria for rice straw that facilitated marketing of straw that met cattlemen's needs.
Impact: The number of successful rice straw feeding operations has increased, which in turn has meant more straw marketed. The bottom line is more rice straw fed to cattle and better air quality resulting from less burning of rice straw.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.01 Agricultural Waste Management

Title: Biochemical and Structural Studies of the Rad17 Protein from S. cerevisiae
Description: Objectives: Cloning of the RAD17 gene from S. cerevisiae. Large scale expression of the protein in bacteria or eukaryote. Development of a biochemical assay to determine exonuclease activity. Assay in presence of other checkpoint proteins to determine whether other subunits are necessary for activity or regulation. Crystallization and x-ray structural determination of the overexpressed protein. One focus of our lab is the structural study of NADH- and NADPH-dependent enzymes catalyzing the reduction of various agriculturally relevant compounds. One of these is the enzyme xylose reductase (XR), which catalyzes the first step of xylose integration into the general metabolism of the yeast C. tenuis. Since xylose is a major agricultural waste product in the state of California, we are collaborating with a colleague at the University of Agricultural Sciences in Vienna, Austria to use this enzyme in S. cerevisiae so that waste xylose can be fermented to produce ethanol. In order for this to happen efficiently, the cosubstrate specificity of the enzyme must be engineered for NADH rather than its current dual NADPH/NADH specificity. As a first step, we have determined the high resolution crystal structure of this enzyme in apo form and in complex with NADPH (ref. 1). As a result of this, we understand the interactions between the enzyme and the cosubstrate as well as Furthermore, we have determined the catalytic mechanism of the enzyme based upon the structure. The structure of the enzyme with the desired NADH cosubstrate is currently in progress and will determine the appropriate mutations necessary to confer the desired specificity for high-flux xylose metabolism. We have initiated work on a second, unrelated NADH-dependent enzyme, mannitol 2-dehydrogenase (M2DH) from Pseudomonas fluorescens in collaboration with the Nidetzky lab. Mannitol is a sweetener which is safe for diabetics and does not promote tooth decay. Currently, it is produced using a chemical reduction of D-fructose to equal quantities of D-sorbitol and D-mannitol which are separated in an expensive chromatographic step. Using M2DH, it may be possible to produce pure mannitol more economically. To understand the chemistry of the enzymatic reduction and the features of the enzyme which are likely to be necessary for stability we have determined its binary and ternary structures at 1.7 and 1.8 Angstroms respectively (ref. 2). The structure of the active site of the enzyme shows that a lysine acts as a base in the oxidation reaction and that an unusual and elaborate proton shuttle system conducts the proton to the bulk solvent. Moreover, the structure explains the enzyme's substrate specificity and lack of reactivity with polyols with fewer than five carbons and mannitol derivatives such as the 1-phosphate and 5-phosphate among others.
Impact: Straw is a major agricultural waste product which is often burned, releasing pollutants into the air. An environmentally preferable option is to ferment xylose (a major component of straw) to produce ethanol. Protein engineering experiments based upon our XR structure are altering this so that the overall efficiency of the conversion process is improved. Our M2DH structure has characterized an enzyme converting fructose to mannitol. Mannitol is a tooth-friendly sweetener safe for diabetics and is currently produced through a chemically inefficient process which will be improved using the structure.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.01 Agricultural Waste Management
Title: Master Gardener Composting Workshops Reduce Municipal Waste
Description: State legislation required cities and counties in California to reduce the amount of solid waste going to landfills 25% by 1995 and 50% by 2000. In response, the City of Napa initiated a yardwaste prevention program to divert solid waste from landfills by encouraging home composting, among other measures. Napa County UC Master Gardeners have conducted

several composting workshops each year. Held in conjunction with the City of Napa and our local waste management company, these sessions have encouraged and taught county residents to compost at home. More than 2,000 compost bins have been distributed and proper composting methods explained. Since the inception of the program in 1997, a total of 59 workshops have been held, reaching approximately 2,600 households.
Impact: According to the California Integrated Waste Managment Board, a typical California household can reduce its amount of organic waste by an average of 850 pounds with home composting. A recent survey indicated that nearly 80% of the compost bins distributed during the Master Gardener composting workshops are still in use. This means that over 840 tons of solid waste are being diverted from the waste stream each year, thanks to this yardwaste prevention program.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.01 Agricultural Waste Management
Title: Structure, Function, and Regulation of Clostridium Celluvorans Cellulase
Description: Objectives: 1. Determine the cellulosomal and non-cellulosomal enzymes produced by Clostridium cellulovorans to degrade various biopolymers such as cellulose, pectin, chitin and alginate. 2. Clone and sequence the genes for the enzymes that are involved in degradation of biopolymers. 3. Characterize the enzymatic, biochemical, and structural properties of the degradative enzymes. 4. Study the assembly of the cellulosomes by producing scaffolding protein and enzyme subunits in Bacillus subtilis. 5. Study the regulation and composition of cellulosomes when the cells are grown with different carbon substrates such as pectin, cellulose and mannan. In order to convert agricultural biomass and waste to utilizable forms of energy, it is necessary to gain a better understanding of the enzymatic processes that can convert plant cell wall materials to sugars that can be fermented to alcohol. For this purpose we are investigating the structure, function, assembly, and regulation of the genes for the proteins subunits of the Clostridium cellulovorans cellulosome. During the past year we have concentrated on studying how the cellulosomal enzymes work in concert to degrade cellulose and hemicellulose, how the properties of cellulosomal enzymes might be improved by DNA shuffling techniques, and how cellulosomal enzyme genes are regulated. We have shown that there is active synergism between the cellulases in cellulosomes, between cellulases and hemi-cellulases in cellulosomes, and between cellulosomal and non-cellulosomal enzymes. By use of natural substrates we have shown that plant cell walls can be degraded by combinations of designer mini-cellulosomes with specific functions. By a proper combination of cellulases, we obtained a degree of synergy of 3. By use of cellulases and xylanase, we have obtained a degree of synergy of 2.9 on a natural substrate such as corn stalk fiber. By DNA shuffling techniques we have recombined genes for two endoglucanases in vitro and obtained more heat resistant cellulase enzymes. This chimeric enzyme was stable at 55 C whereas the parent endoglucanases were completely inactivated at this temperature. This will serve as a model system for further directed evolution studies to obtain enzymes with properties that will make them suitable for biomass degradation. We have obtained evidence that the expression of the genes involved in cellulose and hemi-cellulose degradation are affected by the substrates that are available to C. cellulovorans during growth. For instance, xylanase activity is stimulated if the substrate is xylan. Pectin lyase is not produced at all, unless pectin is present as the substrate. We are interested in learning how these genes are regulated I n order to construct mutants that can produce large quantities of these degradative enzymes. These studies are leading to new

approaches that will allow us to construct novel cellulosomes that should be more efficient in their plant cell wall degrading ability.
Impact: The cellulosomal and non-cellulosomal cellulases and hemi-cellulases of Clostridium cellulovorans can degrade plant cell walls. The conversion of agricultural biomass to sugars by these enzymes can yield sugars that can be converted to utilizable forms of energy such as alcohol. This will lead to an efficient use of agricultural wastes and lead to a cleaner environment as well. This will benefit the farmers as well as the general public.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.01 Agricultural Waste Management
Title: Use of Dairy Manure as Fertilizer
Description: Growers have long known that dairy manure water pumped onto adjacent farmland contains useful plant nutrients. However, because it hasn't been easy to estimate the amounts of nitrogen and other nutrients in the water, farmers have added commercial fertilizer. Under the US EPA'a revised Clean Water Act requirements, most dairy farms will have to prepare management plans documenting all plant nutrients applied to fields. Eventually, the revised regulations will require producers to submit documents showing they are applying manure nutrients at appropriate rates. Final compliance with the regulations will be required by January, 2006. Growers are concerned about the complexity of complying with the new regulations. Now, data from the Biologically Integrated Farming Systems (BIFS) program and other UC research projects using flow meters and nitrogen "quick tests" have made it possible for farmers to measure nutrients in the lagoon water. This enables them to reduce or eliminate use of synthetic fertilizers. BIFS is administered by UC's Sustainable Agriculture Research and Education Program (SAREP). A UCCE associate hydrologist's project on the impact of dairy waste and nutrient management on groundwater quality was conducted in conjunction with a UCCE farm advisor's project on the use of dairy lagoon water in the production of forage crops. The projects laid the groundwork for the dairy BIFS project, involving farmers and pest control consultants as well as UC farm advisors, specialists and other researchers. Field days, workshops, grower surveys and other tools that directly link researchers with farmers have been used extensively in the project.
Impact: In on-farm demonstration projects, eight BIFS dairy farmers in partnership with UC farm advisors and researchers optimized the use of animal manure on their forage crops, reducing the use of nitrogen, phosphorus and potassium and lessening the leaching of nitrates into the soil. Cost savings to the growers averaged $55/acre and went as high as $116/acre. Utilizing this approach resulted in an overall 25% decrease in average shallow groundwater nitrate concentration over four years.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.01 Agricultural Waste Management
Title: Wood Chipping of Prunings to Reduce Air Pollution and Build Soil Organic Matter
Description: Since the passing of The Federal Clean Air Act amendments of 1990, the San Joaquin Valley (SJV) has not met the national ambient air quality standards for particulate matter of 10 microns or less (PM-10). In response, the SJV Unified Air Pollution Control District restricts the burning of agricultural wastes, and further restrictions are likely. Wood chipping is an alternative to burning that would not contribute to air pollution and would add valuable

organic matter to soils. If wood chips could be shown to not interfere with harvest or take nutrients needed by trees, then growers would be more likely to chip their prunings.
In a UCCE experiment, wood chips were mixed with soil and placed in 35-gallon plastic containers, each with a single almond tree. Equal numbers of trees were placed in soil and in containers without wood chips. After two years, wood-rotting fungi and beneficial soil-aggregating fungi were found only in the wood-chipped soils. Soil analysis showed significantly higher levels of zinc, copper, organic matter, phosphorus, potassium, ammonium, calcium and magnesium in the chipped soils, while the pH was decreased and electrical conductivity increased. Also, there were fewer parasitic nematodes and more free-living nematodes in chipped soils.
Impact: This research has shown that (1) wood chips do not interfere with harvest if they are small enough and that (2) they increase soil organic matter and nutrient cycling, microbial diversity and the water-holding capacity of soils. Because of these findings and realizing that more burning restrictions are inevitable because of increased air pollution, many growers already have embraced wood chipping as a sustainable alternative to brush burning. Results of this study are important not only to the almond industry but to all tree fruit growers who burn their prunings.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.02 Air Quality
Title: Pedological Studies of California Soils: Links to Soil Survey, Soil Quality, and Air Quality
Description: Objectives: 1) Study processes of soil formation and landscape evolution in California and implications for soil quality. 2.) Investigate soil impacts on air quality (PM10, PM2.5) in relation to agricultural management and health effects. 3.) Participate in the National Cooperative Soil Survey, on the Western Region Committee on Soil Survey and Inventory, and on the California Soil Survey Committee, and to improve the diagnostic criteria and function of the US soil classification system, and the application of soil survey information to issues of environmental quality. We're continuing our work on lab-generated dust to expand our data set on threshold water content values and dust production rates from a wide range of soil textures. Silty and loamy textures are the dustiest, followed by clayey, then sandy textures. The soils have threshold water contents (mass water content where dust production begins) ranging from about 6% for sandy textures to 12% for clayey textures; loamy and silty soils have intermediate threshold water contents. These results will allow the prediction of which soils are most likely to produce PM-10, and possibly, some management alternatives to reduce dust. A related project showed that conservation tillage (CT) in a cotton-tomato rotation reduces by three-to seven-fold the total and respirable dust measured in the field behind farm implements compared to standard tillage. The reduction is due to fewer in-field operations for the CT system. The addition of cover crops to the rotation in both systems increases dust production due to a larger number of field operations and possibly due to increased organic matter as a dust component. Aggregate stability, soil C, and particulate organic matter contents have not changed significantly in any of the treatments over a three-year period. We plan to expand the study to the commercial scale and to measure dust at off-field locations. Preliminary data on K-fixing soils used for cotton production in the San Joaquin Valley show that soils derived from Sierran alluvium fix significantly more K than do soils derived from Coast Range alluvium, mostly as a function of vermiculite in the clay and silt fractions, but also as a function of soil depth. Soil survey data (SSURGO) is being used to predict the locations of K-fixing soils based on soil texture,

mineralogy, and extent of soil weathering, and to develop soil K management strategies based on subsurface soil properties. Work continues on the relationships among soil C storage, soil mineralogy, and soil microaggregate formation in forested Sierran and Cascade soils. Preliminary data suggest short-range-order compounds, Fe-oxides, and low activity clays lead to protected soil C in stable aggregates. The suite of soil minerals is related to parent material (basalt vs. andesite vs. granite) and to weathering intensity as a function of elevation, hence, soil climate. We plan to measure soil C content and 14C age in a range of aggregate sizes to determine which pools are most resistant to turn over.
Impact: The dust research identifies soils likely to produce dust when disturbed, shows that dust might be reduced if soils are cultivated at soil water contents above the dust threshold, and shows that conservation tillage reduces dust in the field. Research findings are being implemented to significantly reduce particulate matter in the air.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.03 Biodiversity
Title: Agricultural Change, Crop Diversity and Crop Genetic Resources
Description: Carry out a case study of the relationship between cultural (language) diversity and maize diversity in its center of origin and diversity in Mexico and Guatemala. Initiate a regional study in southern Mexico on the historic and contemporary status and trends in maize diversity. Initiate a study in central Mexico on the participation of farmers in programs to promote on-farm conservation of crop genetic resources. Expand research on trends in diversity of California crops. A model was developed to examine the practices of peach producers in Fresno County who increased peach diversity between 1970 and 1990. This model was then contrasted to more general models that predicted the loss of diversity with economic and technological development. An important finding was that consumer demand and market activity led to increased diversity. This contradicts the previous model that views diversity as resulting from environmental services that diminish with technological development and commercial breeding. Analysis continued on maize diversity Mexico. A major activity was to develop larger scale spatial data sets and analytical tools to examine changes in maize diversity in relation to land use changes. New work on the social impact of genetically modified organisms was initiated. This is complementary to data gathering activity in Mexico to estimate the diffusion of genetically modified maize there.
Impact: The conservation of genetic resources for agriculture is a national and an international imperative. In addition to preserving crop genetic resources in gene banks, on-farm maintenance in strategic locations of genetic diversity is now an accepted conservation method. Social science, such as my work in Mexico and California, can facilitate identification of sites and improve programs to promote on-farm maintenance of crop genetic resources.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.03 Biodiversity
Title: The Evolution of Allele Diversity in Aneuploid Species of CLARKIA
Description: Objectives: 1) Sequence alleles encoding allozymes of PGIC having the same and different electrophoretic mobilities from numerous individuals and populations of four species of CLARKIA. It is expected that 20 or more alleles will be sequenced in each species. 2) Construct a tree of their genealogical relationships. 3) Determine the amount and type of sequence divergence within and between each of the species. My laboratory continues to study molecular

evolution of PGIC genes in CLARKIA, a genus of annual wildflower species nearly all native to California. PGIC genes encode the cytosolic isozyme of phosphoglucose isomerase (EC 5.3.1.9), an enzyme that catalyzes an essential reaction during glycolysis and gluconeogenesis. Our present project uses genealogical analysis to examine the relationships and diversity of PGIC genes in a group of closely related diploid species of CLARKIA, distributed along the western foothills of the Sierra Nevada of California. Previous cytogenetic studies showed that the genomes of three of the species have been restructured by chromosomal rearrangements as well as aneuploid reduction in chromosome number. The reduction in chromosome number correlates with geographical distribution. Thus, C. BOREALIS on the north has seven pairs of chromosomes, the ancestral number in the genus, and is thought to have given rise to C. MOSQUINII, with six pairs, now found in the central region. C. MOSQUINII is thought to be the progenitor of C. AUSTRALIS and C. VIRGATA, both with five pairs of chromosomes, and both found to the south. Origin by aneuploidy restricts the number of alleles received from the parent at any locus to no more than two. Such a bottleneck makes it possible to determine which gene lineages in the parent gave rise to genes in the derived species, thereby, providing phylogenetic order to nucleotide substitutions and information about how a family of genes is built up following the origin of a new species. The PGIC gene is complex with 23 exons and 22 introns in the coding region, extending over about 6000 base pairs. For this project, we are sequencing a fragment of 1400 base pairs between exons 10 and 14; to date, we have analyzed 17 genes. The genes were initially selected on the basis of the electrophoretic mobilities of their enzyme products, but both similarity or difference in mobility proved to be a very poor guide to sequence divergence and genealogical relationship. A tree of genealogical relationships showed that the PGIC genes in the three aneuploid species have not yet assorted along species lines, consistent with their recent origins. Thus, although genes from C. MOSQUINII, C. AUSTRALIS and C. VIRGATA constitute a clade distinct from that of C. BOREALIS and C. MILDREDIAE, a related species with seven chromosome pairs also found in the north, those of the two species with five chromosome pairs were nested among those from C. MOSQUINII. Additional sampling is underway to provide better understanding of the genealogical relationships between the gene lineages now in separate species and to assess the relative divergence among them.
Impact: These studies contribute to basic knowledge about the genetic basis of species diversity and the origins of that diversity. The results may be applicable to the conservation and management of the small populations characteristic of many endangered species, and may also be useful to the design of programs to identify wild relatives and source populations of various crops.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.03 Biodiversity
Title: Molecular Mechanisms of Action of Environmental Endocrine Disrupting Chemicals
Description: The overall goals of this research program are to investigate the molecular mechanism by which environmental and agricultural chemicals regulate nuclear hormone receptors and gene expression, with an emphasis on those chemicals which are endocrine disruptors. A major focus will be examine the Ah receptor-dependent molecular mechanism by which potent endocrine disruptor, such as 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and related halogenated aromatic hydrocarbons, exerts their biochemical and toxicological actions. An additional major focus will be the development of rapid cell- and receptor-based bioassays for the detection and characterization of novel endocrine disruptors and TCDD-like chemicals. The results of these studies will provide insights into the mechanisms by which widespread

environmental and agricultural chemicals can alter gene expression and disrupt normal hormone actions. Taking advantage of specific chemical-dependent receptor proteins present in cells in culture, work continued to develop, optimize and validate several novel recombinant cell bioassays for the detection of toxic chemicals. The previously generated cell bioassay system for the detection of halogenated aromatic hydrocarbons, such as the chlorinated dioxins, dibenzofurans and PCBs, was further validated. Soil, ash, exhaust gas and blood extracts were used to validate this bioassay system for the detection of these chemicals by demonstrating a high degree of correlation between the relative amounts of toxic dioxins and dibenzofurans detected using our cell bioassay and instrumental analysis (GC/MS). The utility of this bioassay has been demonstrated to detect polycyclic aromatic hydrocarbons and have shown its application for use in the screening of wildlife tissue samples for assessment of their exposure to crude oil. The high throughput nature of the dioxin cell bioassay was shown by the ability of one person to screen over 12,500 chemicals for dioxin-like activity in less than one week. Work continued on development of endocrine disruptor rcell bioassays and using a recombinant estrogen-responsive human ovarian cell line, we have demonstrated that the mechanism by which dioxins can block estrogen action in these cells requires it to induce expression of a novel antiestrogenic gene product. Overall results clearly demonstrate the application of our novel cell bioassay systems for both basic and applied research.
Impact: Development and validation of bioassay systems for detection and relative quantitation of dioxins and endocrine disruptors provides an avenue for widespread monitoring of environmental, biological and food samples for these hazardous chemicals. Our bioassays are simple, rapid and inexpensive alternatives to the more expensive analysis techniques and they are gaining national and international acceptance and use for monitoring purposes.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.03 Biodiversity
Title: Molecular Population Genetics of Natural Populations
Description: The primary objective of this project is to determine the amount and nature of genetic variation at candidate loci that contribute to standing quantitative genetic variation in bristle number in DROSOPHILA MELANOGASTER. Hundreds of second and third chromosomes from natural populations of DROSOPHILA MELANOGASTER have been have genetically extracted and are being crossed in a "round-robin" design. The numbers of sternopleural and abdominal bristles will be determined for each chromosomal heterozygote. In parallel work, the complete DNA sequence of 20 alleles at each of 5 candidate genes have been determined to identify Single Nucleotide Polymorphisms. The ascertained SNPs are being typed using Pyrosequencing technology in each of the large population samples. The complete sequence of 20 alleles of da, emc and h are complete. The phenotyping and genotyping of the 500 da alleles is complete. The analysis of the h data allowed the association of DNA sequence polymorphisms with specific phenotypic patterns and thus the characterization of the molecular genetic basis of standing quantitative genetic variation in natural populations. The nature of the genetic variation that is the basis of standing genetic variation is, of course, fundamental to both our understanding of evolutionary process and the development of effective plant and animal breeding.
Impact: Fundamental knowledge of the genetic basis of quantitative genetic variation and the forces that shape it are essential to effective plant and animal breeding, as well as management of natural resource populations.
Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.04 Biological Control
Title: Conservation of Biological Control Posterchild, Cottony Cushion Scale
Description: The vedalia beetle is a predator of a major citrus pest, cottony cushion scale. However, many of the new insectides developed to replace organophosphates (neonicotinoids and pyrethroids) or developed as reduced-risk alternatives (insect growth regulators) are quite toxic to this beneficial insect. Biological control is important in the control of cottony cushion scale as insecticides are not very effective against the pest. An Extension Integrated Pest Management Specialist from the University of California, Riverside has taught growers to limit the harm to the vedalia beetle through careful timing of insecticide use or the avoidance of insectides altogether.
Impact: Since 1999, when problems first arose, there has been a noticeable lessening in the disruption of vedalia beetle.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.06 Endangered Species
Title: Analysis and Modeling of Landscape Patterns and Processes of Alluvial Rivers for Conservation and Restoration Strategy Development
Description: Objectives: 1. Create sets of time-series GIS map databases of current and historical land cover and low-flow channels in selected reaches. 2. Map historical floodplain inundation (high-flows) and model current floodplain inundation through compilation of a historical flow database at all gages on the main channel and compilation of current and historical topographic and bathymetric maps in the form of digital elevation models. 3. Develop and implement an integrated set of models of riparian landscape change (e.g., fluvial geomorphic modeling linked to vegetation succession modeling) by measuring floodplain position and modeling floodplain age of various riparian vegetation species and by integration of the vegetation model with a meander migration model. 4. Develop and apply geographic habitat suitability index models for indicator species. 5. Create GIS visualization tools to depict dynamic landscape processes on the river. 6. Create current and historical spatial distribution GIS maps and databases of exotic vegetation species (e.g. on the middle Sacramento River, lower Cache Creek and lower Putah Creek, and San Joaquin Valley rivers) and measure trends of spatial distribution and rates of spread. The Sacramento River is a very significant economic and natural resource to the state of California. It is the largest river system in the state and produces over 50% of the water used in state and federal water projects. Numerous public (federal, state, and local) and private agencies are trying to improve and restore the ecosystem of the Sacramento River. This project addresses the concerns and needs of land managers seeking to restore riparian ecosystem structure and function. Progress has been made on developing several of the spatial data sets and computer models needed to achieve the objectives of the project. The following interim products being developed for the study area on the Sacramento River are completed or near completion at this time: (1) a series of historical low-flow and flooded-channel maps have been completed for the study reach and a summary report is in preparation; (2) a floodplain age model and map from Red Bluff to Colusa has been completed; (3) compilation of a digital terrain model describing the topography (elevation above mean sea level) from Vina to Colusa using data provided by consultants to the US Army Corps of Engineers; (4) a relative elevation model and map from Vina to Colusa; (5) extensive vegetation sampling and data collection during the summer of 2002 using products #2 and #4 to produce unique sampling units

(for stratified random sampling) for the purpose of developing a comprehensive classification of vegetation communities from Vina to Colusa; (6) a detailed chronosequence analysis has been completed for a site to determine vegetation successional trajectories; (7) a habitat suitability model has been improved to predict the presence of endangered bird species; (8) a spatial model to discern and delineate habitat patches has been developed to implement the product in #7 and can be used in the development of other species models. Two masters theses (one in ecology and one in geography) are in preparation that cover the work described in #2, #5, and #6. The data sets and computer models are valuable tools for land managers and other academic researchers studying the Sacramento River.
Impact: This research project is assisting public and private agency land managers to devise restoration plans for the Sacramento River's meandering sector (from Red Bluff to Colusa) and to understand the potential impacts of various proposed land and water management scenarios for the river. There are many endangered species (fish and wildlife) in the Sacramento River system that depend on the dynamic forces of land and water to shape and maintain their habitats over time. The goal of the research work being conducted in this project is to link the objectives and approach of restoration professionals to the needs of the endangered species by providing the tools and data that inform sound decision-making.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.06 Endangered Species
Title: Habitat Fragmentation and Biodiversity of Aquatic Habitats in California
Description: This project assesses the importance of several anthropogenic factors on the regional persistence of a threatened insect species in California, and applies ecological theory to its conservation. The Valley Elderberry Longhorn Beetle (Desmocerus californicus dimorphus) is endemic to California's Central Valley and is vulnerable to extinction because it feeds on a single patchily-distributed resource in riparian woodland, elderberry (Sambucus spp.). The beetle has the center of its range around Sacramento, CA, where most riparian areas have been destroyed by development (e.g., Smith 1980). Additionally, mitigation efforts have had low success, and it was recently discovered that the presence of invasive Argentine ant (Linepithema humile) predators was negatively correlated with occurrence of the threatened beetle (Huxel 2000). There are three interrelated objectives. 1. To construct a population viability model to serve as a decision-making tool for beetle conservation and management. The probability of metapopulation and landscape scale persistence will be predicted with a spatially explicit simulation model, by using various combinations of initial beetle density, mortality across life stages, dispersability, habitat availability (e.g., suitable elderberry tree size/age and density), Argentine ant presence and mitigation site location. Earlier field work (Collinge, Holyoak, Barr and Marty, in press) revealed the need for more detailed information about the above factors, and for their influence to be jointly evaluated in a numerical model. Data will come from Objectives 2 and 3. The model will be used to generate predictions about critical habitat and mitigation site location for use in beetle and riparian conservation plans. 2. To determine the beetle's distribution, abundance and the extent of population fluctuations within sites (elderberry clumps) and metapopulations (tributaries). Data on variation in beetle abundance (and presence) from various spatial scales (from bushes to tributaries) will be used to estimate extinction probability. Patterns of site colonization across space will also allow calculation of probabilities of colonization of sites that are separated by different distances. 3. To assess the relative importance of factors influencing beetle presence or abundance. A small amount of field data suggests that associations between predatory Argentine ants and the beetle are of prime importance for beetle

persistence (Huxel 2000). This project will determine the robustness of negative correlations between beetle and Argentine ant presence, and experiments will test whether ant predation could account for the putative negative correlation. Within sites, this work will test the hypotheses that ants and beetles only partially overlap in space, and that open areas are refuges for the beetle. Monitoring will also determine spatial and temporal variation in the abundance and age of elderberry branches on which beetle larvae can feed; statistical analyses will test for associations between beetle presence or abundance and branch abundance (or age). This knowledge of site suitability for beetles will aid mitigation efforts. During 2002 this project partially completed its second and third aims, to determine the Valley Elderberry Longhorn Beetle's distribution, abundance and the extent of population fluctuations within sites and to assess the relative importance of factors influencing beetle presence or abundance. Fieldwork within the American River Parkway collected data for 1,374 clumps of elderberry, and showed that 3-26% of elderberry clumps were occupied by the beetle. Examination of over 20 habitat factors showed that: beetle occupancy was negatively influenced by distance from the river, and positively influenced by both the presence of tree canopy cover and the size of patches. Beetle abundance was positively correlated in elderberry clumps with the number of stems of 2-7cm diameters, a finding that concurs with earlier studies at larger spatial scales. Investigations of other habitat factors and construction of a population viability model (aim 1) will proceed after another year of fieldwork.
Impact: The project is already producing information necessary for improved mitigation and restoration practices for the threatened Valley Elderberry Longhorn Beetle. In addition to improving the ecological effectiveness of these practices, our work benefits management agencies and the public by reducing the cost of mitigation for this species.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.07 Energy Conservation
Title: Engineering Systems for Sustainable Crop Production
Description: The objective of this project is to develop sustainable production systems for field, fruit, nut, and vegetable crops to: 1) develop in-field sensing technologies to quantify production inputs such as soil fertility or moisture, to identify the location of crop plants or pest infestations, 2) provide real-time in-field mapping of production parameters such as yield, soil fertility, pest populations, etc., 3) allow site specific application of inputs such as fertilizers, pesticides, or water, 4) improve techniques for application of non-chemical pest control alternatives, 5) reduce soil compaction, energy use and dust generation, and 6) improve product quality.
An RTK GPS-based auto-guidance system was tested in transplanted and direct seeded tomato fields. A split-plot experiment was conducted in four blocks with forward speed as the main factor (5-kph and 11-kph) and cultivator knife spacing as the sub factor (5-cm and 10-cm). Results indicate that in the transplanted field there was hardly any damage at the 11-kph forward speed and the 10-cm cultivator knife spacing. In the direct seeded field virtually no plant damage occurred even at the 5-cm cultivator knife spacing and a forward speed of 11-kph. A weed detection algorithm was developed using a neural network-based computational engine. The algorithm successfully identified weeds, cotton plants, and soil in images from a commercial cotton field with 93% of the weeds correctly mapped for precision micro-dosing herbicide application and 91% of the cotton plants correctly mapped for no herbicide application. A micro-dosing system was developed for treating spray targets on a 1-cm scale with dose pulses down to 6 ms. Effects of liquid velocity, jet exit diameter and liquid properties on deposition, splash and drift were determined. Efficacy of micro-dose application of nonselective herbicides against

common weeds was determined through bioassays. A study was conducted to determine the feasibility of using near infrared spectroscopy as a sensing technique to determine soil moisture content. Near infrared absorbance in the 1400-2400 nm region correlated well, r=0.98, with soil moisture content. The study determined that a site-specific calibration was required when the model was applied to soils that were different from those in the original calibration process. Research was conducted on the design of electronic hazing systems for improved control of birds in orchards and vineyards. The original concept was to develop a sensor-based unit to detect when birds entered an area and activate the hazing sounds only when they were present. In this way, habituation would be minimized, thus prolonging the effectiveness of control in the field. Due to the complexity and potential cost of the sensor-based system, a simplified non-sensor unit was subsequently designed with the intention of large scale field use by growers. A manually operated optoelectronic system was developed to count and size fruit and nut trees in commercial nurseries. Calibration tests showed that the system could measure trunk diameter to +/- 1.9 mm (99.7 percent confidence) with the sensor 15-23 cm from the tree line. Leaves, low-level suckers, weeds, and trunk stakes all had the potential to cause inaccurate counting and sizing.
Impact: Intelligent, precision systems for agricultural operations will greatly improve their efficiency and efficacy. Dramatic economic and environmental benefits will result from lower fuel consumption due to fewer tractor trips through a field, less chemicals required, fewer chemicals applied to non-target areas, less menial labor required, and more effective mechanical weed control.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.08 Forest Crops
Title: UC develops information to help establish native oaks
Description: For a century, there has been concern in California that several species of native oaks are not regenerating adequately. Poor regeneration not only threatens the oak forests themselves, but also the wildlife that utilize oak resources. It could also impact recreation, water quality and quantity, the state's visual landscape and lead to the spread of noxious weeds.
This was was one the principal reasons for the establishment of the Integrated Hardwood Range Management Program (IHRMP) in 1986. Since then, the IHRMP has conducted extensive research on the causes of poor oak regeneration and practical, low-cost methods of establishing young oaks. Much of the applied research has been conducted at UC's Sierra Foothill Research and Extension Center in Yuba County, focusing on all aspects of regeneration from collecting and storing acorns to protecting seedlings in the field from damaging animals. One of the 10 current projects is evaluating the effectiveness of "treeshelters" (individual tree protectors) on oak establishment. Beginning in 1989, the IHRMP began hosting a series of Oak Regeneration Field Days at the Sierra Foothill Center. These events, with a total attendance of 700, have contributed greatly to educating practitioners--restorationists, arborists, nursery operators, landscapers and registered professional foresters--about the most up-to-date practices on all aspects of oak regeneration. This past year the IHRMP published a 62-page "how to" brochure titled "Regenerating Rangeland Oaks in California" that provides easy-to-understand instructions on how to plant and grow oaks. More than 700 copies have been purchased.
Impact: The information developed by the IHRMP has been used to help successfully establish oaks in plantings throughout the state. The Nature Conservancy has restored hundreds of acres along the Sacramento and Cosumnes Rivers with woody plants, including valley oaks. Those responsible for these plantings have regularly attended workshops and training hosted by the IHRMP. As a result, the success rate of these planting efforts has continually improved.

Along state highways and intersections, Cal Trans has planted numerous native oaks during the last decade. Many of these have been protected with treeshelters--individual tree protectors that promote rapid growth. These devices have been intensively tested at the Sierra Foothill Center. Their wide use throughout the state is largely a result of this research that demonstrated how effective they can be in establishing oaks.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.09 Forest Resource Management
Title: Biology of Root Rot Pathogens of Conifers and Their Influence on Natural Forest Ecosystems
Description: Objectives: 1) Locate and intensively map disease centers caused by H. annosum and other pathogens in Yosemite Valley for short-term and long-term observations. 2) Measure the spatial distribution and spread of pathogens in individual disease centers (gaps) and for the valley as a whole. 3) Identify trees, shrubs, and herb species within disease gaps and in cloned canopy areas. As part of the Teakettle Ecosystem Experiment we have mapped all pathogens (root rots, dwarf mistletoe, Elytroderma) and bark beetles on 12 four hectare plots. All stems greater than 5 cm diameter were examined and mapped on the plots (approximately 18,000 trees). This information is currently being analyzed to determine spatial patterns of pathogens and insects at landscape scales. Plots were treated in 2001 by a combination of thinning and prescribed fire. In order to understand Arceuthobium and Cronartium ribicola patterns of spread, host effects, and bark beetle interactions in the Sierra Nevada we chose to study these pathogens in 2 different areas (with different management histories. We found the highest prevalence of dwarf mistletoe on Jeffrey pine in the Lake Tahoe Basin (87 percent), followed by dwarf mistletoe on white fir in Lake Tahoe (30 percent), with the lowest prevalence on white fir at the Teakettle Experimental Forest (27 percent). Individuals, of both white fir and Jeffrey pine, in all diameter size classes are susceptible to dwarf mistletoe with the lowest infection rate in the seedling-10 cm diameter size class. Arceuthobium on white fir in Lake Tahoe showed a certain degree of spatial aggregation up to 40 meters. However, random spatial patterns were found for Arceuthobium on Jeffrey pine in Lake Tahoe and on white fir at the Teakettle Forest. The degree of infection and logging history appear to be important in the spatial dynamics of Arceuthobium species in the Sierra Nevada. To understand patterns of pathogen spread, disease dynamics, and host effects of white pine blister rust in two different forest types, we surveyed all 5-needled pine species in 53 ha of mixed-conifer and subalpine forest. In mixed-conifer forests, rust incidence was significantly correlated with the nearness of Ribes to sugar pine hosts and also influenced by environmental conditions favorable for rust infection. Disease was aggregated in these locations with new infections occurring annually. In the subalpine grid, disease was not correlated to the nearness of Ribes and may be influenced more by topography. Average WPBR incidence across the Lake Tahoe watershed was 26 percent and ranged between 0 to 74 percent. Percentage of the alternate host, Ribes, within a stand was not correlated to WPBR and only showed weak relationships with stand slope and solar radiation. In both these forest types, individuals of all sizes are susceptible to WPBR but the greatest number of trees with WPBR are trees less than or equal to 20 cm dbh. Disease is higher than expected on individuals in the 10.1-20 cm diameter size class. Demographic effects of this disease on its pine hosts include juvenile mortality, due to lethal stem cankers, and reduced cone production, due to branch mortality of larger reproductive individuals.
Impact: The information we have gathered will be important for managing California's conifer forests. Information on pathogens and insects will be necessary to determine the impacts of

current management (thinning, prescribed fire) on forest health. As managers attempt to incorporate historical disturbance regimes we predict that there will be a period of uncertainty on how management will affect forests.
Funding Source: McIntire Stennis and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Agriculture Chemical and Organic Treatment:chemistry, Metabolism and Mode of Action
Description: The principal goal is to define the molecular toxicology of selected insecticides with emphasis on their modes of toxic action, biochemical targets, mechanisms of selective toxicity and health implications of exposure. The research is organized into three subprojects on organophosphorus (OP) pesticides, gamma-aminobutyric acid type A (GABA-A) receptor antagonists, and nicotinic receptor agonists. OP insecticides are the principal cause of pesticide-related human poisonings. Recent restrictions on the use of chlorpyrifos and diazinon reflect continuing concern for human health, particularly children. This research focuses on noncholinergic effects. Acetylcholinesterase (AChE)-knockout mice are very sensitive to OP insecticides, establishing the importance of an unidentified non-AChE target for acute lethality; the first specific aim is to identify this non-AChE target. The second aim is to establish the function of neuropathy target esterase (NTE) in OP-induced delayed neuropathy (OPIDN) using mice as a model. The other aims are to confirm the proposed structure of kynurenine formamidase (KFase) (the target for OP-induced teratogenesis) by cloning and expressing functional enzyme, and to define the mechanism and significance of three secondary targets of OP pesticides (endocannabinoid action, disruption of signal transduction pathways, and novel phosphoesterases). Relative to GABAergic insecticides, 60 years and 5,000,000,000 pounds of past and continuing use involves major levels of human and environmental exposure. In addition, three GABAergic insecticides (lindane, endosulfan and fipronil) make up 7 percent of current insecticide use. Two aims are to localize and identify the high-affinity specific binding site and to characterize the toxicological profile relative to subunit composition. Other goals are to define the subsite contribution to two or more apparent mechanisms of toxicity and to establish the metabolic activation and detoxification and target site specificity of other GABAergic pesticides. Cholinergic insecticide research defines the mechanisms of toxic action and selectivity for neonicotinoid insecticides, the only major new class of insecticides of the past 3 decades. Imidacloprid (IMI) is now the main pest control agent for many food crops. The neonicotinoid insecticides act at the nicotinic acetylcholine receptor (nAChR) and at least one of the IMI metabolites and several of the candidate insecticides are similar to nicotine in toxicity to mammals. The aims are: to define the nAChR binding-site specificity for neonicotinoid insecticides relative to receptor subtype, function, neuronal region, and developmental stage; relate neonicotinoid insecticide selectivity to major structural differences in the neuronal nAChR binding sites of mammals and insects; define the metabolic lability of the neonicotinoid insecticides relative to bioactivation products such as desnitro-IMI in mammals. Knowledge of mechanisms provides the basis for safety evaluations and regulation of use. Pesticides are responsible for human poisoning (including children) and a cause of environmental contamination. This project promotes an understanding of the mechanisms for pesticide toxic action, thereby allowing for the safe usage of agrochemicals.
Impact: This research promotes an understanding of the mechanisms for acute and delayed toxicity from pesticides. This knowledge is essential for the safe usage of agrochemicals and to avoid environmental pollution. Three of the most important targets for insecticide action are acetylcholinesterase, the nicotonic acetylcholine receptor and the gamma-aminobutyric acid

(GABA) receptor. Mechanistic studies on these targets compared brain enzymes and receptors from mice and Drosophila to determine the basis for selective toxicity and the toxicological relevance of secondary effects. In the action of organophosphorus insecticides, fatty acid amide hydrolase, dispite its high sensitivity, is less important than acetylcholinesterase and neuropathy target esterase. Chlorpyrifos oxon is the most potent pesticide examined as an inhibitor of the cannabinoid CB1 receptor. The teratogenesis target, kynurenine formamidase, was isolated pure and the primary structure determined and tertiary structure and catalytic triad predicted providing insight into its role in trypthophan metabolism and nicotinamide biosynthesis. The plant growth regulator ethephon is a more effective inhibitor of butyrylcholinesterase than any other esterase examined; the active site serine is phosphorylated by ethephon. Structural features of azidopyridinyl neonicotinoid probes were established for high affinity and selectivity for mammalian a4b2 and Drosophila nicotinic receptors. Desnitro-imidacloprid activates the extracellular signal-regulated kinase cascade via the nicotinic receptor and intracellular calcium mobilization in NTE-115 cells. Imidacloprid metabolism involves both cytochrome P450 isozymes for imidizolidine oxidation and nitroimine reduction and other liver microsomal and cytosolic enzymes for nitroimine reduction and cleavage. The homeric p1 GABAc receptor has a unique insecticide specificity compared with the normal GABAa receptor. cis- and trans-3-Pinanones (the active ingredients of hyssop oil) are easily biodegraded GABAergic agents.
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: The objectives of the revised project include: 1) To test whether the entomopathogenic fungus, Hirsutella thompsoni, can infect Varroa mite, the parasitic mite of honey bee; 2) To understand the infectious mechanisms of the fungus; 3) To test the effects of H. thompsoni on non-target honey bees, 4) To compare the virulence of various isolates of H. thompsoni on Varroa mites; 4) To select the most infectious isolate to Varroa, yet it cause no negative effects on honey bees; 5) To develop culture media appropriate for mass production of the fungus; and 6) To develop proper formulations of the fungus for applications in field bee hives. The Varroa mite, Varroa destructor, is recognized as the most serious pest of both managed and feral Western honey bee (Apis mellifera) in the world. The mite has developed resistance to fluvalinate, an acaricide used to control it in the beehives, and fluvalinate residues have been found in the beeswax, necessitating an urgent need to find alternative control measures to suppress this pest. Accordingly, we investigated the possibility of using the fungus, Hirsutella thompsonii, as a biocontrol agent of the Varroa mite. Among the 9 isolates of H. thompsonii obtained from the University of Florida and the USDA, only the 3 USDA isolates (ARSEF#257, 1947 and 3323) were infectious to the Varroa mite in laboratory tests. Scanning electron micrographs revealed that the membranous arolium of the mite leg sucker is the focus of infection where the fungal conidia adhered and germinated. The infected mites died from mycosis, with the lethal times to kill 50% (LT50s) dependent on the fungal isolates. Thus, the LT50s were 51.1, 72.6, and 94.9 h for isolates 3323, 257, and 1947, respectively. Passage of H. thompsonii through Varroa mite three times significantly reduced the LT50s of isolates 257 and 1947
Impact: The results of the present experiments report for the first time to demonstrate clearly and showed the mechanism that H. thompsonii can infect and kill Varroa mites effectively.

Therefore, H. thompsonii potentially can be used as an agent to control Varroa mite, and benefits the beekeepers worldwide.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Alternative Fumigants for Control of Soil Pest: Strawberry as a Model System
Description: The primary research objective of this proposal is to evaluate the efficacy of alternative fumigants for the control of soilborne pests and weeds in the field. The crop production system that will be used as a model is strawberry, with trials addressing fumigant efficacy in both runner plant nurseries and commercial berry production fields (different soil types and locations in the state). Since this plant is highly susceptible to all these organisms it is a good indicator crop to use. In view of the broad host range of the pests under investigation and the common weed species involved, the results of this work will be applicable to any cropping systems that may use these alternative fumigants for pest control. In addition to registered fumigants, trials will evaluate compounds that are still in the early stages of the registration process. In addition to collecting pest control efficacy data, the experimental design provides an opportunity to evaluate the effects of alternative fumigants on the production of a commercial strawberry crop. The experimental approach includes evaluations at all stages of the production system, beginning with plant propagation in nursery fields and continuing through to work at fruiting field sites, where replicated trials will be paired with approximately 5 acre, unreplicated demonstration plots. The demonstration trials will be used for grower education events at planned field days. In all experiments data will be collected in a manner that will allow for proper statistical analysis of results and an economic assessment of cost differentials of alternative fumigation treatments. Specific objectives: 1)Evaluate the efficacy of alternative fumigants in controlling a range of common soilborne pests and weeds in the field. 2) Determine effects of new application technologies on emissions of MB alternative umigants into the atmosphere. 3) Strawberry plants grown in these treated fields will be assayed for root colonization by pathogens, nematodes and VAM to further evaluate efficacy of control. 4) Evaluate effects of the alternative fumigation programs on plant health and productivity throughout the entire strawberry nursery and fruit production cycle.5) Demonstrate the performance of key alternative fumigant programs to strawberry producers and provide them with pest management and economic information so that they can make informed decisions during the transition to alternative fumigants. The methyl bromide phase-out will have far reaching effects on the production of strawberry. Strawberry production includes two sectors: runner plant production nurseries and fruit production. Fumigant evaluations in California strawberry nurseries and fruiting fields were conducted in the 2001-02 season to evaluate fumigant efficacy on soil-borne diseases, nematode and weeds. Fumigant emissions and dispersal, as well as economic effects on production practices associated with the alternative fumigants were also evaluated. Methods: nurseries. Alternative fumigants were evaluated in 2002 at a high elevation strawberry nursery near MacDoel, CA. Treatments applied were chloropicrin alone (Pic) at 300 lb/A followed by (fb) a sequential application of dazomet at 250 lb/A, 65 percent 1,3-dichloropropene plus 35 percent Pic (Telone C35) at 386 lb/A fb dazomet at 250 lb/A, and 50 percent iodomethane plus 50 percent chloropicrin mixture (IM/Pic) at 400 lb/A. The commercial standard was 57 percent methyl bromide plus 43 percent chloropicrin mixture (MB/Pic) at 400 lb/A. All treatments were shank-injected except dazomet that was applied with a granular spreader. Methods: small plot fumigant evaluations in fruiting fields. The objective was to compare the efficacy of immediate-term alternative fumigants such as Pic or Telone C35 with

short-term alternative fumigants such as IM/Pic or propargyl bromide (PB). Studies were in Oxnard and Watsonville, CA. Drip-applied treatments include Pic plus emulsifier (Pic EC) at 300 lb/A, 62 percent 1,3-dichloropropene plus 35 percent Pic plus an emulsifier (Inline) at 400 lb/A, IM/Pic at 400 lb/A and PB at 180 lb/A. Drip-applied fumigants were applied through two drip lines per bed. The standard was shank applied MB/Pic 67:33 at 275 to 375 lb/A. Methods: large-scale fumigant evaluation. A study was initiated in a fruit production field near Oxnard, CA to measure commercial-scale weeding costs. Drip-applied treatments were: Pic EC at 300 lb/A and Inline at 400 lb/A. The commercial standard was MB/Pic at 375 lb/A. Pic EC and Inline were applied under standard or virtually impermeable film, and with or without a sequential application of metam sodium at 45 gallons per acre. Metam sodium was applied 5 days after Inline or Pic EC were applied. Weed counts and weeding times were measured periodically. Significant findings.1.Pic followed by dazomet was an effective treatment in strawberry nurseries. Daughter plants produced with treatment were as productive in fruiting fields as plants produced with MB/Pic. 2.The level of nematode, soil borne disease and weed control provided by IM/Pic, Telone C35, Inline and PB, did not differ from MB/Pic. 3.Pic alone was often less active on citrus nematode and weeds than MB/Pic. 4. Relative to MB/Pic, net returns in strawberry nurseries will likely be reduced with the alternative fumigants. A sequential application of Pic followed by metam sodium was an effective method to reduce weeding costs where Pic was used as the base fumigant. Sequential applications of metam sodium or the use of VIF plastic were effective methods to reduce weeding costs where Inline was used as the base fumigant.
Impact: Methyl bromide is the basis for control of soil-borne diseases, nematodes and weeds in California's $889 million strawberry industry. We have developed effective alternative fumigant systems, and are currently assessing their economic viability.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Alternative Weed Control Options for California Strawberry and Vegetable Growers
Description: The ultimate goal of the principal investigator is to develop integrated weed management systems for coastal California vegetables and strawberries. Present objectives are to: A.Evaluate new weed management systems for strawberry. B.Determine if preirrigation can be used to improve weed control in conventional and organic vegetable production. C.Evaluate new potential herbicides for lettuce. Our principal research objective is to develop improved weed management options for vegetable crops. This project is focused on three principal areas: (1) the development of season-specific weed management programs for vegetables, (2) the evaluation of herbicides in broccoli and celery, and (3) the development of more effective common sowthistle (Sonchus oleracea) management systems for lettuce. Season-specific weed management. The goal of this project is to develop season-specific weed management programs for vegetables. Weed emergence and soil seedbanks in two vegetable fields were monitored from March 1998 until November 2001. Our methods allowed us to detect seasonal weed emergence patterns. We found that periods when the seedbank was highly germinable correlated with periods of high weed emergence. Annual bluegrass (Poa annua) has emergence peaks in the fall, while common purslane (Portulaca oleracea); hairy nightshade (Solanum sarrachoides) and pigweeds (Amaranthus spp.) have emergence peaks in summer months. Burning nettle (Urtica urens), common chickweed (Stellaria media), common groundsel (Senecio vulgaris), henbit (Lamium amplexicaule) and shepherd's-purse (Capsella bursa-pastoris) emerged all year. We have developed a model to predict the seasonal emergence of annual bluegrass. The model

predicts high emergence in November, and low emergence in June. Herbicide evaluations in broccoli. The crop tolerance and weed control efficacy of an encapsulated formulation of oxyfluorfen was evaluated in direct-seeded broccoli. Oxyfluorfen was applied postemergence at 0.063, 0.125, 0.25 and 0.5 lb ai/A in 3 to 4 leaf broccoli. Oxyfluorfen was safe on broccoli at rates up to 0.125 lb ai/A, and at this rate controlled hairy nightshade, shepherd's-purse, and common purslane. Herbicide evaluations in celery. Celery growers are in need of a way to control yellow nutsedge (Cyperus esculentus). Crop tolerance and weed control efficacy of S-metolachlor, flufenacet and flumioxazin were evaluated in celery. S-metolachlor was applied at 0.5, 0.63 and 0.95 lb ai/A, flufenacet at 0.4, 0.5 and 0.6 lb ai/A, and flumioxazin at 0.063, 0.094 and 0.188 lb ai/A were applied just prior to celery transplanting. The commercial standards linuron at 1.0 lb ai/A and prometryn at 1.5 lb ai/A were applied approximately 2 weeks after transplanting. S-metolachlor and flufenacet controlled yellow nutsedge, while none of the other compounds controlled this weed. All herbicide treatments were found to be safe on celery. Common sowthistle management in lettuce. We are evaluating cultural methods to improve the management of common sowthistle in lettuce. Common sowthistle germinates from very shallow layers in the soil. If sowthistle seed in an infested field can be buried by plowing, and left in the soil for a sufficient period of time so that most seed die, then it may be possible to deplete the soil of viable sowthistle seed. Previously buried sowthistle seed samples unearthed at 6, 12, and 18 months, had seed viabilities (+ the standard error) of 80.3(+8.1), 76.3(+12.2) and 16.9(+5.3)%, respectively.
Impact: California vegetable producers sold over $5.6 billion in produce during 2001. The long-term profitability of California vegetable producers is threatened by the potential loss of vegetable herbicides to regulatory action. Integrated weed management strategies may allow reduced pesticide inputs and ease some of the regulatory concerns that are focused on many of the older vegetable herbicides.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Application of Chemical Ecology for Conservation and Augmentation of Bark Beetle Predators
Description: Objectives: 1. Determine if chemical lures (pheromones/kairomones) can be used to estimate the relative abundance of Ips pini and its predators. 2. Determine if the negative effects of phermononally-based treatments on natural enemies can be minimized by using chemical lures and temporal deployment patterns that maximize the response of predators. 3. Determine if the performance of natural enemies of Ips pini can be augmented by using defined lures. The goal of this research is to develop means to reduce the removal of predators during bark beetle trap-out programs and to increase predator-to-prey ratios in bark beetle-attractive timber harvest sites. Researchers from the University of California, Berkeley, University of Wisconsin, Madison, and University of Montana prepared and received a grant to test whether natural enemies of bark beetles use volatiles from fungal associates of bark beetles to locate their prey. This collaborative work builds on their previous work with the bark beetles. They will characterize the temporal relationships among beetle development, fungal establishment, and natural enemy arrival in lodgepole pines in Montana. They will isolate the major fungal associates, and determine whether their volatiles attract natural enemies in field experiments and laboratory assays. Experiments are funded for the 2002-2003 summer field seasons. In 2001 we completed manuscripts describing field experiments in California in two consecutive years to determine how attractions of the bark beetle Ips pini and its major predators vary between

synthetic pheromones and natural volatiles emitted by host plant material upon infestations by I. pini. Results indicated that I. pini were preferentially attracted to few treatments. In contrast, coleopteran predators showed a broader kairomonal selection than their prey, including those attractive to I. pini. These suggest that pheromonal preferences of both prey and predators at the regional scale should be considered before deploying semiochemicals, and alternative chemicals, other than pheromones, such as plant volatiles, should be investigated in the field to improve overall monitoring programs.
Impact: Results of this study have extensive implications to current forest pest management practices. The results show that accurate assessment of bark beetle populations with the right semiochemicals will reduce impact of bark beetles on forest production. Moreover, timely applications of synthetic semiochemicals will improve monitoring programs relying on biological control agents, particularly predators, and acquire accurate information on both pest and natural enemy populations. Thus, this project is improving the control of bark beetle while reducing chemical applications. This increases forest production while reducing environmental impacts.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Bait Technology for Control of Ants
Description: Ants are the major pests in urban environments. Recent introductions of the red imported fire ant in urban environments in California pose a serious threat to agriculture. Argentine and field ants are a major pest in citrus and grapes, where they tend, or care for, homopteran pests and disrupt biological control. A Cooperative Extension Urban Entomologist and AES Professor of the University of California, Riverside developed low-toxicity liquid and granular baits as alternatives to insecticidal sprays for ant control. The use of baits is more effective and substantially reduces the amount of insecticide used in urban and agricultural settings. The reduction of ants in agricultural settings will increase the effectiveness of biological control agents, thereby reducing insecticide applications. They also are developing delivery systems for baits to minimize the exposure of the environment and crops to insecticide.
Impact: Recently the Environmental Protection Agency approved the UCR propoal to register bait stations and toxicants for use in citrus orchards and grape vineyards in California. The clearance covers toxicants not previously registered for use in all fruit, nut, and vine crops throughout the United States. Use of these baits is reducing the amount of pesticides used in ant control, reducing grower costs and improving environmental quality.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Biological Control and Ecology of Arthropod Pests Attacking Avocado
Description: Objectives: 1. To examine the population biology of newly introduced pest species attacking avocados in California and determine occurrence, distribution, and economic impact. 2. To introduce as necessary natural enemies to reduce population densities and economic damage of pests attacking avocados in commercial and non-commercial (urban) settings. 3. To examine the biology, demography, and behavior (host searching and reproductive behavior and potential) of newly introduced natural enemies attacking avocado pests. 4. To quantify the impact of natural enemies, both resident and recently introduced on avocado pests. 5. To quantify the economic benefits (increased yields and reduced pesticide use) of successful biological control of

avocado pests. Significant results have been achieved in the fifth year of work on the biological control avocado pests in California. First, the overwintering ecology of OLIGONYCHUS PERSEAE has being investigated. 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. The pest thrips SCIRTOTHRIPS PERSEAE, a species new to science at time of discovery in California, has been subjected to augmentative releases of a mass-reared predatory thrips, FRANKLINOTHRIPS ORZIABENSIS. The searching behavior of this predator has been studied, and its attack rates quantified. California insectaries have commercialized this predator using the results of our research findings. We are currently developing an automated sorter to count and categorize predator thrips pupae thereby reducing labor costs associated with sorting. Work investigating the suppressive activity of composted organic mulches under avocados for control of pupating SCIRTOTHRIPS PERSEAE is ongoing.
Impact: Growers, grower cooperatives, and insectary managers are using Franklinothrips orizabensis and composted organic mulch in California for control of Scirtothrips perseae. Mass rearing of Franklinothrips orizabensis, the key natural enemy of avocado thrips in California, has been undertaken by two commercial insectaries using the results of our research.
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, UC PI #1
Description: Objectives: 1) Survey indigenous natural enemies; 2) Conduct foreign exploration and ecological studies in native range of pest; 3) Determine systematics and biogeography of pests and natural enemies; 4) Determine environmental safety of exotic candidates prior to release; 5) Research, establish, and redistribute natural enemies; 6) Evaluate natural enemy efficacy and study ecological/physiological basis for interactions; 7) Characterize and identify pest and natural enemy communities and their interactions; 8) Identify and assess factors potentially disruptive to biological control; 9) Implement and evaluate habitat modification, horticultural practices and pest suppression tactics to conserve natural enemy activity; 10) Assess biological characteristics of natural enemies; 11) Conduct experimental releases to assess feasibility; 12) Develop procedures for rearing, storing, quality control and release of natural enemies; 13) Implement augmentation programs and evalutate efficacy of natural enemies; 14) Evaluate the environmental impacts of biological control agents; 15) Evaluate the economic impacts of target pests and their biological control. Microdus rufipes, a larval parasitoid of the codling moth was imported from China, and reared in glasshouse cages before field release in walnut orchards in California. In addition, monitoring of codling moth cocoon parasitism by Mastrus ridibundus, a parasitoid introduced from Kazakstan, indicated late season parasitism of up to 70% in some orchards. Parasitism of leaf curl plum aphid by Aphidius colemani continued to be high, with aphid populations low again in 2002. A strain of Aphidius transcaspicus collected from mealy aphid on almond in 2001 showed good parasitism of mealy plum aphid in field sleeve cages, but it is not yet known whether they have become established in prune orchards in the Central Valley. Weekly monitoring of the red gum lerp psyllid with sticky traps continues at 29 sites in 17 counties of California. To date 43,000 parasitoids, Psyllaephagus bliteus, have been released in 57 sites throughout the state. Parasitoids are now established in 30 counties and are continuing to increase in density and spread. Adult female counts on the traps were 37% lower in 2002 compared to the year before the parasitoids were released. Most of the areas with improvement are near the coast and parasitoids are just now becoming established at inland sites. Eugenia psyllid populations along with its parasitoid, Tamarixia nsp., continue to be

monitored in Alameda County. The timing of pruning to reduce psyllids and enhance parasitism is being studied and looks promising. Spotted gum psyllid plots have been established in Southern California. The parasitoid collected in Australia in 2002, Psyllaephagus hirtus, was tested in quarantine and found to be specific but the colony was lost prior to release. Foreign exploration for the parasitoid in Australia will be done in early 2003. The sunflower moth, Homeosoma electellum, was consistently more abundant in agricultural than in native sunflower habitats. In contrast, parasitism was 6-10 times higher in native than in agricultural habitats. Also, fewer parasitoid species were found in agricultural habitats, and parasitism by individual parasitoid species was reduced by 90%. These results indicate that patterns of trophic interactions varied by habitat type and were related to plant phenotypic changes and environmental habitat factors such as crop domestication, nitrogen fertilization, and plant phenology. Two molecular markers were developed for detection of Cacopsylla pyricola in the gut of arthropod predators. Detection was possible after 32 h of digestion for both markers. One marker was present in four different psyllid species tested, while the other was specific to C. pyricola and C. pyri. Neither marker was detectable in representatives of the Coccinellidae, Chrysopidae, Hemerobiidae, Anthocoridae, Miridae, Salticidae, Aphididae, Tetranychidae and the Tortricidae, suggesting their suitability for general trophic studies.
Impact: Biological control is reducing pesticide use in food and fiber crops and thus the negative impacts of pesticides in the environment.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AZ, CA, CO, GU, HI, ID, KS, MT, NM, NYC, OR, AS, UT, WA, WY; NON-SAES: USDA/ARS, APHIS

Theme: 4.12 Integrated Pest Management
Title: Biological Control in Pest Management Systems of Plants, UC PI #2
Description: (Objective 1) Survey indigenous natural enemies. (Objective 2) Conduct foreign exploration and ecological studies in native range of pest. (Objective 3) Determine systematics and biogeography of pests and natural enemies. (Objective 4) Determine environmental safety of exotic candidates prior to release. (Objective 5) Release, establish, and redistribute natural enemies. (Objective 6) Evaluate natural enemy efficacy and study ecological/physiological basis for interactions. (Objective 14) Evaluate the environmental impacts of biological control agents. Research continues to be concentrated on the whitefly species PARALEYRODES MINEI, which is a serious pest of citrus in California and some parts of the Mediterranean region. Foreign exploration was conducted in Honduras, yielding two species of PARALEYRODES and two species of ENCARSIA attacking them. One of these parasite species attacked PARALEYRODES MINEI in quarantine in California, and a culture of that parasite was initiated. We have been successful at establishing this parasite into field populations of PARALEYRODES MINEI. We are continuing our work to determine if the parasite can bring about biological control.
Impact: This project concentrates on reducing or eliminating the damage caused by pests, without the use of pesticides. This project has discovered two natural enemies that show potential in the control of an insect damaging to citrus production. These natural enemies will significantly reduce pesticide applications in citrus.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AZ, CA, CO, GU, HI, ID, KS, MT, NM, NYC, OR, AS, UT, WA, WY; NON-SAES: USDA/ARS, APHIS

Theme: 4.12 Integrated Pest Management

Title: Biological Control of Avocado Pests
Description: Two exotic pests, avocado thrips and persea mite, appeared in California in 1990 and 1996, respectively. A model based on 1998 harvest data predicted that growers in the state, who produce about 95 percent of the nation's avocado crop, would experience an estimated $13 million in short-term losses, with annual losses decreasing to $6 million as the industry developed means to deal with the pests. After more than four decades of largely pesticide-free insect control, many avocado growers now find it necessary to spray their orchards to minimize foliage and fruit damage. A Biological Control Specialist of the University of California, Riverside has worked closely with growers to develop biological control strategies to suppress avocado thrips and persea mites. Combating the mites involved three years of evaluation to identify an effective natural enemy, a predator mite known as Neoseiulus californicus that is raised commercially in California, and recommend for use by growers. He developed a motorized sprayer to apply the predator mites directly onto avocado tree leaves. The first step in controlling avocado thrips (Scirtothrips perseae) was to classify the pest and its home range, both of which were unknown until the pest became a nuisance in Ventura County in 1996. He also identified Franklinothrips as an effective predator species. He has successfully mass-reared these ant-mimicking predators, and has developed a new harvesting mechanism and automated sorter that makes it possible to collect predators from their rearing cages and transport them to groves. Field trials evaluating mass-reared Franklinothrips for control of avocado thrips are underway. Another method he determined to be useful to combat thrips is the use of composted organic mulches around the trees. Not only do the mulches aid in retaining water and benefit the soil, they also increase fruit yield by 13 percent and reduce populations of avocado thrips, which fall off trees to pupate, by as much as 50 percent. In addition, mulches help suppress avocado root rot.
Impact: Persea mites can be largely controlled through non-chemical strategies developed by the researcher. Biological and cultural control of avocado thrips that reduces reliance on pesticides has progressed substantially, and techniques developed at UCR are employed by growers. The benefits to the state's $300 million-a-year avocado industry include significant reduction in financial losses due to damaged fruits.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Biological Control of Eucalyptus Pest
Description: The eucalyptus snout beetle, Gonipterus scutellatus, was discovered defoliating eucalyptus trees in Ventura County in March 1994. This insect has been introduced accidentally into several eucalyptus-growing regions around the world from Australia and has caused extensive damage wherever it has become established. Female beetles deposit hard brown egg capsules on shoots and young leaves. Both adults and larvae consume young and tender leaves, buds, and shoots. Extensive feeding completely defoliates trees and kills branches, while intermediate levels of defoliation retard growth and affect tree shape. UC Riverside entomologists responded rapidly to the invasion of this pest by introducing a specific parasitoid of snout beetle eggs, the wasp Anaphes nitens, as a natural biological control agent. The wasps were mass reared and released in Ventura County in 1994 and 1995, and they rapidly became permanently established.
Impact: Snout beetle populations declined dramatically within less than a year. By 1997, snout beetle populations had dropped to barely detectable levels (Hanks, et al. 2000). Although reduced to non-damaging levels, the beetle has continued to expand into adjacent counties.

However, in all cases, the parasitoid distribution has expanded in tandem, to mirror the distribution of its host. Consequently, where pesticide use has not disrupted the actions of the parasitoid, there have not been further reports of damage. The rapid implementation of a biological control program nipped a serious problem in the bud, providing an effective and permanent solution that, in 2003, requires no further input.
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: Grape phylloxera was probably imported into California during the 1850s and 1860s. After detection, damage and spread was well documented. By 1921, W. M. Davidson and R. L. Nougaret reported its presence in all California viticultural regions north of the Tehachapis. Rootstock trials began in earnest in 1905. A variety of rootstocks were used until L. A. Lider recommended the rootstock AXR number 1 for its superior viticultural properties. Failure of this rootstock to phylloxera began in 1983. The virulent phylloxera causing the damage was named biotype B to distinguish it from the then more common biotype A that did not damage AXR number 1. Grape production losses and replanting cost California about 1 billion dollars but is now substantially complete. Rootstocks used in California's cooler wine regions now tend to be only those that are strongly resistant to grape phylloxera while both susceptible own-rooted vines and rootstocks that are not as strongly resistant are used in the Central Valley which is less conducive to the insect and its damage. Pockets of phylloxera infestations and damage are not un-common in many regions and are due to farmers not yet having dealt with AXR number 1 prob-lems or knowingly or unknowingly engaging in risk-taking. It is important to note that the only rootstocks to fail due to phylloxera populations over the approximately 130 years since they were first selected and hybridized, have been the weakly resistant rootstocks with partial V. vinifera parentage. This is not to say that the strongly resistant rootstocks are immune: they can support small, non-damaging phylloxera populations on their feeder roots and many have strong leaf-galling populations neither of which substantially decrease vine fitness. Our main questions are: -Why has resistance of rootstocks to phylloxera been so durable? -What is the risk of failure and what are the risk factors that might accelerate failure? -What can we do to prevent or slow failure? -What tools do we need in order to be prepared to meet that failure if and when it occurs? The long term goals of this project are to: 1. Evaluate and monitor worldwide risk for failure of strongly phylloxera resistant root stocks. 2. Develop methods to prevent rootstock failure and react after it has occurred. To accomplish these goals the 5 year objectives are to: 1. Identify reasons why failure of strongly resistant rootstocks has not already occurred and de-termine factors that may increase or decrease the probability of failure. This knowledge will be used to evaluate and monitor risks worldwide. 2. Determine viticultural methods that can predictably ameliorate phylloxera populations and vineyard damage.
We studied the Fusarium oxysporum isolates collected in 2001 from phylloxerated vines and ranked as high, medium, or low virulence. 1) We began to confirm isolate virulence level on vines newly planted in a Davis, CA field. Six grape rootstocks and a Vitis vinifera cultivar were planted in early summer and in autumn were inoculated with low or high virulence fungal strains or no fungus using single-root cloth enclosures held in place with clips. The study will be evaluated in 2003. 2) Natural selection of low or high virulence characteristics from a mix of the fungal isolates by pathogenic or non pathogenic culture conditions was tested in Petri dish experiments. Results suggest that selection did not occur. The experiment will be replicated in 2003. 3) A small vineyard trial in Hopland, CA tested whether water stress applied to vines

changed apparent virulence of fungal inoculations on roots. Results suggest that stress increases virulence of F. oxysporum isolates. 4) Fungal isolates that have been used were originally extracted from partially necrotic vineyard roots without regard to where in the root the isolate arose. We tested the hypothesis that isolates from necrotic tissue will be less virulent than isolates from tissue that is not yet necrotic at the leading edge of an infection. Results falsified the hypothesis. Virulence was independent of necrotic state of the tissue from which the isolate was taken. L. Kocsis (Vesperim U., Hungary) and I evaluated data collected in 2000 on phylloxera leaf galls suggesting that leaf infestations come from insects overwintering in the soil and that leaf galling is synergized by presence of other leaf galls. These discoveries explain the enigma that populations of leaf galls are very uneven in susceptible vineyards. The rate limiting factor for leaf phylloxera populations is gall formation (this was previously shown with root feeding phylloxera). A common physiological interaction exists between phylloxera and plant independent of feeding site. Preliminary data for both roots and leaves suggest feeding attractants/arrestants may be involved as well as the physiological factors inducing gall formation. We will now focus on identifying factors. We evaluated fungal isolates from Vitis labrusca cultivars in NY in conjunction with G. English-Loeb (NYAES). We had hypothesized that the low level of damage of those cultivars by phylloxera infestations was due to resistance of the roots to fungal infections. This hypothesis was disproved. Instead the low level of damage appears to be due to the lack of phylloxera feeding on the mature roots - their infestation appears to be limited to immature feeder roots which result in considerably less vine damage than does feeding on mature roots. We continued the large field trial using compost to ameliorate phylloxera vine damage in a mature vineyard for the third year. Treatments include plots with and without compost cover, hay cover, and tillage. To date treatment effects with regard to phylloxera populations or root necrosis have not been seen. However treatments with tillage appear to be healthier. This experiment will be continued into 2003.
Impact: Severe phylloxera-caused vine damage is prevented by rootstocks. Since we don't know how rootstocks work and have limited knowledge of the grapevine-insect interaction, we can not trouble shoot problems. This research provides a basic understanding of the nature of phylloxera damage and the plant-insect-soil microbiology interactions. This knowledge will help maintain trouble-free rootstock use.
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: Objectives: 1. To determine the biotype status of the cowpea aphid currently infesting alfalfa in California. 2. To identify alfalfa germplasm containing resistance to the cowpea aphid. 3. To identify, synthesize, and test sex pheromones of the squash bug. 4. To develop pheromone-based management strategies for the squash bug. 5. To utilize reflective mulches to reduce and delay the onset of aphid transmitted viruses and silverleaf whitefly infestations in vegetable crops and to evaluate biological cover crop mulches for insect and disease suppression. Overwintering biology of the corn leafhopper, DALBULBS MAIDIS and the corn stunt spiroplasma, SPIROPLASMA KUNKELII was determined. Leafhopper survival was evaluated using yellow stick cards placed throughout Fresno, Tulare and Kings counties and by taking weekly D-vac suction samples from suspected overwintering sites within the three county area. Adult leafhoppers were collected monthly on yellow sticky cards throughout the winter, from October through March. Likewise, adult leafhoppers were collected in the D-vac

suction samples during the same time period. Adult leafhoppers were most commonly collected in D-vac samples taken from riparian areas adjacent to stream beds that ran in the proximity of corn fields. These areas had a dense covering of winter annual grasses including annual blue grass and Johnsongrass. Leafhoppers were found deep within these grass mats. Adult leafhoppers were also frequently found in alfalfa fields adjacent to corn fields that has been heavily infested during the previous summer and fall. Leafhoppers settled deep within the alfalfa crowns where they were somewhat protected from frost. Although silage corn within the three county area was harvested by late October, numerous fields contained volunteer corn plants. These volunteer plants served to maintain high populations of corn leafhopper well into the early winter. Although frost killed back the tops of the corn plants, the lower portions remained viable as supported leafhopper growth and development. Leafhoppers collected throughout the winter were all females and it appears that this is the only sex that survives the winter. The leafhoppers were tested for the presence of the corn stunt spiroplasma using PCR techniques and individuals collected throughout the winter were positive for the spiroplasma. This indicates that the spiroplasma overwinters within the overwintering adult leafhoppers. Even though corn, the only host for both the leafhopper and the spiroplasma, was not available for approximately three month, January through March, the leafhoppers, and the spiroplasma, overwintered successfully in the San Joaquin Valley. In a survey conducted during the late summer and fall of 2002, the corn leafhopper was found in the following counties: Kern, Tulare, Kings, Fresno, Madera, Merced, Stanislaus, San Joaquin, Solano, Yolo and Sacramento. These leafhoppers are currently being tested via PCR techniques to determine if the also are infected with the spiroplasma. The effectiveness of UV reflective plastic mulch and wheat straw mulches was compared to a pre-plant application of imidacloprid (Admire) insecticide and an unmulched, untreated control. Symptoms of squash silverleaf and virus infection were significantly delayed and reduced by wheat straw that was scattered over the beds and the UV reflective plastic. Pre-plant Admire was not as effective in managing either whiteflies or the virus diseases as were the mulches. Yield of marketable fruit was significantly (P 0.05) higher from plants growing over the scattered wheat straw and the UV reflective plastic mulches than for those growing in the Admire treated plots or the control.
Impact: Studies clearly show that the leafhopper and spiroplasma are capable of overwintering in the San Joaquin Valley. This contradicts previous notions that the leafhoppers could not survive the winter in the San Joaquin and that were due to the leafhopper arriving in the Valley from overwintering sites in Mexico. This knowledge has far reaching consequences on how we prepare management strategies.
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: We will begin the next five years of this project by studying the epidemiology of GWSS-vectored PD. This pathogen system serves as a model to illustrate the objectives and methodologies that are germane to epidemiological research. As other diseases become problems in the state, similar strategies will be followed. 1.Determine the incidence and distribution of disease in the affected geographic area. 2.Determine the distribution and abundance of vectors in the affected geographic area. 3.Determine the relationship of alternate hosts to the distribution of disease and the density of vectors. 4.Describe the epidemiology so that information can be used to develop control strategies. We have concluded most of our work management of silverleaf whitefly, BEMISIA ARGENTIFOLII. Research has shifted away from whitefly biology to

epidemiology of insect-vectored plant pathogens and agriculturally important mites. We see a re-occurrence of greenhouse whitefly, TRIALEURODES VAPORARIORUM, vectored viruses in tomato in southern California. This whitefly has a broad host range and effectively moves from crop to crop throughout the serially-planted agricultural areas. We have determined that greenhouse whitefly is reluctant to leave its host plant and is not prone to take flight as readily as silverleaf whitefly. This lends support for management through crop destruct and rotational programs that create host free barriers in time and space. Other epidemiological studies have focussed on the spread of Pierce's disease (PD) bacterium, XYLELLA FASTIDIOSA, by the glassy-winged sharpshooter (GWSS), HOMALODISCA COAGULATA in table grapes in the Coachella Valley. A significant find this year was the presence of PD in 13 vines from 2 adjacent vineyards in the southeastern part of the Valley. This marks the early stage of the PD epidemic in this area, and puts us in an excellent position to study the development of a GWSS-vectored PD epidemic. We concluded nearly 2 years of area-wide monitoring of GWSS, with several results. First, GWSS numbers appear to be increasing in the area when compared to the same time period as the previous year. Second, GWSS densities are heavy in citrus and almost non-existent in grapes and near urban areas. There is also a declining gradient of GWSS numbers in grapes as trap distance from citrus increases. Third, we have managed our data in a digital GIS, enabling us to identify citrus groves within specified distances of traps that have certain GWSS densities. This is a powerful tool that shows where GWSS management is most needed, as well as groves that are less at risk. In our work on the Banks grass mite, OLIGONYCHUS PRATENSIS we are developing sampling tools and establishing DD models for timing acaricide applications in dates, PHOENIX DACTILIFERA. We continued studies on the coconut mite, ACERIA GUERRERONIS, a pest of queen palm seedlings. We have determined that the mite develops from egg to adult in 6.8 days and that the optimal temperature for development is 29.8C. The thermal optimum is 36.7C. In related research at an infested nursery, large densities of coconut mite were found dispersing through the air via wind. Acaricide trials have failed to identify materials capable of penetrating deep into the meristematic tissue of the plant to provide control. We have continued work on the carob moth, ECTOMYELOIS CERATONIAE, a pest of dates. Our research indicates that moths have retarded development when the moisture level in the fruit drops below 35%. We have found a previously undescribed parasitoid from field collected samples and we will investigate its ecology. We have conducted our first insecticide trial and determined that Dipel and Cryolite provided sufficient control to warrant further investigation. We also are continuing our research into pheromone disruption of carob moth.

Impact: Our area-wide monitoring programs have elucidated crops and weeds that significantly contribute to area-wide whitefly problems, and when these host plants have the greatest impact. The goal of this work is to provide growers with information that helps them time management strategies in the many crops grown in the regions. Since the arrival of the glassy-winged sharpshooter into California, Pierce's disease has had a major impact on several grape-growing regions in the state. While this disease has been present in California for over 100 years, the arrival of this new sharpshooter has altered the epidemiology. The goal of our epidemiological studies is to identify characteristics unique to regions with high and low PD, and manipulate these features to manage the spread of PD. While the current model is area-wide application of systemic insecticide for GWSS control, it is unlikely that this activity can be sustained because of the cost involved. Our research provides information that will be part of a longer-term management strategy. Our work on mites has continued for many years, however recently there has been an increased interest from growers of numerous commodities facing problems with Acarines. In many systems, the basic biology of the mite is lacking, so the producer is faced with repeated applications of acaracides. The research conducted in our program is aimed at reducing

the reliance on these applications toward a more holistic management strategy. Similarly, our work on carob moth will have the same impact.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Biology, Ecology, and Biological Control of Whiteflies Exotic to California
Description: Objectives: 1) Determine the identity and examine the demography of whiteflies, both those affecting California cropping and agricultural systems and those posing risk to such systems on a worldwide basis, to determine what factors contribute to pest status of these species. 2) Introduce as necessary natural enemies of whiteflies to effect biological control of whiteflies affecting agronomic systems. 3) Examine the ontogeny, demography, behavior, genetics and population ecology of natural enemies of whiteflies, including but not limited to predaceous Coleoptera and Neuroptera, parasitic Hymenoptera, parasitic nematodes, and pathogenic fungi, and quantify their impact on pest whiteflies of California agriculture. Research continued to be concentrated on the field establishment and field effectiveness of two natural enemies of the pest ALEURODICUS DUGESII, a whitefly introduced into California, which is a serious pest of landscape ornamental plants throughout southern California, Florida, and parts of Louisiana and Texas. The natural enemies discovered in Mexico in 1997, ENCARSIELLA NOYESII and IDIOPORUS AFFINIS, were released against this species in 1999 and 2000, and the study of these sites to determine the degree of control these parasites can give is ongoing. At study sites with releases for each species of parasite, populations of the whitefly are under substantial to complete control. Continuing studies are expanding the study area to newly infested regions and newly infested environments, to determine the range of control possible with these natural enemies.
Impact: This project concentrates on controlling pests using their naturally occurring predators and parasites, rather than pesticides. While Encarsiella noyesii has been successful at various release sites with some movement, Idioporus affinis has been able to extend the area of control beyond the release sites to areas several miles away. These predators are significantly reducing pests with significant reductions in pesticide applications.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Characterization of Agricultural Nematodes for Improved Systematics and Identification
Description: Objectives: 1) Expand comparison of detailed morphology and development of classical and novel characters of Tylenchida and outgroups. 2) Use results of objective one to develop a more complete phylogenetic hypothesis of Tylenchida and outgroups. 3)Revise the classification of the Cephalobina. 4) Provide electronic aids for identification of Cephalobina and select groups of Tylenchida. The goal is to develop an evolution-based classification system of agricultural nematodes in the context of non-parasitic relatives, with results applicable to both management of agricultural and natural (non-agricultural) ecosystems. During 2002 we moved forward with clearer phylogenetic resolution of Cephalobina (the closest relatives of agricultural plant-parasitic Tylenchida) with publications including new species of Nothacrobeles and Acrobeles (Poiras et al, 2002 and Mundo-Ocampo et al. 2002). Both of these papers involve redefinition of the genus involving fine structure, including features previously unknown. In addition, we have submitted a manuscript clarifying the intraspecific pathogenic variability, including new diagnostic tests of a cephalob nematode parasite of horses, Halicephalobus. We

are moving forward with a collaborative molecular/morphological phylogeny of Cephalobina that we expect to submit for publication during 2003-2004. Currently underway is an SEM and TEM resolution (focusing on the feeding system) of the bacterial feeding nematode, Bunonema, including discovery of new characters that bring resolution to previous apparent discrepancies between molecular and morphological evolution. Outreach including new insight into nematode taxonomy is addressed in broader publications including Baldwin, 2003; Baldwin and Perry, 2003)
Impact: Results move us closer to our goal, with collaborators, of developing a sound phylogenetic classification of Tylenchida. A classification system based on evolution supports all other nematology research because, for example, it is the basis of predictability and repeatability of experimentation. These taxonomic systems are critical to natural ecosystems for surveys in developing a base-line and monitoring for ecological and invasive species. Fine structural characterization of feeding systems in parasitic nematodes, within an evolutionary context provides a starting point to manipulate these systems to favor agricultural production.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Characterization of Gene Conferring Nematode Resistance to Plants
Description: Objectives: 1. To characterize the nematode resistance gene Mi from tomato and investigate its mechanism of action. 2. To characterize a new nematode resistance gene, Mi-3, and to work toward incorporation of this gene into cultivated tomato. The tomato gene Mi-1, which confers resistance to three of the most damaging species of root-knot nematodes as well as to some isolates of potato aphids, was previously cloned in our laboratory. To increase our understanding of how this single gene can recognize the presence of the nematode and trigger a defense response, we have manipulated the gene and reintroduced altered versions of it into tomato roots and tobacco leaves. These experiments have provided insights into how this gene is controlled to trigger a defense response only when the nematode is present. One end of the molecule appears to repress the signaling of the response and to release this repression in the presence of the nematode. We have also identified parts of the gene product of Mi-1 that are required for recognizing the nematode. We have increased our understanding of the pathway leading to nematode resistance and find that the signaling molecules salicylic acid and nitric oxide play a crucial role. Currently Mi-1 is the only nematode resistance gene present in cultivated tomato. The value of Mi-1 has been compromised by the appearance of variant nematode strains and species that infect Mi-1-bearing tomato. We have identified and genetically mapped a new root-knot nematode resistance gene, Mi-3, in the wild tomato species Lycopersicon peruvianum. Mi-3 has been localized to a region of the genome of less than 40 kilobases and DNA sequence analysis has identified candidates for the resistance gene. DNA spanning these candidates is being introduced into both wild and cultivated tomato to be tested for resistance.
Impact: Root-knot nematodes cause considerable damage to thousands of crops worldwide. This research should result in improved availability of host resistance by incorporation of new natural resistance genes or modified resistance genes into susceptible crops. Host resistance reduces damage caused by parasitic nematodes and reduces the need for use of chemical pesticides.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management

Title: Characterization of Microbial Microhabitats on Leaves
Description: Objectives: Determine the spatial and temporal heterogeneity of sugar availability at small scales on leaf surfaces using whole-cell bacterial biological sensors. Assess the differences in cell survival and other behaviors of bacteria occurring in aggregates on leaves compared to solitary cells. Compare the chemical environment of solitary bacterial cells with aggregated cells on leaves. Determine the contribution of cell-cell signaling molecules on the fitness of aggregated bacteria on plants. Evaluate strategies of interference with, or degradation of, cell-cell signals in epiphytic bacteria as means of inhibiting their colonization of plants
A novel strategy termed habitat-inducible rescue of survival (HIRS) was developed to identify genes of Pseudomonas syringae that are induced during growth on bean leaves. This strategy is based on the complementation of metXW, two co-transcribed genes necessary for methionine biosynthesis and required for survival of P. syringae on bean leaves exposed to conditions of low humidity. We constructed a promoter-trap vector, pTrap, containing a promoterless version of the wild-type P. syringae metXW genes. Only with an active promoter fused to metXW on pTrap did this plasmid restore methionine prototrophy to the P. syringae metXW mutant B7MX89 and survival of this strain on bean leaves. Promoter activity experiments using a gfp reporter gene revealed that these plant-inducible gene promoters had very low levels of expression in minimal medium. Based on GFP fluorescence levels, it appears that many P. syringae genes have relatively low expression levels and that the metXW HIRS strategy is a sensitive method to detect weakly expressed P. syringae genes active on plants. Of the 130 plant-inducible loci isolated following metXW-HIRS selection, a subset of 46 was characterized and their transcriptional regulation examined by fusion to a promoterless inaZ reporter gene. Most loci had very low levels of transcriptional activity in culture media, whereas their expression typically increased between 10-100 fold on either wet or dry leaves. These plant-inducible loci encode proteins involved in virulence, stress response, nutrient acquisition, membrane structure, chemotaxis, and other miscellaneous functions. Over half of the plant- inducible loci encode ORFs that are either novel or have no obvious function. Another subset contains promoters located either in internal portions of known genes or in the non-coding strand of known genes. The latter possibly encode antisense transcripts that result in down-regulation of genes that are either not required for or are detrimental to epiphytic fitness. Of those loci containing obvious promoters to genes with known function, two were shown to contain genes that, upon deletion, reduced the mutants' competitive ability to grow with wild-type P. syringae in protected sites on dry leaves. The first gene is homologous to oriB, a gene of unknown function located in the Conserved Effector Locus of the P. syringae hrp/hrc pathogenicity island, which suggests that hrp/hrc-associated genes are involved in epiphytic fitness. The other gene, ssuE, gene encoding a NADPH-dependent FMN-reductase involved in the sulfate starvation response was induced not only on leaves but also in P. syringae cells grown in culture media containing sulfur sources other than sulfate. Furthermore, a P.syringae ssuE mutant strain exhibited impaired growth in media lacking sulfate or cysteine. Our findings suggest that there is a limited supply of sulfate on leaf surfaces, and that the primary sulfur source for P. syringae located in protected sites may be plant-derived compounds other than sulfate.
Impact: The identification of genes of the plant pathogen Pseudomonas syringae that are induced while this bacterium is on leaves provides much information on the nature of the leaf surface environment. Furthermore, we have identified many adaptive traits that this good epiphyte expressed only while it is on leaves. Such adaptive traits, if transferred to, and expressed in, beneficial bacteria such as biological control agents should improve their fitness on plants and lead to better biological control of plant diseases and frost injury. This method of

selecting for genes expressed in plants should be a powerful means to study other plant associated bacteria.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Characterization of Root-Knot Nematodes that Infect Resistant Tomato
Description: Root knot nematodes have a very broad host range and infect a large number of crop plants, yet there is considerable variability within species in virulence and host range. The long range goal of this research is to understand how root-knot nematodes change genetically to acquire virulence against new hosts or hosts with specific resistance genes. The interactions of root-knot nematodes with tomato plants carrying the well-characterized nematode resistance gene, Mi, provides an excellent model system for these studies. The current objectives are to: 1)Identify molecular differences between a closely related pair of root-knot nematode strains that differ in their ability to reproduce on tomato with Mi and 2)Identify a gene that is responsible for the virulence difference between nematode strains VW4 and VW5. The tomato gene Mi-1 confers resistance against several species of root-knot nematode. We had previously identified two closely related nematode strains, VW4 and VW5, that differ in their ability to reproduce on tomato with Mi; VW4 cannot reproduce on resistant tomato whereas VW5 can reproduce. We used the DNA marker technique, cDNA-AFLP, to identify differences in the gene expression pattern between these two strains. One clone, CG1, was found to be expressed in nematode juveniles of the avirulent strain VW4 but was lacking in the virulent strain VW5. DNA blot analysis revealed that this gene was a member of a gene family, one member of which was missing in strain VW5. The expression difference was confirmed by RT-PCR. We obtained the DNA sequence of this clone and have obtained additional clones of this region on the nematode genome. So far no strong similarity to genes of know function has been identified. More than one transcript size appears to be produced from this region of the genome and no long open reading frame has been identified. As an approach to understanding how pathogens such as nematodes may circumvent resistance, we have investigated the effects of selected compounds on resistance mediated by Mi-1. We have found that the plant hormone cytokinin can cause loss of resistance and that salicylic acid appears to be required for host resistance to function.
Impact: Root knot nematodes cause major damage to thousands of crop species. Host resistance is a preferred control mechanism. However, the ability of nematodes to overcome resistance is an important problem. It is necessary to understand how this asexual species can change genetically to bypass host resistance in order to prolong the utility of this resistance.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Characterizing Nematode Biodiversity Through Phylogenetic Analysis of Gene Sequences
Description: Objectives: 1)Refine methodologies for obtaining molecular (DNA sequence) data and archiving morphological (light microscope image) data from individual nematodes, including small microbivores obtained directly from soil. Establish a database protocol for efficient management of these systematic and specimen data. 2)Use these refined methodologies to evaluate the biodiversity of nematodes, including various groups of vertebrate parasites, and representatives of a major suborder (Cephalobina) that includes both free-living nematodes and parasitic species. In particular, two major clades of Cephalobina (superfamilies Cephaloboidea and Panagrolaimoidea) will be the focus of investigation. Certain genera of the subfamily

Cephalobinae (Cephaloboidea) will serve as a model system for assessing the biodiversity of soil nematodes. For the Panagrolaimoidea, biodiversity of insect-parasites of the family Steinernematidae (Steinernema) will be investigated. When feasible, in vitro cultures of nematode isolates representing these superfamilies will be established. 3)Perform phylogenetic analyses of nucleotide sequences to assess relationships among sampled terminal taxa and to determine which lineages are demarcated by autapomorphies, and thus can be delimited as separate species using these data. Assess if sequence data provide a basis for simple molecular methods of diagnosis (e.g., PCR/RFLP) among the sampled taxa.
The focus of this project is to advance our understanding of nematode biodiversity. Practically, the inability to easily identify nematodes to species handcuffs many areas of investigation, ranging from characterizing the nematodes in a field sample to understanding how environmental samples differ with respect to their nematode communities. The research in this project involves using molecular systematic approaches to delimit nematode species through phylogenetic analysis. Molecular approaches are necessary for many groups of nematodes because there are few readily observable characters available via light microscopy (Stock et al., 2002). During the reporting period the lab has focused on two areas, one fundamental (and theoretical), and the other applied. On the fundamental side, we have addressed how species should be delimited using gene trees, and some of the potential problems that may be encountered when this approach is used (Nadler, 2002). Developing a theoretical framework for delimiting species is essential for additional progress in nematode systematics and biodiversity. On the applied side, our lab has experimented with various methods to isolate DNA from individual microscopic soil nematodes, and in using PCR to amplify multiple genetic loci from individual nematodes. This approach is requisite for delimiting species and developing molecular methods for their identification. Preliminary work on a common genus of soil microbivores (Acrobeles) has been successful; a graduate student is now using this approach to assess how many species of Acrobeles are found in specific sampling plots in Southern California. Although Acrobeles can be established as in vitro cultures, this research is performed directly on individual nematodes obtained from soil samples, which is the requisite approach for the large fraction of nematodes that cannot be easily cultured. Preliminary work on Acrobeles and other distantly related nematode genera suggests that the internal transcribed spacers of nuclear ribosomal DNA provide useful characters for species delimitation. Certain mitochondrial loci, including cytochrome oxidase subunit 1 (unpublished) and 12S rDNA (see Nadler, 2002) have also provided data useful for phylogenetic species delimitation. During the reporting period, ribosomal sequence data have been obtained for many species in the suborder Cephalobina. This database of sequences provides a useful comparative tool for analysis of taxa that are difficult to identify. During the next year this research will be extended in two ways. First, a multilocus approach will be used to obtain more complete datasets on a model nematode system (Acrobeles). Second, these methods will be used to test hypotheses of species for hookworm parasites of marine mammals (Uncinaria in pinnipeds), and to understand more about the biodiversity and genetic structure of ascaridoid nematodes from skunks and raccoons (Baylisascaris spp.) that are important causative agents of visceral larva migrans in vertebrates.
Impact: This research provides a theoretical and practical framework for characterizing nematode biodiversity with molecular tools. This approach provides a foundation for characterizing the number of nematode species in various environmental samples. This approach can be used for other small organisms, including certain species of invertebrates that are difficult to tell apart based on morphology.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Chemical and Cultural Practices as Alternatives to Methyl Bromide Fumigation For Vegetable Crop Production
Description: The primary research objective of this proposal is to identify alternative chemicals and cultural practices to eliminate the use of methyl bromide for soil fumigation. Specifically, to test alternative fumigants and other agents that are effective, economical, and environmentally sound. Determine irrigation management practices that are efficient and will maximize yields under a range of pathogen pressures. Develop and demonstrate crop production practices under a range of pathogen pressures that provide acceptable yields and economic returns and minimize use of chemical fumigants and environmental damage from agricultural chemicals
Methyl bromide (MeBr) is applied extensively in CA as a preplant biocide for production of vegetable crops and strawberries. The main objective of this project is to develop, field test, and demonstrate crop production practices that will eliminate the use of methyl bromide in California. Four field research experiments and three demonstration projects were initiated to test and optimize chemical alternatives to MeBr in the coastal areas of California. Research Experiments: The objective of this study was to compare the efficacy of several alternative fumigants applied through drip irrigation systems for strawberry production in CA. Four research plots were initiated in Watsonville, Salinas, and Oxnard. The alternative chemicals tested were chloropicrin (300 lbs/ac), Inline (400 lbs/ac), iodomethane (400 lbs/ac), and propargyl bromide (180 lbs/ac). This research found that fruit yields were significantly greater in the chemical treatments than in the untreated plots. Drip fumigation with any of these chemicals provided excellent control of soil borne pathogens and produced yields equivalent to those of MeBr/chloropicrin fumigation. Growers Demonstration Project: Three demonstration plots (each approx. 2 acres) were established on growers' fields in Oxnard, Santa Maria, and Watsonville between July and October, 2002. Chloropicrin and Inline were applied at three rates (100, 200, and 300 lbs/ac) under virtually impermeable film (VIF) standard polyethylene film. The purpose of this project is to demonstrate drip fumigation to growers and to evaluate reduced rates of fumigants under VIF for different soil types. Initial results suggest that reduced rates (less than 200 lbs/ac) are sufficient to control pathogens if applied under VIF. Pathogen evaluation is in progress. Fruit harvest will begin in January, 2003.
Impact: Industries valued at more than 5 billion dollars in California depend on MeBr soil fumigation. The phase out of MeBr will result in great crop losses from soil-borne pathogens and weeds. This multidisciplinary project evaluates alternative chemicals and practices for crop production. Our research effort resulted in the development of techniques to apply alternative fumigants through drip irrigation systems for crop production (strawberry and vegetable crops). The demonstration project provides growers with application technologies of alternative fumigants through drip irrigation systems that are efficacious and lower risk, and lower cost than MeBr fumigation.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Chemical Ecology and Ipm Programs for Pest Insects
Description: Objectives: 1. To identify pheromones and other semiochemicals of true bugs, for development into tools for pest management programs. 2. To fully identify the pheromones of major lepidopteran pests for which pheromones have not been completely elucidated, so that the pheromones can be properly developed for grower use. 3. To investigate mechanisms involved in

the replacement of one pest species by another in a shared habitat niche. The male-produced pheromone blend for a major stink bug pest of tomatoes, nut crops, and legumes, the red-shouldered stink bug, has been completely elucidated, synthesized, and field tested. Male bugs produce a 4-component pheromone blend consisting of an ester with 3 sesquiterpene hydrocarbons. However, female bugs appear to be attracted to blends of the ester with any one of the 3 hydrocarbons. Furthermore, the bugs appear to be tolerant of isomers and impurities, so that it should be possible to use impure technical grade pheromone for trap lures. Tests were also conducted with highly purified (>99% pure) versus technical grade (
Impact: From several years of field testing, pheromone lures for red-shouldered stink bug can be formulated from only two of the 4 pheromone components, and the two components do not have to be highly pure. Similarly, Consperse stink bugs are attracted equally to highly pure or technical grade pheromone. This should make it much cheaper and easier to commercialize these pheromones for grower use. Work is in progress to assess the importance of the short range vibrational signals produced by stink bugs, and to develop devices to incorporate vibrational signals into traps.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Comparative Genomic Studies of Mi-1 Related Sequences in Solanaceous Plants
Description: The tomato gene Mi-1 confers effective resistance against several species of root-knot nematodes as well as against some isolates of the potato aphid. There are at least six highly similar sequences that are tightly linked in susceptible and resistant tomato. We will isolate and compare the sequences of Mi-1 related genes from resistant and susceptible tomato, from the wild species L. peruvianum and from potato. Organization of these genes in each genome will be compared. The tomato gene Mi-1, which confers resistance to three of the most damaging species of root-knot nematodes as well as to some isolates of potato aphids, was previously cloned in our laboratory. Southern blot analysis indicated that there are seven Mi-1 homologs in susceptible tomato, Lycopersicon esculentum, on chromosome 6. These genes are organized in two clusters about 200 kilobases apart. The corresponding region of resistant tomato that was introgressed from the wild species Lycopersicon peruvianum also carries seven Mi-1 homologs, which are present in two gene clusters on chromosome 6. We have cloned each of these genes and determined their sequence and arrangement in the genome. Using DNA markers that flank the resistance genes, we have ascertained that a genetic inversion has occurred between the two clusters in cultivated tomato compared to wild tomato. This inversion may account for the severe repression in recombination that occurs in the Mi-1-region. We have identified additional copies of Mi-1 homologs on a different chromosome in tomato. We have partially characterized about 70 homologous sequences from several other solanaceous species. These genes are located near disease resistance genes that function against other pathogens. We are focusing on genetic characterization of the homologs in the wild potato species Solanum bulbocastanum. Our analysis indicates that several of the Mi-1 homologs in tomato and its wild relative are expressed in leaves and roots and carry open reading frames that may code for unknown resistance functions.
Impact: Root-knot nematodes cause serious damage to many crops worldwide. This research also addresses the evolution of host resistance to nematodes and lays the groundwork for development of strategies to generate novel resistance by molecular manipulation of the cloned genes. Our findings provide information that will be useful to breeders who are introducing new traits from wild species.

Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Cotton Harvest Aid - Defoliation
Description: Before cotton can be harvested, the leaves have to be removed from the plants, a process known as defoliation. This is done with harvest aid chemicals. Improper choice of materials or time of application results in poor defoliation. Ideally, the material should defoliate the entire plant with minimal desiccation of remaining leaves. Under the constraints of EPA registration as well as environmental concerns, certain defoliants may not be available in the future. There is need to evaluate alternatives to current programs to insure both effective defoliation and minimum impact on air quality. More than 10 years of field research has shown that organophosphates in combination with ethephon have provided consistent performance. Ginstar, particularly in combination with ethephon, has also provided consistent results. However, rates of sodium chlorate and Ginstar must be adjusted to achieve performance and to prevent leaves from freezing on the plant. Effective results have depended on temperature at defoliation and crop vigor. Usually, sodium chlorate fits best as a low-cost second application to desiccate remaining leaves before harvest. Under some conditions (rank growth, poor boll set, excessive moisture and/or nitrogen) enhancers such as Cotton-Aid have increased efficacy when used in combination with Ginstar, Def or Folex. Field studies have also identified potential sources of arsenic on Pima cotton fibers, tracing the source of contamination to overuse of arsenical compounds for final desiccation.
Impact: Our research has provided growers with guidelines for (1) selecting the best defoliants under specific crop and weather conditions, and (2) proper timing to protect both yield and quality. This has resulted in improved quality and greater returns to the grower. Another result is that growers have been replacing organophosphate defoliants, which have unpleasant odors, with Ginstar. This has resulted in improved air quality during the harvest period (Oct-Dec). Also, a registered defoliant was taken off the market because our studies indicated that cotton lint from treated fields contained high arsenic levels, preventing its fiber from being used in children's clothing.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Cotton Host Plant Resistance To Silverleaf Whitefly Is Discovered
Description: Since 1991, Silverleaf whitefly, Bemisia argentifolii, has caused severe economic losses to cotton and other crops in California and the US. In 1996, 554,215 acres of cotton were reported to be infested in Arizona and California. Lint losses were estimated at 24,891 bales, resulting from reduced yield and contamination of lint with honeydew and sooty molds. Cotton leaf crumple disease, transmitted by the whitefly and caused by cotton leaf crumple geminivirus (CLCV), can also cause extensive reduction in yield. Host plant resistance offered one possible alternative for whitefly control in cotton. UCCE test results showed significant differences among cotton varieties and breeding lines for whitefly infestation levels. Two resistance mechanisms were discovered, smooth leaf cotton and okra-leaf shape cotton. Smooth leaf cotton supported fewer whiteflies than hairy leaf cotton. Leaf hairiness is associated with increased boundary layer humidity on leaf surfaces. Extremely high air temperatures, low relative humidity, and limited irrigation in the desert southwest may result in subtle changes in underleaf humidity influencing Bemisia egg and nymph survival. Okra-leaf cotton had fewer whitefly

adults, eggs and nymphs than normal-leaf cotton. The okra-leaf characteristic may provide higher ambient temperature and lower humidity in the cotton canopy, creating a micro-climate unfavorable to whitefly survival.
Impact: Host plant resistance to whiteflies is clearly offering an economical and non-polluting alternative to whitefly management in cotton. Planting of the cotton varieties DP 5415 and NuCotn 33B, which are less susceptible to infestation by silverleaf whitefly, contributed to a reduction in insecticide use on cotton in Southern California since the early l990s. FiberMax okra-leaf cotton varieties with some whitefly resistance are now being marketed in the US and California, giving growers an additional whitefly management option.
Funding Source: Smith-Lever 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: Objectives: 1.Establish the orientation mechanisms used by male moths and female mosquitoes to orient to semiochemicals. 2.Determine how the broadcast application of mating disruptants interferes with `normal' patterns of mate finding. Use knowledge of how insects orient to odors to improve formulations of mating disruptants and patterns of application. Measure atmospheric concentrations of disruptant in field plots. 3.Use simulation modeling and field tests to determine how trapping efficiency, rate of release of attractant, and trap density modulate the sensitivity of odor-baited surveillance traps. Use these findings to suggest improvements in trapping protocols. Many kinds of insects use odors linked to resources to locate and identify such resources. We are examining how flying insects navigate upwind to such odors. To enable us to track precisely insect movements under specific odor plume conditions, we use wind tunnels with defined plume structures and we measure the movements of insects using two video cameras, followed by reconstruction of their tracks in 3-D. Our most current studies are examining the interaction of visual cues that are used to set a course (optomotor feedback) with the overall cross-sectional envelope of the pheromone plume, seeing how these factors modulate the path the moths fly. Visual cues (in this case large red dots presented from below, laterally, or a visually depauperate setting) modulate both path and velocity. The position of the outer edges of the plume similarly alters path and velocity. Other experiments are designed to determine how antennal morphology in moths affects detection of the plume's fine-scale structure. Feathery and filiform morphologies seem equally efficient at preserving the delectability of odor filaments at frequencies of presentation up to 25 Hz, as determined by Fourier analyses of electroantennograms. Feathery antennae might have been expected to 'filter' out the higher tested frequencies, but this was not the case.
Impact: One application of our models of plume dispersal and insect flight to pheromone sources is in improving the sensitivity and false negatives of odor-baited traps that have been designed for the surveillance of invasive pest insects. We are testing the hypothesis that there is a substantial trade-off between increasing the active space of a trap (its area of effective coverage) by elevating the rate of semiochemical emitted versus improving the capture rate of insects that have located the trap. These can be opposing forces, because high rate of semiochemical release can impede trap entrance, which for some insect systems is less than 10%, and trap types in general vary widely in their efficiency of capture. Using a sensitivity analysis to model these interactions will suggest how these two phenomena interact and led to field tests based on these predictions.
Funding Source: Hatch and State
Scope of Impact: State Specific

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: Objective: Evaluate newly developed strategies and tactics that will replace methyl bomide use in commercial vineyards, orchards, and nurseries. Three years after removal of a 39-yr-old walnut orchard the population levels of Pratylenchus vulnus reduced from 700 to 1.3 per 250 cc of soil collected at 1.7 m to 4 m soil depths. Above the 1.7 m depth population levels were dependent upon soil preparation and the type of pre-plant soil treatment. A tarped methyl bromide application of 450 kg/ha provided three-years of complete nematode absence within the surface 2 m depth of soil profile. An application of 550 kg/ha Telone II in the 3.7 m-wide planting strip plus a surface treatment of 120 kg/ha metam sodium within 10 cm-ha water provided nematode-free status within the surface 1.7 m of soil profile for the first year of replants only. Eighteen months after tree replanting nematodes were detected at each 30 cm increment sampled in the surface 1.7 m of soil profile of the Telone-treated strip. Roots of new walnut trees reached 1.7 m depth 8 months after replanting and reached 1.7 m laterally at 15-months after tree replanting. A pre-plant treatment of 350 kg/ha Sectagon in 22 cm-ha water did not affect nematodes below the 1.3 m soil depth. Our inability to reach deeper into the soil was a result of treating dried soil instead of moist soil. Although nematode control in the surface 1.3 m of soil was excellent during the first year after re-planting; the nematode-free benefit was short-lived. In addition to pre-plant treatments with biocides, trees within some of the 3 ha orchard received applications of Garlon herbicide prior to their removal. Garlon applications killed remnant root systems and 99% of P. vulnus within the roots in the first year. Without Garlon treatments live roots could be detected 2.5 years after tree removal when P. vulnus finally reached 99% reductions within. At three years after tree removal no live walnut roots were detected at three observation pits. Garlon applications tended to reduce soil and root population levels of P. vulnus. This effect was significant where pre-plant treatments gave only short-term nematode protection. Where methyl bromide was used there was no measurable benefit to the use of Garlon. At the end of two full years there were no differences in tree size associated with the various soil treatments indicating that all treatments plus one year of fallow corrected the rejection component of the replant problem. Only methyl bromide corrected the nematode component of the replant problem.
Impact: In California, Telone II is not registered for use in excess of 332 kg/ha except as a strip treatment. Metam sodium has usefulness as a methyl bromide alternative but must be properly applied. A Garlon trunk treatment to walnuts has utility because the effect reaches deep into soil hastening root decay and directly impacting the food source for P. vulnus. These findings indicate that methyl bromide alternatives are currently inadequate especially for walnut growers farming finer-textured soils. These studies are the first to quantify the enormity of nematode populations associated with deep-rooted perennial crops.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Development, Evaluation and Safety of Entomopathogens for Control of Arthropod Pests
Description: Objective: Development, evaluation and safety of entompathogens used in cryptic and soil habitats. Larval and adult activity of the oriental beetle (Exomala orientalis), an important pest of turfgrass in Korea and the USA, was investigated. Adult emergence was first observed on the greens in late May with peak adult emergence occurring two weeks later.

Surveys of turfgrass at golf courses showed that oriental beetle grub densities varied from course to course with more grubs on the tees and fairways than on the greens. As the greens cannot tolerate grub damage, this part of the course became the focal point of the study. A common denominator was that beetle grub densities were always higher at greens with Japanese chestnut trees around them. Emergence holes left by the adults and the presence of chestnut trees appear to be good indicators of high grub densities on the greens for infestations in the following year. In another study, female crickets served as a means for mechanical transmission of the nematode Mehdinema alii to male crickets. This nematode only develops and reproduces in the gut of adult male crickets and is sexually transmitted from infected males to females back to males. The female cricket is promiscuous and will mate multiple times with different male crickets over her lifetime. Immature male crickets are not infected by the nematode.
Impact: By understanding the spatial distribution of the oriental beetle grub, a control strategy can be developed. Sampling for beetle grubs can take place where they are most likely to occur and control tactics can be implemented. The research with the cricket-nematode system will provide insights on host behavior and fitness and into the ecological and evolutionary implications of a sexually transmitted parasite.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AL, AR, AZ, CA, CTH, FL, GA, ID, IL, KY, LA, ME, MN, NJ, NYC, NC, OH, SC, TN, TX, VA, USDA/ARS, USDA/FS, DE, PA

Theme: 4.12 Integrated Pest Management
Title: Diagnostic Lab Helps Fresno County Growers Solve Pest and Disease Problems
Description: The San Joaquin Valley's multibillion dollar agricultual industry, involving hundreds of animal and food crops shipped around the world, is threatened by that very diversity. In addition to native pests and diseases, new ones are introduced to Valley agriculture every year. Initial detection of any pest or disease is essential in maintaining high yields, quality produce and healthy production systems. Timely diagnosis is crucial in eliminating or managing problems so that losses are minimal. UCCE Farm Advisors organized a diagnostic laboratory to serve the needs of Fresno County farmers. The state-of-the-art lab is outfitted with equipment that allows for a quick turnaround time, which is essential in controlling pest and disease outbreaks before they spread. As a result, growers now have another tool that helps them make informed decisions about what pesticide would work best against specific pests or diseases.
Impact: Growers are able to submit field samples for quick identification of diseases or pests. Once problems are diagnosed, growers, pest control advisors or UCCE farm advisors can develop specific plans to contain and control field problems before they become epidemic. The shortened interval between problem discovery and diagnosis has saved growers time and money in identifying and treating the infected area. The lab also allows us to conduct follow-up research on pests or diseases that persist year after year. Lab research helping farmers this season has included screening of new grape varieties against Phomopsis viticola; identification of fungi affecting vegetable crops; and analysis of blood, feed and manure of dairy cattle to determine feed utilization.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Effect of Cultural Practices on Control of Diseases of Prunus spp.
Description: Objectives: To validate and demonstrate the use of various irrigation systems in a deficit irrgation program to manage hull rot disease of almond trees and to compare the effects of

orchard management systems on incidence and severity of Alternaria leaf spot, fungicide efficacy, and orchard climate. Alternaria leaf spot is a defoliating disease of almond trees. When severe, trees may loose most or all leaves in late spring and early summer. Early defoliation is followed by bloom in fall, and weakened fruit wood. This reduces crop and ultimately weakens the tree. Warm temperature, high humidity and frequent heavy dews favor epidemic outbreaks. Leaves exposed to the sky, those on which dew is most likely to form, are infected first thus trees trained to open spreading canopies that have many leaves in that orientation are more severely affected than more upright trees. The trial initiated in 2000 to compare the effects of three pruning systems, each designed to alter tree shape, on disease development has produced no differences in yield even in the heavily pruned treatments. In 2002, trees were beginning to assume the different forms intended by the pruning techniques. Slight but not significant differences were found in disease incidence. In a separate trial, several unregistered and registered fungicides were tested for efficacy. Three were found to be potentially useful. To better understand the effects of environmental parameters on disease incidence and to establish baseline data on which a prediction model may be based, we monitored leaves weekly on trees in three orchards. In each, weather recording instruments were located next to the subject trees. Disease developed in two of the three orchards. Dews were most frequent in the orchard in which the disease was most severe and developed first and least where disease did not occur. Data collected from this year will be valuable in developing a disease progress curve and a future risk assessment scheme. Isolates of the pathogen were collected at several times during the season from three orchards. The current taxonomy of this pathogen maintains that there are three species involved: Alternaria alternata, A. tenuissima, and A. arborescens. The species composition of the population in the field may differ through the season. We collected leaves from three orchards at intervals during the season from which isolates were cultured. These will be identified to species according to the current taxonomic criteria.
Impact: The development of a disease progress curves and resultant risk assessment scheme would provide growers with important tools in making decisions about treatment. Expanding the types of fungicides available for treatment will result in improved control and aid in preventing the development of fungicide resistance in target pathogen populations. Pruning systems that shape trees in ways that do not favor disease development would contribute to disease control. Combining pruning with fungicide treatment may further reduce disease.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Efficient Mosquito Control
Description: The impending introduction of West Nile (WN) virus into California has heightened our need to improve control of mosquito disease vectors in the state. Since the virus was first detected in New York in 1999, it has spread rapidly westward across the USA. Vertebrates susceptible to the virus become infected via the bite of mosquitoes. In 2002 in the U.S., 201 humans and over 13,000 birds (mainly crows) died and over 3,300 humans and 9,000 horses became ill from WN virus infections. No vaccine is available for humans, and our best line of defense against this virus is by control of mosquito vector populations. AES assistant professor Anthony Cornel of UC Davis led research that detected resistance in California mosquito populations to currently used pesticides. Mosquito abatement personnel are now aware of this and have focused more on applications of rotations and mosaics of pesticides to mitigate further spread of resistance. Cornel and ANR GIS analyst Kris Lynn designed a Geographic Information System (GIS) interface for control of mosquitoes in mosquito abatement districts.

Cornel detected resistance to pesticides in several mosquito populations in a small-scale statewide mosquito pesticide tolerance surveillance program. He trained mosquito personnel on how to conduct pesticide susceptibility testing so that districts can conduct the tests themselves. After developing the GIS interface, Cornel and Lynn trained the Fresno Mosquito and Vector Control District manager on the use of the GIS package. The district has successfully implemented this interface for six months and during that time has become more efficient in controlling mosquitoes.
Impact: There have been no further reports of resistance spreading since the discovery of resistance to currently used pesticides. This is testament to the Mosquito Abatement District's use of better resistance management and mitigating strategies. Since evaluation and use of the GIS interface in Fresno County, mosquito abatement district manager Dave Farley is convinced that GIS use will mitigate the effects of future budget cuts his district may have to face. He predicts that the district will save a conservative $138,000 per year -- 15 percent of the current budget -- beginning in 2008-09 and that GIS will improve services.
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: Objectives: 1. To determine the species diversity and abundance levels of the arthropod fauna (herbivores, predators and parasites) associated with the various flowering plant species established in the diversified cropping systems. 2. To determine to what extent beneficial insects depend on the resources of the planned plant biodiversity continued existence in the vineyards and annual vegetable crops evaluated. Which attributes and resources (i.e., pollen, nectar, hosts, etc.) of the associated plants are important for the natural enemies? 3. To determine if the vegetational assemblages influence the species diversity and abundance of entomophagous insects and whether this enhancement of beneficial arthropods results in lower insect pest loads on crop plants. 4. To assess the population levels of insect pests in diversified crops and monocultures that have been subjected to organic or chemical fertilization regimes, and determine the mechanisms at play that may explain observed density differences on plants subjected to differential nutritional treatments. Provision of flowers in the form of summer cover crops (buckwheat and sun flowers) in vineyards enhanced populations of parasitic wasps Anagrus sp. and several predaceous arthropods. Such flowers provided abundant alternative food sources (pollen, nectar and neutral insects) to beneficial insects which moved from the flowers to vines attacking grape leafhoppers and thrips. Mowing the flowers forced movement of greater numbers of Anagrus sp and predators which led to significant reductions of grape herbivores. Mowing however was most effective when timed to coincide with leafhopper oviposition, when eggs were most available for Anagrus wasps. Cover crops were mowed every other row in order to leave flowers in the vineyard as habitat for natural enemies to build-up and exert mortality pressure on second generation leafhoppers.
Impact: Lowering leafhopper and thrips populations through provision and manipulation of flowering cover crops in vineyards that enhance Anagrus wasps and predators eliminate the need to use chemical and botanical insecticides in grapes while reducing costs without sacrificing yields.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Enhancing the Benefits of Plant-Associated Bacteria
Description: Objectives: 1) Define how root-colonizing bacteria increase carbon availability from roots, naturally and under predation by nematodes; 2)Define how bacterial-feeding nematodes enhance growth of both the palnt and root-colonizing bacteria. This project is defining molecular events that influence how soil bacteria colonize roots and influence plant growth. Important aspects of the problem involve how bacteria enhance carbon release from plant roots and how nematode predators of bacteria find their prey on the root. Work relating to riboflavin and biotin synthesis in Sinorhizobium meliloti bacteria was published this year. Current activities focus in two areas. First, the characteristics of amino acid flux (inward and outward) from roots are being defined under sterile conditions and in the presence of particular microbial compounds. Data indicate that both bacteria and fungi can have major, direct effects on these process. Second, the role of plant signature compounds in attracting bacterial- and plant-feeding nematodes in being examined. Initial data show that beneficial bacterial-feeding nematodes and undesirable plant-parasitic nematodes respond differently to some compounds.
Impact: Organisms and/or natural products identified on this project have provided the information needed by commercial inoculant companies to supply agriculture with new bacteria or chemicals that enhance plant growth through a more efficient use of mineral resources.
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: Objectives: 1) Determination of the potential enhanced degradation of registered and experimental fungicides efficacious against Sclerotinia minor; 2)Comparison of lettuce drop incidence in different bed configurations and irrigation methods; 3)Determination of the genetic and virulence variation in isolates of S. minor and S. sclerotiorum and relate it to cropping practices, lettuce and soil types, and weather within a GIS framework; 4) Development of rapid molecular diagnostics for Verticillium dahliae infectious to lettuce; 5)Development of a decision-support system for lettuce based on the inoculum density-disease incidence relationships for lettuce; 6) Determination of the role of seedborne Verticillium dahliae in the transmission of Verticillium wilt on lettuce in the field and its potential to establish the disease in uninfested fields. Over the past year, we modified lettuce downy mildew warning system by incorporating the temperature and solar radiation thresholds, confirmed the seedborne nature of Verticillium wilt on lettuce and identified several weed hosts, elucidated the reasons for the geographical isolation of Sclerotinia minor and S. sclerotiorum in California and continued our efforts to identify sources of resistance to V. dahliae in lettuce, and to Sclerotinia minor in lettuce. To improve the predictive value of the previously developed lettuce downy mildew warning system, the effects of temperature on infection of lettuce by Bremia lactucae was investigated. High temperatures during wet and dry periods reduced subsequent disease incidence. Analysis of historical data revealed that days without infection had significantly higher temperature than days with infection. Similarly, solar radiation during 0500 to 0600 PST in conjunction with leaf wetness ending between 0900 to 1000 PST was associated with downy mildew infection. Thus, warning system was modified to include the threshold leaf wetness requirement to begin after sunrise when solar radiation to accommodate the effects of temperature and solar radiation. This modified warning system was more conservative when the disease potential was high and recommended fewer fungicide sprays when conditions were not conducive to downy mildew. We also documented the further spread of Verticillium wilt on

lettuce into the Salinas Valley and characterized the populations of microsclerotia in these soils. As previously reported, the soil populations in infected lettuce fields were the highest recorded for any host thus far. We further confirmed the seedborne nature of Verticillium dahliae in lettuce using a GFP-transformed isolate and reproduced the disease from infested seed. We also proved that V. dahliae recovered from several weeds are indeed pathogenic to lettuce. Another major discovery this year has been the elucidation of reasons for the geographical isolation of the two species of Sclerotinia causing lettuce drop within California. Sclerotinia minor is not prevalent in the San Joaquin Valley because it does not survive the high summer temperatures in this area. Sclerotinia sclerotiorum despite the excellent survival in all areas, the airborne phase does not occur in the Salinas Valley because conditions for apothecial production do not occur during the cropping season. Over the past year, we have identified a new disease on lettuce caused by Phoma exigua, and assessed the host range of this pathogen. Furthermore, lettuce germplasm are being evaluated for resistance to all three pathogens and resistance identified is being utilized in a breeding program. Evaluation of the progenies for resistance is also in progress. We completed the study on the effects of rotations of strawberry with broccoli on soilborne diseases and yield in both the conventional and organic production systems.
Impact: Because of the applied nature of our work, the results always have a direct impact on disease management in many vegetable crops. The new downy mildew warning system reduces fungicide sprays and improve efficiency. We have identified production practices that would have a major impact on vegetable crop diseases. Progress has been achieved in developing resistance against S. minor and V. dahliae in lettuce.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: A Field Key to Lygus Species of the San Joaquin Valley
Description: Lygus bugs are a key economic pest of many crops in California, including field crops, vegetables, nuts and fruits. There are 43 species of Lygus bugs in the world, 34 of which are known to exist in North America. Three species are reportedly found in the central San Joaquin Valley of California: Lygus hesperus, Lygus elisus, and Lygus lineolaris. To date, there has been no simple method to distinguish among these three species. Pest management strategies must begin with correct identification. A team of UC DANR scientists collaborated on a pictorial key to the three species of Lygus bugs commonly found in agronomic crops of the central San Joaquin Valley. A UCCE Fresno County Farm Advisor worked with a UC Davis Entomologist and a UC IPM Entomologist to improve her understanding of Lygus bug ecology and identification. One outcome of her work was development of a field key with photographs showing significant differences among the species. The pictorial key is based on characteristics that are easy to observe and is illustrated to highlight important morphological features. The key also contains a detailed description of Lygus as well as pictures of other similar-appearing plant bugs, which helps prevent misindentification. A "quick guide" to identifying the species can be removed from the publication and used independently once the user is familiar with key distinguishing features. Although primarily developed for use in field crops, the key can also be used to identify Lygus found in other cropping systems. These two ANR publications, "A Field Key to the Most Common Lygus Species Found in Agronomic Crops of the Central San Joaquin Valley of California" and "Key Features of Common Lygus Species in the Central San Joaquin Valley", are available on the web at Lygus.uckac.edu or through the ANR Publications E-catalog http://anrcatalog.ucdavis.edu/. The ANR Lygus Management Workgroup supported this work and has provided funds to print 500 copies.

Impact: Growers, pest control advisers and researchers now have a simple tool available to allow them to identify species of an important economic pest. Because proper identification of a pest organism is the first step in IPM, a detailed key to the Lygus species and its companion "quick guide" are improving pest management strategies and effectiveness. In addition, the ability to correctly identify various Lygus species can improve interpretation of research results or enhance progress in areas such as biological control and assessment of economic damage.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Fine Mapping of Novel Nematode Resistance Clusters in Tomato
Description: The specific objectives of this project are: to develop closely linked markers to the two pairs of root-know nematode resistance genes; to localize their chromosomal positions; to fine map one of the clusters based on higher recombination frequency. LYCOPERSCON PERUVIANUM accession LA2157 contains a single dominant resistance gene, MI-9, that confers resistance to root-knot nematodes (RKNs) at temperature above 32 C. We generated an intraspecific cross L. PERUVIANUM LA2157 x LA392. F1plants, derived from LA2157 x LA392 cross, were resistant to M. INCOGNITA, M. ARENARIA AND M. JAVANICA at 25 C and 32 C. The F2 population segregated as a 3:1 ratio confirming the monogenic dominant inheritance of MI-9. A combination of different markers was used to fine map this gene between Rex-1 and CF2 on the short arm of chromosome 6. In addition we have identified several R-gene homologues that cosegregated with the heat-stable resistance in this genetic interval. Additional resistance was also identified in PI 270435-2R2 . We developed F1 seeds from PI128657-3R4 x PI 270435-2R2 and screened them for both heat stable and MI-1-virulent nematode resistance. A single F1 plant was crossed to the susceptible L. PERUVIANUM, 126440-9MH. We refer to this population as 1x2. Seeds from individual fruits were planted and screened for heat stable nematode resistance and resistance to Mi-1-virulent nematode. A total of 52 pseudo back cross progeny were evaluated, in two replications, for heat stable resistance against M. INCOGNITA at 32 C. Genetic analysis resulted in 28 susceptible and 26 resistant plants (X squared equals 0.18, P less than 0.05), confirming that this trait was controlled by a single dominant gene, MI-2. BSA was performed with high throughput AFLP system on automated DNA sequencer. A total of 128 ECORI/ MSEI primer combinations were used for BSA. Co-segregation analysis with individual DNAs constituting the bulks, revealed that 11 markers were co-segregating with MI-2. Linkage analysis with the whole population with these 11 putative markers identified one marker to be tightly linked in repulsion-phase, and another marker in coupling-phase with a distance of 16 cM from the gene. Work is in progress to clone these AFLP markers for mapping and development of a reliable PCR-based marker. Resistance to MI-1-viruent nematode was also evaluated with this population. Ninety-two pseudo backcross progeny were screened with MI-1-virulent M. INCOGNITA at 25 degrees C. Genetic analysis revealed the presence of 26 resistant and 66 susceptible individuals 1:3; (X squared equals 0.016 P less than 0.05) suggesting that the resistance to virulent nematode may be governed by more than one gene. The roots of a subset population, consisting of 52 plants, were air dried and weighed. We observed a large variation in the number of egg masses per gram of root in this population. These finding suggest that, contrary to earlier report, resistance to M. INCOGNITA is quantitatively inherited. Therefore, quantitative trait loci mapping approach will be undertaken to identify loci controlling resistance and the phenotypic contribution of each locus to the trait. A more precise evaluation method for quantitative phenotyping (number of eggs per gram root) is also considered.

Impact: Resistance breaking due to high temperature and appearance of MI-1-virulent root-knot nematode isolate is a serious concern to the tomato industry. Cloning these nematode resistance genes with novel phenotypes is important for the success of US tomato growers.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Function and mechanism of gene silencing suppression by plant virus-encoded proteins
Description: Objectives: 1)To investigate if Cmv2b suppression of transgene RNA silencing is associated with a reduced transgene DNA methylation. 2)To investigate if Cmv2b suppression of transgene RNA silencing is associated with a reduced accumulation of the 25nt RNAs. 3) To investigate if Cmv2b interferes with the functionality of the gene silencing signal. 4) To isolate Arabidopsis mutants defective in Cmv2b suppression of transgene RNA silencing. 5) To map the domain of Tav2b critical to the induction of the Tav2b/CMV synergistic disease. Post-transcriptional gene silencing (PTGS) or RNA silencing was first discovered in transgenic plants in 1990. The 1998 discovery that potyviruses and Cucumber mosaic virus (CMV) encode suppressors of RNA silencing provided the strongest evidence for a natural antiviral role of RNA silencing in plants. Our previous results showed that the CMV 2b protein (Cmv2b) carries a functional nuclear localization signal and silencing reversal by Cmv2b occurs only in the newly emerged tissues. The mechanism of RNA silencing suppression by Cmv2b was investigated in two distinct silencing systems. The results from a number of independent assays showed that Cmv2b inhibits the activity of the mobile signal and interferes with DNA methylation in the nucleus. In addition, an animal virus-encoded protein, B2 of flock house virus (FHV), which was considered a functional homologue of Cmv2b, was shown to be a potent inhibitor of PTGS in plants and in Drosophila cells. Further work found that FHV infection triggers PTGS in Drosophila cells and requires B2 suppression of PTGS, thereby establishing a natural antiviral role for PTGS (also called RNA silencing) in the animal kingdom. How Cmv2b might inactivate the silencing signal and what host genes are involved in the RNA silencing antiviral pathway will be investigated.
Impact: Evidence obtained indicates a novel viral counter-defensive strategy by inhibiting the systemic virus resistance mediated by the mobile antiviral silencing signal and supports a naturally antiviral role for the conserved RNA silencing pathway in the animal kingdom. These findings will have major implications on the control of both plant and medical viral diseases.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Genetic Analysis of the Control of Cell Division Orientationin the Nematode Caenorhabditis Elegans
Description: Objectives: 1) Determine if the DEP domain of LET-99 functions in localization to the cortex/membrane or association with other proteins, and whether cortical localization is required for any aspect of LET-99 function. 2) Determine if the spindle positioning defect in spn-3 mutant embryos is due to alterations in polarity and/or changes in the anterior forces on the spindle. 3) Isolate the spn-3 gene and determine the localization of the SPN-3 protein in embryos. 4) Examine genetic and molecular relationships among spindle orientation genes and the G protein signaling pathway. My laboratory studies the mechanisms of polarity establishment and mitotic spindle orientation during asymmetric divisions using the nematode Caenorhabditis elegans as a model system. Asymmetric divisions produce daughter cells with

different fates and are important for development in a wide range of organisms. For a division to be asymmetric, the cell must be polarized with respect to cell fate determinants, and then the division furrow must form such that determinants are unequally partitioned to the daughters. In animal cells, the placement of the division furrow is determined by the position of the mitotic spindle, which must align along the polarized axis for asymmetric division to occur. We have been studying a number of genes required for asymmetric division in the early C. elegans embryo. Our previous studies of the let-99 gene showed that it is not required for cellular polarity, but rather is specific for orienting the spindle correctly on the axis of polarity. The LET-99 protein is asymmetrically localized at the cell periphery in response to the polarity proteins (e.g. PAR-3), and we proposed that LET-99 acts as an intermediate that transduces polarity cues to the cellular machinery that positions the spindle. Although a number of cell fate determinants that are localized in response to polarity cues have been identified, LET-99 is the first protein required specifically for spindle orientation in the embryo to exhibit such a polarity-dependent asymmetric localization. In the past year, we have shown that the mislocalization of LET-99 in certain polarity mutants correlates with defects in spindle orientation during the first asymmetric division, consistent with this proposed role for LET-99. These observations also suggest a new model for the mechanism of spindle orientation, which we are currently testing. In the past year, we have also made significant progress in the study of another gene required for spindle orientation, called spn-3. Our studies indicate that polarity cues are normal in spn-3 mutants, and that spn-3 plays a critical role in establishing the proper length and/or dynamics of the microtubules that make up the spindle. Thus, spn-3 appears to be part of the downstream cytoskeletal machinery that positions the spindle in the cell. Because asymmetric divisions are important for development in numerous organisms, and the polarity proteins are conserved in many organisms and cell types, our studies in C. elegans will extend the understanding of the mechanisms of asymmetric division in other organisms including humans.
Impact: These studies expand our scientific knowledge of basic cell biological and developmental mechanisms. In addition, the reproduction and development of C. elegans is quite similar to that of some parasitic nematodes; thus in the long term these studies could have impact with regards to the control of agriculturally important nematodes.
Funding Source: Hatch and State
Scope of Impact: State Specific

T**heme:** 4.12 Integrated Pest Management
Title: Genetic Control of Crop Pests by Transgenesis and Paratransgenesis
Description: Objectives: 1.Improve methods of developing transgenic strains of pink bollworm and other target species. 2. Develop methods of detecting putative transformants. 3.Develop methods of testing conditional lethal genes for use in population control. 4.Develop selective toxins for use in paratransgenesis to control Pierce's disease. 5.Exploit paratransgenesis to protect grapes.
Permits are being obtained (pending) to ship transgenic pink bollworm from Riverside to the USDA-APHIS pink bollworm laboratories in Phoenix. This strain carries a marker gene for selection and a lethal gene behind a tetracycline repressor element. In the presence of tetracycline the lethal factor is suppressed allowing mass rearing. The conditional lethal element comes from Oxitec, a company associated with Oxford University, Oxford, England. We hope to cure grape plants of Pierce's disease by using endophytic bacteria, Alcaligenes spp., to deliver anti-Pierce's agents to the pathogenic bacterium Xylella fastidiosa. Both endophyte and pathogenic bacteria are carried in the same area of the mouthparts in the vector insect, Glassy-winged sharpshooter, GWSS, and both are transmitted to the plant and occupy the same spaces

there; therefore, this paratransgenic approach is feasible. We will next test anti-Xylella agents for use in crop protection.
Impact: In July of 2002 achieved genetic transformation of pink bollworm with a conditional lethal gene. In the past six months this strain has been back-crossed to homozygosity and is now being prepared for inverse PCR analysis to identify the transgene and insertion site. Our collaborators at USDA-APHIS have requested permits to ship the strain to their larger quarantine facilities in Phoenix, AZ. The lethal gene, a nipp or nuclear inhibitor of protein phosphorylase is help off by a tetracycline repressor system from Clontech. Preliminary results show that mortality occurs when the transgenic pink bollworms are reared on tetracycline-free diet. The lethal gene was supplied by Luke Alphey at Oxitec in England. The goal for this project is to supply an Autocidal Biological Control (ABC) pink bollworm during the pink bollworm eradication project planned for the next several years. ABC is a new method designed to improvement the Sterile Insect Technique first perfected by the USDA. We have demonstrated the feasibility of controlling Pierce's disease by use of paratransgenesis. Anti-Pierce's strategies are to be delivered by shuttle bacteria identified as typical endophytes that occupy the same space in the vector insect and host plants as the pathogenic bacterium, Xylella fastidiosa. The next step in this project is to test agents for expression in the endophyte to control Pierce's disease.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Genetic Diversity of Nematodirus Species and Development of Nucleotide-Based Diagnostic Methods
Description: Objectives: 1. Determine the nucleotide sequence(s) for the ribosomal-DNA internal transcribed spacers of N. battus (5 geographic isolates) N. filicollis, N. helvetianus, N. spathiger, and quantify the amount of nucleotide differentiation among taxa. 2. Infer phylogenetic relationships among Nematodirus taxa based on rDNA sequences, and use inferred pattern to explore the geographic source of N. battus introduction to the United States and evolutionary relationships among species. 3. Design species-specific PCR primers for diagnosis of taxa, and assess the sensitivity, specificity, and reliability of this diagnostic procedure. Nematode parasites in the genus Nematodirus were the subject of this project. These nematodes are responsible for disease and economic losses in cattle and sheep in the United States and California. In particular, N. battus, a species introduced recently to North America, is known to cause morbidity and mortality in lambs, with losses of up to 30%. The pathogenicity of other Nematodirus species infecting livestock varies, and the diagnosis of these species is compromised in routine helminthological exams because some of these nematodes cannot be identified to species without isolation of adults (preferably males) from the gastrointestinal tract of their hosts. Thus, the pathogenic potential of a particular infection frequently cannot be determined from routine parasitological examination. Because of the increased risk of economic impact due to introduction of N. battus, a nucleic-acid based approach was used to develop new methods for species-level diagnosis, and to characterize genetic differentiation among N. battus populations, in an attempt to identify the geographic source(s) of N. battus introduction to the United States. Accomplishments during the course of the project included amplifying and sequencing nuclear ribosomal DNA from Nematodirus, cloning and sequencing DNA, building phylogenetic trees representing species and populations, development of a polymerase chain reaction/restriction fragment length polymorphism test for Nematodirus species, and characterization of intraspecific sequence variation in N. battus. Results showed that single

geographic populations of N. battus consist of individuals with multiple rDNA types. Comparison of cloned rDNA and directly sequenced rDNA PCR products from individual nematodes showed that multiple rDNA repeats are maintained within individuals. Despite intraindividual variation, nuclear rDNA sequences can be used to diagnose Nematodirus species. A simple polymerase chain reaction/restriction fragment length polymorphism method was developed for use with Nematodirus DNA. This method supports simple diagnosis of three species infecting ruminants (filicollis, spathiger, and helvetianus) that cannot be identified based on morphology and morphometry of eggs. Analysis of ribosomal sequences also provided an evolutionary tree for Nematodirus species that is consistent with caprine bovids as ancestral hosts, with a subsequent host-shift to Bovinae in Nematodirus helvetianus. More than 70% of Nematodirus battus ribosomal sequences were found to be unique, and the fewest variable nucleotide sites were observed in samples from the United States and Canada, consistent with a population bottleneck at introduction. A mitochondrial gene (ND4) was also amplified and sequenced in some N. battus isolates, but this region provided insufficient variation to investigate the phylogeographic history of introduction for this species.
Impact: Sequences of DNA obtained from nematodes of the genus Nematodirus have been used to develop a test to distinguish species that are difficult to tell apart based on eggs recovered from ruminant feces. Because these nematodes are important pathogens of ruminants, these molecular diagnostic tools can provide a clearer understanding of which species are responsible for disease in a particular host.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Genetic Variability in the Cyst and Root-Knot Nematodes, UC PI #1
Description: Objectives: 1) Characterize genetic variability as related to PPN responses to resistance, environment, biological processes, and morphology. 2) Determine nematode fitness and adaptability relative to environment, host plant, and host-plant resistance. 3) Design and develop management strategies for cyst and root-knot nematodes relative to genetic variability. The bacterium Lysobacter enzymogenes strain C3 produces chitinases, lipases, and proteases and so has potential as a biological control agent of plant parasitic nematodes. We assessed the influence of L. enzymogenes strain C3 against the bacterial-feeding nematode Caenorhabditis elegans, and the plant-parasitic nematodes Heterodera schachtii and Meloidogyne javanica. Exposure of C. elegans to commercial chitinase at a rate of 0.21 unit/ml in agar resulted in five times fewer progeny juveniles than without chitinase. Exposure of C. elegans to L. enzymogenes strain C3 on agar plates resulted in almost complete elimination of egg production, and death of 94 percent of hatched juveniles after two days. Hatch of H. schachtii eggs on a lawn of L. enzymogenes on agar was about 50 percent as compared to 80 percent hatch on a lawn of E. coli, and hatched juveniles died as the cuticle and body contents disintegrated. Juveniles of Meloidogyne javanica died after exposure to a seven-day old broth culture of L. enzymogenes for four days. The death and disintegration of juvenile nematodes suggests activity of proteases and lipases as has been reported for this strain. It is possible that the strain C3 may be a natural parasite of nematodes. Our research led us to further assess how environmental stress influences C. elegans. We found that wild-type and mutant C. elegans respond to starvation and stresses such as antimicrobial agents, high salt concentrations, and antagonistic bacteria by retaining eggs so that progeny hatch internally. Some of the resultant larvae consumed the parent body contents and became long-lived, resistant dauers, even under conditions of complete starvation. During this process, the parent life span was shortened. The internally produced larvae have similar life

span and fertility as compared to larvae arising from laid eggs. We also observed that in C. elegans, the internal retention of larvae in response to stress and starvation allows the larvae to feed on the parent body contents and so obtain sufficient nutrition to reach the resistant, long-lived dauer stage. Our evidence shows that intra-uterine hatch is a part of the C. elegans life cycle, and complements androdioecy and the dauer stage to enhance progeny survival and dispersal under stress. The phenomenon may also provide insights into the evolution of reproduction and longevity. Understanding trade-offs among parental life span, reproduction, and survival of progeny in the model C. elegans may provide insights into survival of plant-parasitic nematodes.
Impact: Because the bacterium Lysobacter enzymogenes strain C3 produces chitinases, lipases, and proteases, it has potential as a biological control agent of plant parasitic nematodes. It may function in new integrated nematode management tactics to decrease numbers of plant-parasitic nematodes in agricultural soils. Further research on this possible biological control agent will be conducted.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AR, CA, HI, ID, MI, NE, NM, NC, OR, WA, WY

Theme: 4.12 Integrated Pest Management
Title: Genetic Variability in the Cyst and Root-Knot Nematodes, UC PI#2
Description: Objective 1. Characterize genetic variability as related to PPN responses to resistance, environment, biological processes, and morphology.
In the past year, we have made steady progress towards our goal of developing a molecular phylogenetic framework for the nematode family Mermithidae. This nematode taxonomic group includes ROMANOMERMIS and other insect-parasitic nematodes. We have made strides in three areas: (i) deducing interspecific relationships using mitochondrial cytochrome oxidase I (COI) DNA sequences within the genus ROMANOMERMIS. Our studies include the species R. CULICIVORAX, R. NIELSENI, R. IYENGARI, R. COMMUNENSIS and R. KIKTOREAK. These ROMANOMERMIS species represent isolates along a north/south transect that ranges from Northern Canada to Mexico. Our results have unmasked likely speciation events along this cline and signal mosquito host migrations and additional vectoring into these regions. (ii) Using the polymerase chain reaction (PCR), we have amplified a DNA segment from the nuclear 26S ribosomal DNA D3 region as well as the aforementioned COI locus from from eight different mermithid nematode genera that represent a wide range of insect hosts (pillbugs, mosquitos, spiders, leafhoppers, grasshoppers, spiders, and mites) and incorporate a worldwide sampling. We have complete, double-stranded nucleotide sequence from all 16 PCR products (two loci x 8 nematodes) and have performed phylogenetic analysis on aligned DNA sequences using three different methodologies (Maximum Parsimony, Maximum Likelihood, and Kimura 2-parameter distance). All methodologies generate congruent trees. Our studies continue to reveal that the mermithid nematodes appear to co-evolve with their insect hosts. Nematodes that parasitize aquatic insect hosts form a clade distinct from related mermithids that replicate within terrestrial insect hosts. We have learned that COI and D3 gene sequences from two different isolates of the mermithid THAUMAMERMIS COSGROVEII (from California and New Zealand) cluster together to the exclusion of all other mermithids tested despite being derived from two different arthropods, suggesting a host switch upon introduction of this nematode to the Americas. This result furthers our interests in the evolution of insect parasite host preference. (iii) We have obtained nucleotide sequence and determined mitochondrial gene order for 50% of the T. COSGROVEII mitochondrial DNA molecule. We have learned that the gene order in T. COSGROVEII mtDNA is ND3-COII-COI-COIII-ND1-CytB, a gene architecture significantly

different from the one other available mermithid mtDNA gene order, that of R. CULICIVORAX, established in our laboratory some time ago. These gene orders also differ from all other nematode mitochondrial genomes described to date. Understanding comparative mermithid mitochondrial gene order and overlaying this information on the molecular framework established using the COI and D3 regions are significant because this information will enable an understanding of how host-preference evolved. In turn this scientific information will assist furthering the use of entomophagous nematodes as efficient biological control agents.
Impact: Specific information on the evolution of nematode parasitism among insect hosts will help define the utility of nematodes as efficient biological control agents. By using DNA sequences derived from both the nuclear and mitochondrial genomes, precise predictions as to which nematodes might attack a broad range of hosts will be enabled. Our expectation is still a viable goal, namely one or several nematodes will be identified that can simultaneous parasitize and destroy multiple insect pests. Broad scale insect pest management of this sort will diminish the cost of employing nematodes as biological control agents.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AR, CA, HI, ID, MI, NE, NM, NC, OR, WA, WY

Theme: 4.12 Integrated Pest Management
Title: Grower-Directed Research and Outreach on Integrated Weed Management for Vegetable Production
Description: An advisory committee will be formed to direct and evaluate activites. Research activities will center on crop rotation, cover crops, and non-chemical weed control for nutsedge and other problem weeds. Extensive collaboration with growers and public and private entities will enhance effectiveness of research and outreach. Vegetable growers identified nutsedge as the major weed problem for southern California. We began a multiyear experiment to determine if crop rotation and other cultural practices were effective controls. Initial results are promising, especially when crops form shading canopies during the warmer months. Results were presented at several grower and agri-industry meetings. We found significant reductions in weed populations when mixtures of cowpea and sudangrass were grown as cover crops. Growers are anxiously awaiting new varieties with enhanced pest resistance. We have collaborated with breeders to develop new varieties of cowpea that shade out weeds and resist other pests. These varieties should be ready for release in a few years. Collaboration with colleagues across America has led to a series of articles in American Vegetable Grower magazine on alternative weed control. We are in the planning stages for a series of training sessions and a new manual on organic vegetable production. Cost of production studies have been developed for various management options in a spreadsheet format that growers can readily adapt to their situation. We are working to expand our activities with the many NGO's that serve the organic community, principally by providing them information to disseminate to their clientele.
Impact: Growers will have new cultural tools to manage nutsedge and other weeds. This is obviously essential for organic growers, who have fewer weed management tools. But conventional growers are also very interested in our nonchemical methods, as many crops are losing pesticide registrations. Our training sessions fill a void for practical information on how to grow organically. We believe they will serve growers nationwide, and should be useful for more crops than just vegetables. The American Vegetable grower articles will be immediately available to vegetable growers across America.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: High Temperature Soil Solarization for Control of Soil Pests
Description: To avoid pests that attack young seedlings or transplants, clean soil is particularly important for nurseries and for container production of plants, as well as for home gardeners. Until recently, chemical treatments, expensive steam generators or purchase of treated potting mixtures were the only ways of obtaining soil free of debilitating plant pests.
High temperature soil solarization, using passive solar energy to disinfest soil, has been developed by a group of UC researchers and students at the Kearney Agricultural Center. The group, representing the Statewide IPM Program, UC Riverside and UC Davis, found that in warm summer weather, containers of soil can be heated by a plastic "double-tent" technique to 140-158 degrees Farenheit or higher. The result is rapid elimination of nematode, weed and fungus plant pests without chemical treatments or expensive steam generation systems. Data supporting the technique were submitted to the California Department of Food and Agriculture (CDFA) for consideration as an officially-approved nematicidal treatment for commercial nursery use.
Impact: The "double-tent" solarization treatment (soil exposure at 140 degrees F for 30 minutes or 158 degrees F for 60 minutes) was approved by CDFA to ensure against nematode infestation of containerized stock in commercial nurseries. In addition, this inexpensive technique can be easily used by home gardeners and organic producers in warmer areas who wish to produce their own pest-free container or potting soil, without chemical or expensive steam treatment. This is reducing the application of pesticides, improving economic return and environmental quality.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Influence of Irrigation Practices on Development and Impact of Phytophthora Root Rot
Description: The principal objective is to quantify the effects of soil moisture and irrigation practices on the development of Phytophthora root rot.
Field experiments were completed over 4 years at Tulelake, CA, to examine effects of inoculum level, sprinkler irrigation, and fungicide on pink rot of potato tubers caused by Phytophthora erythroseptica. Low percentages of roots and stolons, were infected within 5 weeks of planting, and the low levels of pink rot present at harvest were initiated early in tuber development. Applications of the fungicide metalaxyl (Ridomil) directly to seed pieces, or once after emergence, or twice later in the season, gave partial control of pink rot and increased yield significantly. Variations in the amount of sprinkler irrigation applied (20-48 cm water) in the second half of the growing season had little effect on yield or pink rot incidence. The occurrence of Phytophthora root and crown rots in California strawberry production systems was investigated as part of a larger cooperative project on alternatives to methyl bromide. While P. cactorum was the most frequent cause of root and/or crown rot, other pathogenic species were present at low frequencies. In field experiments where inoculum was buried in soil, standard fumigations with mixtures of methyl bromide and chloropicrin were highly effective in killing inoculum of both P. cactorum and Verticillium dahliae. While equivalent and some lower rates of chloropicrin alone, 1,3-dichloropropene with chloropicrin (Telone C35), and methyl iodide with chloropicrin were also effective at killing buried inoculum of V. dahliae, many of the same treatments gave incomplete control of P. cactorum. Greater control of P. cactorum in soil was achieved when alternative fumigants were applied using a highly impermeable (VIF) plastic mulch. Propargyl bromide, when drip applied, gave a high level of control for all pathogens tested. Fumigation has also been found to reduce other fungi damaging to roots of strawberry and

to increase populations of beneficial rhizosphere bacteria. Variations in current drip irrigation practices had small effects of Phytophthora root and crown rots of strawberry.
Impact: Management strategies were found to reduce the occurrence of destructive levels of pink rot in potato tubers caused by Phytophthora erythroseptica. In addition, this project helped to identify soil-borne disease risks and some effective chemical alternatives to methyl bromide for fumigation of soil for strawberry nurseries and strawberry production in California. Some non-chemical alternatives to methyl bromide were also explored.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Integrated Pest Management for Santa Cruz County
Description: Pesticide use and its potential impact on the environment and health and safety of Santa Cruz County citizens is an issue of great importance and increasing concern. In August 2000, Santa Cruz County's Board of Supervisors adopted an Integrated Pest Management (IPM) Policy for the management of pests on all county maintained facilities and properties. The goal was to eliminate the use of pesticides wherever possible and, in situations where pesticides could not be eliminated, to reduce the quantity and risk level as much as possible. A two-year contract was awarded to UCCE Santa Cruz County to plan, develop, and implement an IPM Program. Critical to the success of the program was the hiring of a UCCE-based IPM coordinator, setting up a novel relationship between the county and local UCCE programs. An IPM Department Advisory Group made up of UCCE and county staff members and representatives of various departments and community organizations was established to assist in the implementation process and to report to the County Board of Supervisors. IPM policies in other municipalities and organizations were studied and data were collected on pesticide use, as well as possible alternatives, in the county. Subcommittees were established to tackle the most significant barriers to implementing the goals of the policy. These included gopher control (for the local levee system and parks), control of roadside vegetation, and control of the Glassy Winged Sharpshooter (GWSS). An IPM Program Manual was prepared and distributed by UCCE and county staff and the IPM Department Advisory Group. This "hands-on" manual was designed to assist all county departments in better understanding pests and pest management in general, and in making appropriate management decisions when pest problems arise.
The UCCE county director and environmental horticulture advisor continue to work with the county through continuing research (gopher control on levees), subcommittee work (GWSS and vegetation management), meetings of the IPM Department Advisory Group, and advice for sound IPM practices specific to Santa Cruz County.
Impact: A road map to good IPM practices has been established for Santa Cruz county. Pesticide use on county property has been reduced by 87% since the beginning of the program. All pesticides identified by the State of California as causing cancer or reproductive harm (Prop 65 list) as well as pesticides listed by the EPA as known human carcinogens were eliminated. The program received an honorable mention from the California State Association of Counties in 2002.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Integrated Pest Management in Ornamental and Floricultural Crops

Description: The primary objectives are to determine the relative resistance and susceptibility of the more common commercially available varieties of several important southern California ornamental crops, and to determine the effects of plant nutrient and water stresses on the relative resistance and susceptibility of ornamental plants to their major insect pests. These objectives will initially be determined for the following species (other species will be added on a priority basis): Dendranthema morifolium, Gerbera jamsonii, Nerium oleander, Encelia farinosa, and Euphorbia pulcherimma. Finally, as new pests enter into the state and are detected, a secondary objective will be to develop the knowledge data base (knowledge of insect life histories, seasonal phenologies, etc.) necessary to design adequate pest detection and sampling methods.
Under this reporting period, my lab focused on two major research areas: (1) improving pest management in ornamental plant production using host plant resistance and modification of cultural techniques, and (2) biology and control of glassy-winged sharpshooter (HOMALODISCA COAGULATA) and the plant pathogen XYLELLA FASTIDIOSA. Using chrysanthemum as a model, fertilization, watering, and plant variety all had an impact on the resistance of chrysanthemum to western flower thrips. The variety 'Pink Lady' demonstrated the most susceptibility to thrips; increasing fertilization level and decreasing watering levels led to enhanced thrips susceptibility. Fertilization and watering showed no significant impact on populations of melon aphid on chrysanthemum; however, plant variety strongly affected melon aphid fecundity, longevity and survivorship. The cultivar 'White Diamond' demonstrated the most susceptibility to aphid infestations while 'Pink Lady' demonstrated the most resistance. When using poinsettia as a model, the cultivars `Red Velvet', `Supjibi' and `Pepride' were less preferred for oviposition by the silverleaf whitefly. The cultivar `Peterstar' was the most preferred oviposition host. Whitefly longevity and fecundity showed no difference among seven cultivars evaluated; however development time was significantly longer in `Pepride' than `Petoy' and `Red Velvet'. My laboratory established the glassy-winged sharpshooter as the major vector of oleander leaf scorch (XYLELLA FASTIDIOSA). We determined the seasonal flight activity of the glassy-winged sharpshooter in Southern California and showed two distinct flight periods per year (early spring and mid summer). The mid-summer flight period demonstrated the most sharpshooter activity, and citrus groves supported the greatest number of sharpshooters among the habitats sampled. Results indicate the majority of sharpshooters infesting grapes and transmitting Pierce's disease in the Temecula area of California overwinter in citrus, and limited control of the insect in grapes may be achieved by applications of the pesticide imidacloprid to citrus. We also documented the effects of selected insecticides on sharpshooter mortality, feeding behavior, and disease transmission. Oleanders treated with fenpropathrin and imidacloprid caused significant mortality to caged sharpshooters within 4 h of exposure, and oleander leaf scorch transmission by glassy-winged sharpshooter was blocked by applications of acetamiprid, imidacloprid, and thiamethoxam. Our research in vineyards has shown that applications of acetamiprid and kaolin clay not only reduce the population of glassy-winged sharpshooters, but also reduce the incidence of Pierce's disease by 30%. My lab also has discovered the occurrence in California of a predator wasp which specializes on the glassy-winged sharpshooter. This wasp (PSENEO PUNCTATUS) likely entered the state within the soil of nursery containers. We are currently evaluating this species' potential as a supplementary biological control agent for sharpshooters.
Impact: Our research has shown the utility and value of simultaneously using host plant resistance and cultural control techniques (modified fertilization and watering) to limit pest populations in commercial ornamental plant production. Using such an approach, we estimate a significant reduction in pesticide applications can be achieved for both chrysanthemums and poinsettia. Our research with glassy-winged sharpshooter documented the abilities of this insect

to transmit oleander leaf scorch an important landscape plant of California. We also documented the seasonal phenology of this insect allowing much improved and targeted monitoring and detection methods to be developed. Finally, our work with controlling sharpshooters has demonstrated that the application of neonicotinoid pesticides coupled with a foliar barrier, such as kaolin, reduced the spread and incidence of Pierce's disease in grapes.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Integrated Pest Management Strategies for California Horticultural Crops
Description: Objectives: 1. Evaluate alternative controls for key insect and mite pests of horticultural crops which are potentially affected by loss of widely used insecticides and acaricides. 2. Evaluate mortality and sublethal effects of specific pesticides on natural enemies of pests in horticultural crops. 3. Develop practical monitoring methods and thresholds for key pests of horticultural crops. 4. Integrate new and available tactics into IPM programs for various horticultural crops. IPM research was conducted on strawberry, tomato, almond, prune peach and olive insects. New acaricides were tested for control of TETRANYCHUS URTICAE spider mites in strawberry, and for impact on their predators including the predatory mite PHYTOSEIULUS PERSIMILIS, minute pirate bug ORIUS INSIDIOSUS and green lacewing CHRYSOPERLA CARNEA. Seasonal movement, population dynamics, damage potential and control of greenhouse whitefly, TRIALEURODES VAPORARIORUM, a new pest of strawberries is now being studied in 2 major production areas. A phenology model for consperse stink bug, EUSCHISTUS CONSPERSUS, was validated in commercial fields and proved that alternatives to traditional organophosphate insecticides could be used for control when timed properly. Damage relationships of potato aphid, MACROSIPHUM EUPHORBIAE, were evaluated by establishing different levels of aphid densities at different times during the growing season, and were shown to reduce tomato yield by as much as 10 percent during a 4 week period from 4 to 8 weeks before harvest. Six commercial tomato lines were evaluated for impact of potato aphid feeding, but significant differences in yield reduction due to aphid feeding were not detected between them. Sampling methods from San Jose scale, QUADRASPIDIOTUS PERNICIOSUS, were compared in almond orchards. Males captured in pheromone traps during the first generation were correlated to both scales on almond spurs and crawlers on sticky tape bands. This relationship did not prove significant in subsequent generations. Moving dormant spray insecticide treatments to a much earlier dormant season timing resulted in significantly less organophosphate runoff from orchards than did conventional timing. Autosamplers measuring water flow offsite indicated that this was probably due to water infiltration when soils are drier. Efficacy of earlier treatment timing against the key target pests Q. PERNICIOSUS and peach twig borer, ANARSIA LINEATELLA, was not significantly reduced relative to later season treatments. Research on phenology of olive fruit fly, DACUS OLEAE, and susceptibility of olive fruit at different stages of maturation was initiated on this newly introduced insect. Weekly collection sites have been established in 11 counties.
Impact: While California's producers of fruits, nuts and fruiting vegetables may lose uses of organophosphate insecticides as current uses may violate the Food Quality Protection Act and/ or the Clean Water Act, the results of this project provide options for control of key insect pests which affect fruit quality, yield and the environment in the absence of organophosphates. The decision support tools for monitoring pest resistance, abundance and phenology are maintaining continued effective use of product and practices which might otherwise be lost.
Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Integrated Soil Solarization-Low Rate Fumigation: Mode of Action and Optimization
Description: This project is proposed to investigate the feasibility and mode of action of integrated soil solarization-low rate fumigation and develop this integration as an alternative to methyl bromide fumigation. Such integration will not only reduce the use and thus the associated risks of fumigation, but also allow solarization to be used under less favorable climatic and soil conditions. Alternative fumigants are likely the main replacements for MeBr. These alternatives include 1,3-D, MITC precursors, chloropicrin, and potentially methyl iodide and propargyl bromide. All these compounds share some of the properties of MeBr, and their use can potentially result in negative effects on humans and the environment. In particular, these fumigants can rapidly emit into the air after application, which may result in human exposure for field workers and nearby residents. In this project, we investigated integration of soil solarization-low rate fumigation as an option to reduce fumigant use and risks, while improving the effectiveness of non-chemical alternatives such as soil solarization. We conducted two multiple-treatment field trials in the Southern California Region. The first study was carried out in Coachella Valley, CA, during July-November, 2000. The climate represents a desert environment with intense sunshine. In this study, we tested integrated solarization-fumigation treatments, with the fumigant being used at full or reduced rates. Two alternative fumigants, Telone and metam sodium, were considered. Soil solarization was initiated three weeks before the fumigation treatment with regular polyethylene films covering raised beds. Solarization continued for three additional weeks after the fumigation treatment. Cantaloupe seedlings were then transplanted and grown till harvest. Results showed that soil solarization was effective in controlling native nematodes, weeds, and fungi, and consistently increased cantaloupe yields. Soil solarization allowed low rates of fumigants to be effective for pest control. Because of the reduced fumigant rates used in these integrated treatments, emission into the atmosphere was directly reduced or essentially eliminated. This study suggests that the integrated practices could potentially offer multiple advantages; they improve the efficacy of non-chemical control methods, and at the same time minimize the health and environmental hazard of the pest management practices. The second field trial was conducted during July-December 2001, in a field near Irvine, CA. The site represents a coastal climate with variable solar radiation in the summer. In this study, we tested integrated soil solarization with reduced rates of 1,3-D or metam sodium, and non-solarized beds were used as control. Solarization was continued for 4 weeks. The treated plots were planted with industry-grade tomato seedlings and grown till harvest. In un-fumigated plots, solarization increased the yield by 54%. In fumigated plots, solarization resulted in general increases in tomato yield, and the increase ranged from 2 to 56%. Integrations of solarization with medium-rate fumigant treatment were in general as effective as the integration with the high rate. This study suggests that the integration may be also suitable for coastal climates and may be used to shorten the solarization duration.
Impact: Our study has consistently shown that soil solarization, alone or in combination with fumigation, improves the efficacy of pest management in the southern CA region. Such integrated practices are not only decreasing the use of chemical fumigants, but also improving the efficacy and consistency of the nonchemical practices. These integrated approaches therefore promote the gradual adoption of totally non-chemical pest management practices.
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: Objective 2, Interactions 12 and 13: 1. To determine which synthetic lures attract ratios of predator-to-bark beetles that arrive at host trees. 2. To determine which combinations of synthetic attractants generate the highest bark beetle-to-predator ratios during simulated trap out. 3. To determine the pheromonal mixtures that would most augment predator arrival rates. (To be addressed in year 3 of the project) Objective 2, Interaction 14: Measure the effects of different fire intensities from prescribed fires on tree vigor and its susceptibility to beetle attack.
Fire and fire surrogate study - effects on leaf litter invertebrates at Blodgett Forest: Pitfall trap samples were collected over the summer of 2002 in replicated compartments throughout Blodgett Forest, repeating 2001 sampling. Pre-treatment data were collected over the course of both summers, and sampling will continue after these plots undergo one of four treatments in the next two years: control, prescribed burn, mechanical (timber harvesting, etc.), or mechanical followed by burning. We captured 28 species of ground-living beetles (Carabidae and Tenebrionidae) in 2001 (5500 trap-days) and 775 samples in 2002 (3875 trap-days). Ants were the most abundant arthropod group captured (58% of 44,762 individuals). Most of the spiders captured were in the family Lycosidae (4331, 61% of total spiders). Other groups (Opiliones, Acari, and Pompilidae) were captured in lower, but still substantial numbers. All taxa show strong seasonal variation in terms of catch, while some taxa also show year to year differences. There is also significant spatial variation among some taxa, probably due to local vegetation and microhabitat differences between forest compartments. We found the following effects of prescribed burning on tree vigor and susceptibility to bark beetle attack on two study sites in the northern Sierra Nevada. (1) Fall burns had more mortality than spring burns. (2) Of all the species, Jeffrey pine had the greatest disparity between fall and spring mortality rates. (3) Of the spring burns, only Lassen National Park showed significant tree mortality by insects. (4) Linear models were used to determine which fire severity measure was most important for determining `killed by insects' and `killed by fire'. (5) Fire and forest managers need to re-evaluate the ecological role of some of these insects following prescribed fire. Insects like Phloesinus, Ips pini, and D. valens are behaving differently following fire. (6) The bark beetle D. valens is contributing to tree mortality. On average, trees killed by insects with valens had 2.6 attacks while those that were not killed only had 0.7 successful attacks. (8) Accumulated duff mounds and bark char code 3 helped to predict D. valens activity. Also makes intuitive sense as those are good predictors of root and stem damage at the base and root collar. (9) Woodpecker foraging is contributing to mortality rates in small pines. Mean diameter for those dead trees with woodpecker activity was 11.1 cm with an average of 7 successful D. valens attacks. Green trees were larger averaging 20.3 cm.
Impact: The results from the FFS study are important to foresters when making decisions about management practices. This information provided forms the basis of knowing the impact of management tools on local biodiversity. . Effect of fire on tree mortality caused by bark beetles is another impact of management methods on forest health. This information has proven to be critical in order to make informed decisions in how to implement practices on large scales.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA, CO, FL, IA, MN, OH, OR, WI, UT, USDA/FS, NON-SAES: UNIV. OF MT, MN

Theme: 4.12 Integrated Pest Management
Title: Management of California Red Scale , #1 Pest of Citrus in the San Joaquin Valley

Description: In lost production and fruit quality, California red scale infestations cause major economic losses to citrus growers. Historically, management of this pest centered on pesticide applications, with timing based on visual examination of the trees. The expense of the spray was a major part of a grower's total production cost. Pesticide used for this one pest was a major component of the total pesticide load applied to citrus in Tulare County.
Working as a team, Neil O'Connell, Citrus Farm Advisor in Tulare Co. and Dr. Gregory Walker, Associate Professor of Entomology at UC Riverside, conducted a three-year field trial at the UC Lindcove Research and Extension Center. Weather stations and traps for the insect were established at multiple sites on the station. Sequential sprays were applied in spring and summer, with timing based upon temperature and the development of the insect. The results, evaluated by counting surviving scale on leaves, twigs and fruit, were immediately delivered to growers in the spring and fall citrus meetings and by newsletter.
Impact: Application of these results by growers and pest control consultants (PCA's) has (1) significantly increased efficiency of spray applications, (2)lowered grower costs for managing the pest and (3)substantially reduced the amount of pesticides applied on citrus in Tulare County.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Management of Forage Quality In Strip-Cut Alfalfa
Description: Lygus bugs prefer alfalfa to many other crops, but don't damage it. Alfalfa can sustain high populations of lygus, but when the fields are cut every month the pest moves into neighboring susceptible crops. Retaining lygus populations in alfalfa fields is the centerpiece of a promising regional pest management strategy. This involves leaving strips of uncut alfalfa which act as a temporary habitat for lygus bugs, thus limiting their movement out of the field. The method works well, but growers are concerned about the effect that the strips of more mature alfalfa have on hay quality and marketability. A strip cutting trial has been conducted for the past three years. At each of three cuttings during each production season, hay bales were produced with various mixtures of old and new growth alfalfa, ranging from no old growth to 100%. Bale compositions were created during swathing and raking. Chemical analysis as well as visual inspection detected reduced quality of bales containing 14%, 25% or 50% old hay. However, bales containing only 7% old hay were similar in quality and appearance to bales with 100% new hay. When quality is lower, the hay value is less and the markets may be limited. For example, dairy hay must meet a very high standard of quality. Blended hay with more than 7% old hay would not be acceptable to this market, but could be used in the beef or horse markets.
Impact: Forty-five percent of cotton growers surveyed said they use strip or block cutting of alfalfa as part of their pest management program. Using the information developed by UCCE, they can now make informed decisions how to manage the hay in the uncut strips. They may choose to blend it with the new growth and handle the lot as a single unit, or they may segregate out the bales containing the old hay. By having a much better idea of the reduced quality that will result from blending old hay with the new, growers may be more willing to use this strategy to limit lygus migration from alfalfa hay fields.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Management Strategies for Arthropod Pests and Natural Enemies on Citrus and Avocados in California

Description: Objectives: 1.Evaluate the impact of various pesticides in control of citrus and avocado thrips. Emphasis will be on selective chemicals that allow effective biological control of other pest species. Monitor pesticide resistance development. 2.In order to improve biological control of black scale in southern California and citricola scale in the San Joaquin Valley, study parasitoid basic biology, import new parasitoid species, develop economical laboratory/insectary rearing methods for various parasitoids, and evaluate the potential of various parasitoids for use in inoculative or augmentative field releases. 3.In order to evaluate the potential for biological control of citrus thrips, determine what predators feed on citrus thrips to various degrees in commercial citrus orchards and determine what prey are fed on by the predaceous mite Euseius tularensis. Import Goetheana incerta from South Africa, clear it through quarantine, screen it against beneficial thrips species, develop a method of laboratory rearing, and evaluate it against citrus and avocado thrips. 4.Evaluate the impact of various pesticides on important natural enemies of citrus. Emphasis will be on new insect growth regulators being developed for California red scale control and new materials anticipated for use against citrus thrips. 5. Develop improved means of dealing with two pests of quarantine significance -- bean thrips as it impacts shipment of navel oranges to Australia, China, and New Zealand and Fuller rose beetle in relation to shipments to Japan and other countries in Asia. Research this last year focused on solving pest management problems facing the citrus and avocado industries in California. In April 1996, a researcher searched through Italy, Israel, and Turkey for parasitoids of black scale and citricola scale and imported METAPHYCUS sp. nr. FLAVUS from a location near Kozan in central Turkey. Working with a UC laboratory, we have now evaluated augmentative releases of this parasitoid for control of citricola scale in California's San Joaquin Valley - the parasitoid is effective in the field but further work will be necessary to determine if sustained control will be achieved with economically practical releases. Research with Mediterranean fruit fly showed that the male-only Vienna-4 strain is similar in quality to the bisexual Maui-93 strain that has been used in the Preventative Release Program in southern California over the last several years. Evaluation of lacewings eggs obtained from 3 commercial insectaries in California showed slight differences between insectaries, justifying use of any of these sources by growers wishing to use this predator in control of avocado thrips on avocados. An economic analysis of the impact of avocado thrips on California avocado production indicated that short-run losses due to this pest were approximately $8.51 million annually. Field trials indicate that abamectin (Agri-Mek) is an effective treatment for this pest that can provide up to 8 weeks of control. A degree-day model was developed for the egg stage of the glassy-winged sharpshooter.
Impact: Citricola scale is a major impediment to the biologically-based integrated pest management program we have developed for San Joaquin Valley citrus. If proven to be effective and economical, METAPHYCUS sp. nr. FLAVUS could solve this impediment. The joint CDFA/USDA Medfly Preventative Release Program is run at an annual cost of ca. $18 million. There was some concern about switching to male-only Medfly releases based on low trap catch reported initially with this strain in comparison to standard strains. Partially based on our research, the Program has decided to switch to male-only releases, which are less expensive and are considered to be more effective. The avocado thrips was discovered in California in June 1996 and caused considerable short-run damage (estimated at $8.51 million annually) due to fruit down-grading and increased pesticide application costs. Our research helped to develop an effective treatment for this pest and over the past several years, economic damage has been significantly reduced.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Methyl Iodide Preparation Offers Needed Alternative
Description: For more than 50 years, U.S. agricultural producers have used methyl bromide as a broad-spectrum soil fumigant to combat nematode pests, soil pathogens, insects, and weeds. An estimated 21 million killograms of methyl bromide were used annually in the United States by 1990. However, in 1993, the Environmental Protection Agency classified the chemical as an environmentally harmful ozone-depleting substance and instituted a gradual phase-out that began in 1999 and is scheduled to culminate in a total ban by 2005 (except for "critical uses" exemptions). An agency of the U.S. Department of Agriculture has estimated that the loss of methyl bromide will cost the agricultural industry and consumers $1.3 billion to $1.5 billion annually. A more conservative estimate by the National Center for Food and Agricultural Policy put the cost at $484 million annually. A Professor of Plant Pathology and Chemist of the University of California, Riverside with colleagues developed two patented methyl iodide uses as an alternative to methyl bromide. Five years of field trials indicated that methyl iodide is as effective, if not more so, than methyl bromide in combating weeds, nematodes, and soil pathogens. Methyl iodide is not an ozone depletor because it has an average lifetime in the atmosphere of about 1.5 days compared to 1.7 years for methyl bromide. With methyl iodide being one-and-a-half times heavier than methyl bromide, agricultural producers also can use about two-thirds less of the methyl iodide preparation. UC Cooperative Extension research has estimated that about 150 pounds of methyl iodide per acre applied via drip irrigation would provide the same benefits as about 250 to 270 pounds per acre of methyl bromide.
Impact: One of his patented uses was licensed to Arvesta Corp. in 1999. Arvesta has named its iodomethane product Midas and is continuing field trials and working to develop the best application methods. The company expects EPA approval by summer 2003 for the use of the fumigant on strawberries, tomatoes, tree and vine crops, and ornamentals and turf. Currently, Midas is expected to cost 20 percent to 50 percent more than methyl bromide. However, because less of the methyl iodide can be used to achieve the same control as methyl bromide, the cost difference for growers could be minimal.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Mite Devastating Date Crop Is Foiled
Description: Riverside County is the number one producer of dates in California as well as the nation but successful, economical production is limited by Banks grass mite (BGM), the leading pest of dates in the state. Sulfur is the only registered pesticide for use in controlling BGM. However, sulfur disrupts natural enemies and no longer controls BGM. Alternative chemicals must be found. A UCCE advisor from Riverside County, was asked by area growers to find an alternative pesticide for controlling BGM. In one year of testing products she came up with an alternative pesticide, Savey. Meanwhile, a faculty member(UCR) and a farm advisor (UCCE, Riverside County) investigated why sulfur was no longer effective in controlling BGM.
Impact: After one season of testing, the advisor was able to get EPA to approve an emergency registration for Savey in California for the following season. The miticide, sprayed with water once early in the season, gives season-long control. In the first year of its introduction, nearly 50% of the growers used it. Three years later over 90% of growers had traded in their dusting machines for sprayers so that they could use Savey. Since Savey's introduction there no longer are nuisance or health issues that were provoked by dusting sulfur. From pesticide applicators and field workers to packing line workers, injuries and illnesses due to sulfur exposure have been

nearly eliminated. Savey not only gives season-long control but is easy on the natural enemies (good bugs) and overall crop quality is ideal. It was also determined that the mites had developed high resistance to sulfur which was why it no longer gave adequate control.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Molecular and Cell Biological Approaches to the Population Biology and Pathology of Comycetes and Powdery Mildews
Description: Objectives: (1) conduct an ornamental nursery survey in southern California. (2) determine the host range and symptom expression of P. ramorum among ornamental and horticultural plants grown in southern California. (3) continue molecular genetic analysis of worldwide populations of P. infestans and P. palmivora. (4) develop efficient genetic transformation methods for P. palmivora, P.megakarya, P.tropicalis and P. nicotianae as a prelude to initiating genetic studies with these important pathogens. (5) evaluate several distinct molecular groups (A, B, etc) of P. megasperma originally isolated from cruciferous host species for their ability to parasitize Arabidopsis thaliana genotypes. (6) collect, characterize and maintain tomato isolates of Leveillula and Oidium. (7) identify resistance to multiple isolates of Leveillula in wild tomato species. (8) conduct cytological, cytochemical and ultrastructural analyses of differences in both the host epidermal cell wall and the extrahaustorial matrix (EHMAT) of powdery mildew-infected mutants of Arabidopsis. Oidium neolycopersici was a pathogen only known from rare herbarium specimens prior to the 1980s. In a few short years this `new' pathogen became a major threat to tomato production in Europe, Africa, North and South America, and Asia. By the 1990s it had appeared in California where it has been troublesome in glasshouse grown crops, especially in the coastal region of Central California. It has yet to establish itself in the main field-growing areas of the Central Valley but this may change. In southern Europe this pathogen has spread into the warmer field production areas. Ideal control of these important plant pathogens would be through using tomato lines with durable resistance. Unfortunately, all tomato varieties tested are very susceptible to both powdery mildew pathogens. However, various reports have indicated that some collections of wild tomato species show resistance to O. neolycopersici. The collections of L. hirsutum and L. hirsutum f. glabratum which had resistance to our UCR strain of O. neolycopersici are LA1252, LA1255, LA1264, LA1265, 101266, LA 1353, LA1354, LA1775, LA1777, LA1778, LA1779, LA2098, LA2099, LA2100, LA2101, LA2103, LA2105, LA2106, LA2107. All the L. pennellii and L. pennellii var. puberulum accessions tested were also highly resistant. Amongst the L. parviflorum and L. peruvianum collections there was variation in the degree of susceptibility or resistance.
Impact: Due to the emergence of new highly aggressive strains of the late blight pathogen, the resultant disease is a major threat to tomato and potato production worldwide. Our contribution to its control has included identifying new sources of resistance in a wild tomato species, especially LYCOPERSICON HIRSUTUM, as well as careful monitoring of the population in 'hot spots' such Russia. The global nature of its rapid spread has required international collaborative efforts. In California late blight is a major threat to both the fresh market and processing tomato industries. Within the last year a new PHYTOPHTHORA has been identified as the cause of Sudden Oak Death, a potentially devastating disease of live oaks and other important native species.. Research has begun on the biology, pathology and spread of this important pathogen.
Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Molecular Genetics of Californian Arboviral Vector Mosquitoes
Description: The overall goal of this program is to improve our understanding of both the heritable and non-heritable factors that influence virus-vector relationships, vectorial capacity as a whole, and insecticide resistance mechanisms. The specific objectives will be: 1) to evaluate the vector competency of Californian mosquito arboviral vectors, with particular emphasis on western equine encephalomyelitis virus and the vector species CULEX TARSALIS; and 2) to develop a molecular genetics program on the mosquito CX. TARSALIS and other Californian disease vectors. Primary emphasis will be placed on CX. TARSALIS because it is the major vector of arboviruses in California. Attention will be given to developing and then improving techniques for conducting laboratory-based mosquito vector competency assays that more closely resemble the natural situation and current viral activity. Developing a molecular genetics program will involve research along many different facets, including selection of mutant stocks of mosquitoes; development of chromosomal DNA physical mapping techniques; production of cDNA and DNA genomic libraries; and production of high-resolution genetic and physical maps. The potential for development of tolerance to pyrethrum and pyrethroids in medically important mosquitoes in California remains a serious issue especially in light of the impending spread of West Nile virus into California. Resistance to the pyrethroids has developed in one population of Cx. pipiens pipiens in California (Marin County). Studies on a colony of these mosquitoes indicate that they are resistant due to the possession of the kdr type resistance gene and pyrethroid specific metabolizing oxidases. Oxidase mediated resistance was shown in biochemical assays using a novel oxidase specific substrate that was developed this year by a collaborator and synergist bioassays. Recent field studies of the Marin mosquitoes proved that the combination of these resistant mechanisms resulted in respectively only 3 and 34% mortality one hundred feet away from high dose aerial applications of unsynergized pyrethrum and permethrin and respectively 80 and 92% mortality in PBO synergized pyrethrum and permethrin. Higher mortality was recorded with synergized formulations, as PBO is an oxidase inhibitor. Studies completed this year indicate that considerable exchange of genes occur between Cx. pipiens pipiens and Cx. pipiens quinquefasciatus in California. This is important, as insecticide resistance genes, if not eliminated or reduced, will spread from one subspecies to the next resulting in resistant populations throughout the distribution of these subspecies from southern to northern California. Correlation's between bottle bioassays and World health Organization (WHO) discriminate dose impregnated paper assays for pyrethroids remain difficult to obtain due to the action of multiple pyrethroid resistant mechanisms occurring in unison in individual mosquitoes. Studies on other insecticides and mosquito species also continued this past year. Laboratory bottle bio-assay, WHO discriminate dose paper assays and field studies have indicated that there is widespread resistance to Naled (organophosphate) in California populations of Culex tarsalis. Concerns raised about the poor control of Ochlerotatus squamiger in coastal San Mateo County achieved by Bacillus thuringiensis israelensis was proven to be due to problems of application and not resistance. Resistance to methoprene in Ochlerotatus nigromaculis continues to exist in Fresno County despite the reduced use of methoprene. As an extension to work on insecticide resistance a GIS based package for use by mosquito abatement personnel has been developed and is in use in Fresno County Mosquito and Vector Control district. This spatially based package has resulted in vast improvements in efficiency of mosquito control and reduced operational costs.

Impact: The knowledge of pyrethroid tolerance in mosquitoes in California has impacted the mosquito abatement districts operations directly. The districts have been encouraged to use rotations of chemicals and to reduce their use of pyrethroid adulticides as much as possible to mitigate extensive spread of pyrethroid resistance. Several districts that were not previously conducting insecticide tolerance bio-assays are doing them now in collaboration with this laboratory
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Molecular Identification of Plant-Parasitic Nematodes
Description: Objectives: 1. To develop DNA-based assays to distinguish species and populations of plant parasitic nematodes in soil samples and as single worms. 2. To use DNA markers and genetic analysis to investigate the inheritance of virulence and the ability of root-knot nematodes to infect specific hosts. We are developing polymerase chain reaction (PCR)-based DNA assays that can be used to distinguish species of plant parasitic nematodes. We have developed and tested an assay that can be used to test soil samples for the presence or absence of root-knot nematodes. Our validation tests show this method to be very sensitive and effective at identification of specific nematode species from different soil types. A manuscript describing this assay is in preparation. We are currently developing a similar assay to test soil samples for the presence or absence of lesion nematode species. Lesion nematode species differ considerably in importance as pathogens of fruit and nut trees in California, but are very difficult to distinguish by classical microscopic techniques. We have produced cultures of isolates of the most important species of this group. Together with scientists at the University of California, Riverside, we have developed an assay that can identify the each species in our culture collection. The assay that we have developed can differentiate single worms and so is useful for characterizing mixed populations. The test is straightforward to use and should be applicable in extension laboratories that have expertise in molecular techniques. We have developed additional DNA markers that can distinguish some isolates of root-knot nematode that differ in virulence on tomato or potato.
Impact: Plant parasitic nematode species differ in their importance on specific crops. Therefore, management of these important pests requires species identification. Classical methods for identification are labor intensive and require considerable specialized expertise. The easy to use molecular techniques that we are developing are important for management decisions that minimize costs and chemical inputs in agriculture.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Monitoring Insecticide Resistance of California Red Scale
Description: San Joaquin Valley citrus growers have depended on the relatively cheap and very effective organophosphate and carbamate insecticides for control of California red scale and other pests since the 1950s. Not surprisingly, California red scale began to develop resistance to these two groups of insecticides in the early 1990s. A Cooperative Extension Integrated Pest Management Specialist with the University of California, Riverside, documented California red scale resistance to organophosphate (Lorsban and Supracide) and carbamate (Sevin) insecticides throughout the San Joaquin Valley during 1991-1997. She did this by demonstrating that the resistance was due to an increase in esterase enzymes in the resistant scale. She and her

colleagues collected scale from many orchards and used a colorimectric test that measures the level of esterase enzymes in individual scale to test them for resistance. More than 300 populations of California red scale in Kern, Tulare, and Fresno counties were tested, with many populations found to be resistant to organophosphates and carbamates. This documentation supported rapid registration of the reduced-risk insect growth regulators (Esteem and Applaud). It also convinced a number of growers to utilize natural enemies (Aphytis wasp releases) for scale control, rather than insecticides. Growers had a sense that resistance was a problem, because they found that they had to spray more frequently. Documentation of resistance helped to convince them that it was time to use other control tactics.
Impact: Replacement of organophosphate and carbamate insecticides with the insect growth regulators buprofezin (Applaud)and pyriproxifen (Esteem) for scale control and spinosad (Success) for citrus thrips control resulted in a 71 percent reduction in OP and carbamate use (from 1.2 million pounds in 1997 to 0.3 million pounds in 1999) in San Joaquin Valley citrus.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: More Efficient Mating Disruption Reduces Insecticide Use, Saves Costs
Description: To control codling moth in pear orchards, the primary alternative to organophosphate (OP) insecticide is pheromone mating disruption (MD). This technique is currently used in nearly all pear orchards in California. But there are problems with traditional pheromone dispensers: (1) unreliable emission rates, especially in the spring and (2) need for labor. These problems have been particularly acute on the North Coast with its cold springs and higher labor costs. A more efficient and reliable alternative to OPs for codling moth control has been needed. Starting in 1996, the pear industry supported research on a new emitter, or "puffer," that regulates pheromone emission better and also drastically reduces labor cost. Research was conducted on 160 acres in Lake County from 1996-1998. Based on successful results, in 1999 two large areawide demonstration projects were conducted in Lake County (10 growers, 500 acres) and Mendocino County (five growers, 360 acres). The trials compared MD using puffers to standard insecticide programs and to completely untreated controls. In 2000, the Lake County trial expanded to 820 acres and 10 growers, and in 2001 to 1,350 acres and 19 growers. The projects were sponsored by California Dept. of Pesticide Regulation, USDA Codling Moth Areawide Management Program (CAMP) and the pear industry. Results were extended via weekly faxes to all project participants, at meetings and in numerous trade magazines.
Impact: The puffer both successfully controls codling moth and is easy and relatively inexpensive to use. It also has proved to be an ideal tactic for use in areawide MD programs, because as acreage increases the number of needed units/acre decreases. Organophosphate insecticide use for codling moth control has almost entirely ceased in participating orchards. A recently completed UC cost study showed that puffers save $9 per ton or nearly $200 per acre, based on 20 tons per acre. The cost savings came from (1) less insecticide use due to fewer outbreaks of secondary pests such as mites and pear psylla, and (2) less need to operate spray equipment, which is becoming increasingly expensive. The project received the 2000 IPM Innovator Award from California Department of Pesticide Regulation. The puffer is now commercially available and in use on over 2,000 acres on the North Coast. This success has catalyzed new efforts by other UC and USDA researchers to determine strategies for apples, pears and walnuts.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Mosquito and Agricultural Pest Management in Riceland Ecosystems
Description: Objective: To develop a database on the bionomics of rice pests, riceland mosquitoes and beneficial aquatic fauna coming to associate with harvested rice fields flooded in the winter. Most rice growers formerly managed residual rice straw by burning, but many now leave straw on the fields in combination with flooding to aid decomposition. These practices may change pest population sizes because straw is a resource for the food web. Our purpose is to measure effects of 8 straw management techniques on populations of mosquitoes, arthropod pests and beneficial arthropods.
Impact: This project, 'Mosquito and agricultural pest management in riceland ecosystems' is a broadly-based project on ricelands and similarly-managed wetlands. Mosquito management techniques used in rice are also applied to seasonal wetlands managed for duck populations, wetland endemics like tadpole shrimp, and other fauna of concern, therefore this research is conducted in both rice fields and managed wetlands. Assessing the effects of mosquito control on both mosquitoes and wildlife is of increasing importance because the threat of West Nile Virus and other invasive diseases makes it likely that mosquito control will be more widespread in future. Wildlife managers are often suspicious of mosquito control because of the potential for toxins to be introduced into the environment, or for pesticides to harm the food webs that support wildlife. Our data helps managers evaluate risks. Our progress this year includes two publications of research on how ducks, eggs of other birds, and non-target invertebrates are affected by applications of a mosquito larvicidal oil, Golden Bear 1111 (GB1111). Bird eggs developed normally when GB1111 was applied at label rates, and ducklings maintained their weight and condition when they were corralled in a site treated with this pesticide. However our study raised the concern that application of the oil could lead to feather-matting and loss of thermoregulatory ability for the ducklings in cold weather. Air-breathing aquatic insects were depleted by the pesticide. A third publication shows that a bacteria used to control mosquitoes, B.t.i., is safe for an endangered tadpole shrimp. A new project begun this year evaluated the potential for an agricultural pesticide to disrupt the control of mosquitoes by mosquitofish in rice fields. Label-rate applications of the synthetic pyrethroid insecticide lambda-cyhalothrin caused 100% mortality in mosquitofish, plus loss of all predatory invertebrates. Treated sites became safe for fish re-introduction after a week, but beneficial invertebrate populations did not recover for at least three weeks. We are preparing a manuscript to present these results. Wildlife managers are using information from our studies of GB1111 Oil and b.t.i. to negotiate pesticide use proposals with mosquito abatement districts (MADs). Mosquito abatement districts also use this information to justify management practices to their boards and regulatory agencies. Our lambda-cyhalothrin work helps MADs maintain biological control by re-introducing fish as needed.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AR, CA, FL, IL, LA, TX

Theme: 4.12 Integrated Pest Management
Title: Nematode Management in Annual Crops with Emphasis on Host Plant Resistance.
Description: Objectives: 1. Examine nematode biology in nematode interactions with soil and with plant hosts, specifically including the abiotic factors temperature and moisture, and biotic factors of interacting organisms (fungi, bacteria, other nematodes) and plant host status. 2. Develop, refine and implement management strategies for root-knot and comparative nematodes on field and vegetable crops, emphasizing non-host rotations, resistant and tolerant cultivars and

nematicides, singly or integrated where appropriate. 3. Identify, characterize, introgress and implement host plant resistance traits, corresponding to genetic variation for parasitism in nematode populations. 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, lima bean and tomato. Genetic analysis in cowpea showed that the Rk resistance locus has at least four forms based on the specificity of resistance to different nematode populations. The gene locus was mapped to linkage group one of cowpea and a fine-mapping of the Rk region is being conducted to generate useful molecular markers for cowpea breeding and for a positional gene cloning effort. A series of near isogenic lines in a blackeye background is being developed, for use in comparing the value of each Rk gene form in protecting cowpea from nematode infection in field experiments. A series of recombinant inbred lines was developed from crosses between root-knot susceptible and resistant Lima bean genotypes. The resistant parents represent different R gene sources. The genetic analyses of the resistance revealed several recessive and dominant genes that control nematode reproduction on roots, nematode induced root-galling, or both. Combinations of the R genes were shown to be necessary in providing Lima bean plants with adequate broad-based field resistance. Nematode infested field nurseries in the San Joaquin and Coachella Valleys of California were used to advance several hundred breeding lines of fresh market type carrots with resistance to M. JAVANICA and M. INCOGNITA. The resistance was shown to be an adequate replacement for soil fumigation treatment when combined with prior planting of non-host or resistant rotation crops and (or) use of delayed planting time of carrot in the fall. Analysis of root-knot nematode, M. INCOGNITA, and Fusarium wilt resistance in cotton was started using crosses between resistant and susceptible genotypes of both pima and upland cottons. AFLP polymorphisms are being screened in a search for gene markers for use in cotton breeding programs.
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: Nematode Management Techniques
Description: In Imperial County, there are several species of nematodes (microscopic roundworms) that can cause damage to many crops. Nematode-infested roots are inefficient in taking up water and nutrients, and yield or quality of the product is reduced. Although these pests are widespread and the damage is substantial, the most commonly-seen symptom in many cases is simply lack of vigor. For that reason, the cause of the problem is frequently misidentified.
To educate agricultural professionals about these microscopic pests, a UCCE Farm Advisor organized a meeting in Imperial County and presented information on susceptibility of crops and weeds to nematodes. General background and specific techniques for controlling nematodes were presented by nematologists from UC Riverside. Topics included host range, susceptibility of specialty crops to nematode species, chemical control and biological control. In addition, results of a study were presented in cooperation with Turini, of root-knot nematode reproduction on weed species.

Impact: As a result of UCCE's efforts, growers and consultants are more capable of recognizing when a nematode infestation may be actually damaging a crop. They now know (1) what symptoms to look for and (2) how to take samples to confirm their suspicions. Once the problem is identified, they can better determine a management strategy that will work in their situation. In addition, they are now armed with information regarding which crops are subject to attack from which nematodes, as well as current biological and chemical control techniques.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Nematode Population Biology
Description: Objectives: 1. Develop, verify and validate predictive and explanatory population models of nematodes functioning at various trophic levels in food webs. 2. Develop and calibrate bioindicator systems for soil faunae and soil health. 3 Relate function to structure in soil food webs. We identify two dimensions of the soil food web as indicated by nematode faunal analysis, the enrichment trajectory and the structure trajectory. The enrichment trajectory measures response in the abundance of opportunistic species, and subsequent successional events, after enrichment input. We documented the succession in the nematode fauna from Rhabditidae to Cephalobidae and Aphelenchidae in field plots and through collaborative studies. The structure trajectory indicates species richness and numbers of trophic links in the food web. We have determined that omnivorous and predaceous nematodes are more sensitive to osmotic and specific ion stresses imposed by fertilizer practices in conventional agriculture. That contributes to the lower structure index in those systems than in undisturbed or low-input systems. We continue to evaluate isothiocyanates, produced through hydrolysis of glucosinolates in the Brassicaceae, for efficacy against plant-feeding nematodes. The studies have provided a basis for optimizing both greenhouse and field investigations of organic amendment of soil to alter the behavior and mortality of nematodes. Through collaborative research with a scientist in Korea, we have developed a better understanding of the concepts underlying the economic threshold when applied to nematodes. The evolving concept allows consideration of the economic consequence of less than 100% efficacy of the nematode management, as often the case in the use of organic amendments. We are developing grape rootstocks with broad and durable resistance to nematodes, a critical problem for California grape growers that is exacerbated by the phase-out of soil fumigants. We have identified five rootstock candidates that exhibit resistance when exposed to three root-knot and one dagger nematode species in combination and eight that exhibit resistance when exposed to the four nematodes individually.
Impact: We continue to identify soil management practices that are beneficial to maintaining and improving soil health and those that are not. Results from our work on organic amendments is to improving the likelihood of success with those approaches in nematode management. Both aspects have significantly improved soil health.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Nematologist Works on Resistant Grape Rootstocks
Description: Grape vines are susceptible to diseases caused by various nematode species, including root-knot, root-lesion, ring, citrus, and dagger nematodes. Research has indicated that root-knot nematode species often adapt to invade previously resistant rootstocks within two to 14 years after planting. Once nematode populations develop the means to exploit one rootstock,

they are then able to attack all the plantings using that rootstock. The damage caused by nematodes is economically significant, resulting in lost fruit and vine vigor for growers.
An Extension Nematologist began in 1987 to characterize existing commercial rootstocks to determine their resistance and vigor levels. A USDA breeder made a cross between two rootstocks, Ramsey, a high-vigor rootstock which offered resistance to endoparasitic nematodes, and Schwarzmann, a low-vigor rootstock with resistance to several ectoparasitic nematodes. For nine years, he evaluated about 800 vines produced from the seeds of the cross. The work identified two superior rootstocks produced by the cross: RS-3, a medium- to high-vigor rootstock, and RS-9, a low- to medium-vigor rootstock.
Impact: The RS-3 and RS-9 rootstocks will be released to California nurseries in spring 2003, with growers expected to have them in two to three years. More than five years of grower field trials have indicated that the rootstocks offer resistance to a broad grouping of nematode species. RS-3 also has proven tolerant to grape fan leaf virus in commercial settings. In addition, the rootstocks offer two choices of vigor level. This is a desired quality because vines with too high vigor for a particular soil can produce fruit and wines of lower quality.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: New Bait Technology Controls Ants in Urban, Agricultural Environments
Description: Ants are the major pests in urban environments. Recent introductions of the red imported fire ant in urban environments in California pose a serious threat to agriculture. Argentine and field ants are a major pest in citrus and grapes, where they tend, or care for, homopteran pests and disrupt biological control. A Cooperative Extension Urban Entomologist and AES Professor of the University of California, Riverside are developing low-toxicity liquid and granular baits as alternatives to insecticidal sprays for ant control. The use of baits is more effective and will substantially reduce the amount of insecticide used in urban and agricultural settings. The reduction of ants in agricultural settings will increase the effectiveness of biological control agents, thereby reducing insecticide applications. They also are developing delivery systems for baits to minimize the exposure of the environment and crops to insecticide.
Impact: Recently the Environmental Protection Agency approved the UCR propoal to register bait stations and toxicants for use in citrus orchards and grape vineyards in California. The clearance covers toxicants not previously registered for use in all fruit, nut, and vine crops throughout the United States.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: New Cotton Varieties Resist Leaf Crumple Disease
Description: Cotton leaf crumple disease (CLCr), caused by cotton leaf crumple geminivirus (CLCrV) and transmitted by the silverleaf whitefly, can substantially reduce seed cotton yield and has been causing damage in Southern California since the mid-1950s. Insecticides provide temporary control of the whitefly, but CLCrV still infects cotton. A long-term solution that offers economic and environmental advantages is needed. Host plant resistance offers an economical, non-polluting alternative for managing CLCr disease in cotton. A team of UC researchers collaborated to develop and screen cotton breeding lines, seeking resistance to CLCr disease. Cultivars and breeding lines were evaluated in field plots from 1999 through 2001 at the UC Desert Research and Extension Center in the Imperial Valley. Cotton entries were rated for

severity of CLCr disease symptoms, and the presence of CLCrV was confirmed through the use of molecular techniques. Significant differences in whitefly infestation levels and virus disease severity were detected among the entries.
Impact: Three CLCr disease resistant varieties have been developed. Our research has given cotton growers in California the option of planting CLCr disease-resistant varieties to prevent yield losses.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: New Developments in Melon Powdery Mildew Management
Description: Powdery mildew of melon is a common problem in all California melon production areas and multiple fungicide applications are used to control it. Resistant melon varieties are available, but plant resistance-breaking strains of this pathogen can render them susceptible. In addition, some fungicides are no longer effective due to the development of fungicide-resistant strains of the pathogen. The most sustainable control strategy integrates the use of varieties with mildew resistance and prudent use of fungicides. In this way, an entire melon producing area is not completely reliant on either approach to control the disease. Also, rotation of fungicides with different modes of action is an important strategy in reducing selective pressure that causes resistance. A search for such fungicides may lead to registration of new materials. This would aid in mildew control and resistance management. In addition, there is a need to assess powdery mildew susceptibility of modern melon varieties in the low desert production area of California. Cooperative Extension Advisors conducted trials comparing both the susceptibility of muskmelon varieties and the effectiveness of new fungicides. In addition, they tested fungicides in rotation to encourage techniques to reduce the likelihood of resistance being developed by the mildew. This information has been made available to California farmers and pest control professionals at field days and in farmers' trade journals and meetings.
Impact: As a result of these UC experiments, new materials are available for use against powdery mildew. Data were submitted to the EPA to help support registration of new fungicides that will aid in preventing development of resistance. One of these materials, Procure, was approved for use in California in January, 2003. Also, melon growers know more about the use of fungicides and resistant varieties to manage the disease. Many farmers are now using fungicide rotation programs. Pest control professionals use information from these trials to select varieties and to choose fungicides. Agricultural professionals from many production regions in California have contacted us regarding these studies.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: New Virus Disease in Melons and Squash Is Identified and Described
Description: In 1991, silverleaf whitefly became a devastating pest of melon and squash crops, destroying 96% of Imperial County's fall melon crop and resulting in an estimated loss to growers of $12.5 million dollars. In succeeding years, the county's fall melon production dropped from approximately 12,000 acres annually to under 2,000 acres. In the late 1990's a related problem arose, a virus plant disease transmitted by the whitefly. This newly developing disease problem and management approaches to deal with it needed investigation. In 1998, a team of UC Cooperative Extension and Agricultural Experiment Station researchers discovered a new geminivirus disease. The next year, a survey showed that the problem was widespread in

cantaloupes in the Imperial Valley and Yuma Valley, but did not infect honeydew melons. In 2000, we identified the new cucurbit-infecting, whitefly-transmitted geminivirus and named it cucurbit leaf crumple virus (CuLCrV). Host range studies at the UC Desert Research and Extension Center showed that CuLCrV infects most squashes, watermelons, cantaloupes and a few other melons as well as gourds, but did not infect honeydew melons, Crenshaw melons, casaba melons and several other melon types in the trial. Surveys of weeds, non-cucurbit crops and whitefly populations showed that (1) the CuLCrV is able to overwinter in the Imperial Valley, (2) weed species tested are not hosts of CuLCrV and (3) beans are a host. We also determined that CuLCrV is present in the Coachella Valley and Palo Verde Valley in Riverside County and Arizona. We determined that silverleaf whitefly is the vector of CuLCrV with the help of a USDA ARS researcher in Salinas, CA.
Impact: Our research increased the awareness of squash growers, melon growers and pest control advisors (PCAs) about this new disease and how it is spread by silverleaf whitefly. As a result, growers and PCAs now know which melon and squash types and species are susceptible to damage from CuLCrV disease. Growers use this information in making important management decisions.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Non-Chemical Strategies for Managing Plant-Parasitic Nematodes
Description: To identify relationships between pre-plant levels of selected plant-parasitic nematode species and the performance of selected crop varieties. To evaluate factors (plant factors, nematode distribution, environmental factors) that may influence the relationship between pre-plant nematode levels and plant growth. To develop or modify sustainable and economically feasible nematode management strategies with an emphasis on vegetable and ornamental crops. We showed earlier in greenhouse experiments that plants that are older at time of nematode attack are much more tolerant. We are currently evaluating these results under field conditions. To simulate the attack o plants at different stages in their development, three treatments were applied to field grown melon plants: 1) plants were inoculated in the field at seeding or at two, four, or six weeks after seeding; 2) plants were inoculated at seeding but the nematodes were added at different depths (5, 25, and 50 cm under the seed), and 3) nematodes were "eliminated" from the plants at seeding, or two, four or six weeks after seeding by drenching the soil around the plants with oxamyl. The initial results from these experiments indicated that delaying nematode inoculation (1) and adding nematodes at different depths (2) had a strong effect on fruit yields. Our preliminary conclusions from these experiments are that most of the damage occurs within the first two to four weeks after seeding, and that nematodes in the upper 25 cm of the soil are the ones that are almost exclusively responsible for yield reductions. These experiments will be repeated in the coming year. The first round of experiments on the susceptibility of Lisianthus to root-knot nematode species was repeated last year in a set of greenhouse experiments. Previous results showing that Lisianthus is a host to all of the three tested root-knot nematode species (M. hapla, M. inocgnita and M. javanica) were confirmed. Experiments were initiated to study the possibility to avoid root-knot nematode damage in two vegetable crops (tomato and melon) by grafting susceptible varieties onto nematode resistant rootstocks. Results with tomato were unexpected: tomato grafted onto a "resistant" rootstock yielded ca. 1.5 times as much as the non-grafted tomatoes. The levels of nematode reproduction on the resistant and susceptible rootstocks however were not significantly different and severe galling was observed on the "resistant" rootstock. The reasons for the failure

of this rootstock to suppress nematode reproduction is being studied. Melon plants grafted on resistant rootstocks also yielded more than melons grown on their own susceptible rootstock. Total (root+stem+fruit) fresh plant weights of the susceptible plants did not change under increasing nematode populations. The lack of fruit production under high nematode infestation levels was compensated by the very strong increase in root weight (severe and large galling).
Impact: Our research on interactions between plant development and nematode attack demonstrates that, in order to avoid yield losses in annual vegetables, plants do not necessarily need to be protected from nematodes throughout the growing season. This would increase the potential for partially or temporarily effective control strategies such as soil solarization, mulching, etc. Our continued research on the cut flower Lisianthus benefits growers directly as it will make them aware of nematodes being a potential problem in this crop. Finally, our research on vegetable grafting indicates that this allows vegetables to be grown under relatively high nematode populations without compromising yield, but it also shows that a reduction in nematode densities will not necessarily occur, specially when initial populations are high.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Pest Control Advisor Advanced Training
Description: Pest control advisors (PCAs) in California are college-educated professionals who examine agricultural fields and recommend control measures for crop pests. They help to ensure a plentiful, high-quality crop at harvest time. UC researchers are constantly developing new pest management techniques and PCAs are challenged to stay current with these developments. Although PCAs are well trained and spend much of their time in the field, they can become overwhelmed by the amount of new information. UCCE advisors occupy a pivotal role in educating PCAs, ensuring that agricultural professionals are aware of the latest pest management tools and techniques as quickly as they are developed. Farm advisors inform PCAs of recent science-based developments through meetings, newsletters, e-mails and personal contact.
In Imperial County, 'Ag Briefs' are published monthly to keep PCAs aware of timely issues that can affect them. To address more urgent needs, UC advisors put information into Pest-O-Gram, a newsletter tailored for professional crop consultants. In addition, some advisors make information available to the growers electronically via the Internet. Integrated Pest Management information crop by crop is posted on our website http://ceimperial.ucdavis.edu
Impact: The PCAs receive information about UC variety trials regarding pest resistance and the most environmentally sound methods of pest control available. In addition, PCAs are briefed on the biology and life cycle of plant pests. In this way, the PCA can best judge when a pest will cause damage to a crop and when to make a recommendation to avoid damage. Just as important, PCAs will be able to judge when a treatment is not necessary.
The PCA also is informed of the danger of pesticide resistance to chemicals. He or she can learn which materials are most at risk of becoming useless, and how to reduce the likelihood of developing a resistant pest that cannot be controlled.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Pest Management Alliances Lead to IPM Adoption
Description: Farmers are facing increasing regulation of pesticides, in part the result of environmental concerns about pesticides in water supplies and health effects on farmworkers.

UC IPM (Integrated Pest Management) advisors have been leaders in many of the Pest Management Alliance (PMA) projects funded by the California Department of Pesticide Regulation to develop and demonstrate pest management systems that reduce pesticide risks. The Almond Alliance established long-term demonstration/education sites in Butte, Stanislaus and Kern counties to show growers that reduced pesticide spray programs work. For four years, no sprays were applied in some of these orchards and reduced-risk (less pesticide) sites showed no increase in damage at harvest. Pesticide use in almonds went down, with a 20% reduction in 2001 alone. The key to the program is winter sanitation, a practice that UC IPM has been promoting for 20 years. In prunes, the Pest Management Alliance focused on developing and demonstrating sampling plans and treatment thresholds that help growers determine whether sprays are needed for each economically damaging pest. A major goal is to reduce dormant sprays. For two years, the Alliance compared a five-minute search of mite populations to the more time-consuming presence-absence sample technique. This research showed that the two methods are highly correlated, resulting in PCA acceptance of the simpler, faster five-minute search technique. The Walnut PMA has worked closely with researchers to refine pheromone techniques for controlling codling moths. The Alliance has (1) developed monitoring protocols to help growers and PCAs determine when the pheromone confusion technique requires supplemental sprays,(2) worked with researchers to learn how to use the new bi-sexual lure and (3) field-tested and learned how to use a walnut blight model, XANTHOCAST.
Impact: Almond growers have reduced their total pesticide use by 65% since 1990. The California Almond Board attributes much of this to the results of the almond PMA. Prune growers have been able to reduce their overall pesticide use by 34%. Results of the Walnut PMA's demonstration of reduced-risk practices on 30,000 acres indicate that walnut growers will be able to reduce their insecticide use by 75%.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Pheromone Mating Disruption in Peach Orchards
Description: The two key insect pests of cling peaches, oriental fruit moth and peach twig borer, are conventionally controlled with broad-spectrum toxic insecticides. These sprays can create problems such as contamination of surface water due to runoff from orchards, development of pest resistance from overuse, and safety concerns for field-workers and pesticide applicators. Because peaches are one of the top 20 foods consumed by infants and children, eliminating pesticide residues is also an issue. In 1987, pheromone mating disruption became available as an alternative to broad-spectrum sprays for controlling oriental fruit moth in peaches. In 1995, the first pheromone product to control peach twig borer became commercially available. However, adoption of these new pest management strategies depended on convincing growers and pest control advisors that the new appro aches can control targeted pests and are economically competitive. Over the past few years, on-farm demonstrations by UCCE researchers statewide have implemented pheromone-based integrated pest management programs. Pheromone mating disruption was more recently demonstrated at several farms through the Peach Pest Management Alliance and implemented with Gerber baby food growers. Various strategies have been developed for integrating pheromones with sprays to lower costs while still reducing insecticide use. Economic comparisons have documented cost differences between the conventional and reduced-risk programs.
Impact: In 2003, about one-third of all peach growers in the Sacramento Valley are using some form of pheromone product for pest control. As one result, the potential of insecticide residue in

peach baby food has been greatly reduced. Effectiveness and desirability of this pest control method is demonstrated by the Natural Resources Conservation Services (NRCS) providing cost share funding for growers using pheromone mating disruption in 2004.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Pheromones for Sampling Major Mealybug Pests of Vineyards and Tree Fruits
Description: Objectives: 1.To identify and synthesize pheromone components of the four most important mealybug pests in North American vineyards, the grape, vine, obscure, and longtailed mealybugs. 2. To conduct all field studies required to develop economical and practical pheromone-baited traps and trapping protocols for monitoring the four target mealybug species. 3.To facilitate the implementation of pheromone-based trapping for monitoring mealybugs through transfer of technology to PCA's, farm advisers, grower groups, and companies that manufacture pheromone products. The sex pheromone of the vine mealybug Planococcus ficus has been developed for use in traps for sampling mealybug populations. All operational details, such as dose, trap type, field longevity of lures, etc. have been worked out, and pheromone-baited traps were used in a statewide survey for this pest in California during the 2002 growing season, carried out under the direction of project collaborators. In particular, the pheromone baited traps were able to detect low-level infestations of vine mealybug that had escapted detection by manual sampling methods at numerous locations. Many of these infestations are relatively small and isolated, and project collaborators are developing methods of eradicating these small scale and localized infestations before they spread further. Furthermore, a preliminary trial using a sprayable pheromone formulation for mating disruption of vine mealybug gave promising results, with trials to be greatly expanded in the 2003 growing season. Identification of the sex pheromones for grape, obscure, and longtailed mealybugs are underway, with laboratory colonies of all three species established. One of these pheromones have now been tentatively identified and awaits synthesis, and both of the other pheromones now have been partially identified. For the latter two pheromones, pheromone collections are being made to provide sufficient material for completing the identifications.
Impact: Since its introduction into California less than 10 years ago, the vine mealybug has rapidly become one of the most important vineyard pests in table, wine and raisin grapes. The sex pheromone baited traps developed in our research group have provided a simple and highly sensitive method for detecting new populations of this insect as it continues to spread, and for monitoring population cycles in areas where the vine mealybug is now entrenched. The traps have been the cornerstone of a statewide survey for this insect, and the pheromone is now commercially available from at least 3 companies in the US, and at least 2 companies in other countries.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Phytobacteriology and Bacterial Disease Control
Description: Objectives: 1. Investigate the etiology of new bacterial diseases, improve methods of diagnosis, and develop methods of disease control. 2. Investigate mechanisms of virulence in bacterial plant pathogens, especially in Xylella fastidiosa and Erwinia chrysanthemi. 3. Investigate mechanisms of biological control with beneficial bacteria and develop strategies for competitive exclusion and inhibition of pathogens from plants and insect vectors. As part of

ongoing collaborations with University of California county advisors, we identified and characterized a new bacterial disease of spinach, caused by a non-fluorescent strain of PSEUDOMONAS SYRINGAE. The disease occurred in the Salinas Valley of California in 2000 and 2001 and consisted of leaf spots that coalesced to cause death of large areas of leaves. The causal organism was isolated, and Koch's postulates were completed to prove its pathogenicity on spinach. Fatty acid methyl ester analysis indicated that the spinach strain was most closely related to P. SYRINGAE pv.MACULICOLA, although there were differences in carbon source utilization between that pathovar and the spinach strain. Inoculations of the spinach pathogen to hosts of P. SYRINGAE pv.MACULICOLA (cabbage and cauliflower) were negative, and only the spinach strain caused leaf spots of spinach. In addition to this study, the the majority of our efforts were directed toward Pierce's disease of grapevine. Pierce's disease of grapevine and other leaf scorch diseases caused by XYLELLA FASTIDIOSA are associated with a gummy matrix, thought to be xanthan gum, and subsequent blockage of water uptake. We began to isolate endophytic bacteria that produce xanthan-degrading enzymes to target this specific virulence factor of X. FASTIDIOSA. For enrichment of xanthan-degrading bacteria, it was not feasible to produce enough xanthan gum for our studies from XYLELLA. Instead, we genetically modified a strain of XANTHOMONAS CAMPESTRIS to produce xanthan gum with the same chemical structure as that from XYLELLA. We used the modified xanthan gum from the XANTHOMONAS mutant as the sole carbon source for enrichment culture from surface-disinfected diseased grapevine stems and oleander with leaf scorch disease. Eleven strains were confirmed to effectively degrade xanthan gum. Six of these had low or non-detectable cellulase activity and will be further tested for biological control efficacy in plants. Another approach we are pursuing for control of Pierce's disease is to construct non-pathogenic mutants of the Pierce's disease pathogen to be used in a competitive displacement strategy. We are employing a systematic process of identifying which virulence genes are important for disease expression but are not essential for colonization of plants in a nonpathogenic state. Knock-out mutations in selected genes were created through homologous recombination in XYLELLA, and these are being tested in grapevines. Another project has been to identify the alternative sources of inoculum for Pierce's disease in the Temecula Valley by repeatedly sampling other plant species in agricultural, landscape, and natural areas adjacent to vineyards. In addition to grapevine, several plant species harbored significant populations of XYLELLA, and studies to characterize these strains and investigate insect transmission to and from these plants are underway.
Impact: Knowledge of the cause of a new disease, such as the spinach leaf spot disease, is essential for the design of control strategies, such as seed treatments or other means of reducing the introduction of a bacterial pathogen into a field. The development of biological control agents for Pierce's disease, through isolation of xanthan-degrading endophytes or the construction of non-pathogenic derivatives of XYLELLA, offers the potential for a relatively near-term strategy for reducing the damage that the bacterium causes to grapevines. Knowledge of the source of disease inoculum for Pierce's disease is critical to the choice and management of plant species surrounding vineyards.
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: Objectives: 1) To understand the role of receptor protein/plant virus protein interactions in acquisition and pathogenesis of persistent, circulative, propagative viruses (using tospoviruses and thrips as a model). 2) To explore diversity in semi-persistent, foregut-borne

viruses, with special emphasis on how viral components and insect vectors interact to mediate virus acquisition and transmission and virus phenotype (using aphid transmission of CTV as a model). 3) To determine the role of MI-mediated resistance in virus transmission by avirulent insects. This project was revised October 1, 2000. 1) During our investigations of putative thrips receptors for tomato spotted wilt virus (TSWV) we discovered a symbiotic bacteria in the western flower thrips hindgut. Preliminary results from far western blotting suggested a direct interaction between TSWV and the bacteria. We have explored this possibility and learned that bacterial proteins specifically bind antibodies against TSWV membrane glycoprotiens (GPs), anti-idiotypic antibodies against monoclonals to the GPs and antibodies against the non-structural protein from the TSWV middle RNA (NSm). The interaction between these serological tools and the bacteria allowed us to reveal very serious artifacts in some previous work and have stimulated us to completely alter our research strategies. In addition, we have obtained purified, his-tagged GPs from a baculovirus expression system (German laboratory, University of Wisconsin) and tested their interaction with the bacteria. These results are not yet complete, but should help us to determine whether any direct interaction occurs between the virus and the symbiotic bacteria. We are beginning the process of making a new thrips library and will use the his-tagged GPs for screening in the next year. 2) We have completed a detailed virus population structure study on our citrus tristeza virus isolate collection that reveals that aphid transmission can both narrow an increase genetic diversity of virus populations. We have also identified a highly conserved region of the virus genome that is associated with transmissibility of isolates. Further exploration of the role of the sequences in aphid transmissibility is underway. 3) We have completed our research on Mi. We have shown that aphid biotypes rapidly adapt to this resistance gene, Mi expression does not determine susceptibility to aphid populations and loss of resistance is not due to gene silencing. Lastly, Mi does not seem to mediate reduced transmissibility of plant viruses, although we may need to explore this further.
Impact: We have shown how thrips symbiotic bacteria may influence virus acquisition and create artifacts for tospovirus researchers. We have shown that aphid transmission of citrus tristeza virus can act both as a bottleneck and as a mechanism for increasing virus genetic diversity. Thus, aphid transmission is an important selective force in epidemics. Our findings with Mi are important to design of resistant plants and are in use by the biotechnology industry.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Population Biology of Nematophagous Fungi: Mortality, Efficacy, and Formulation
Description: Determine whether organic amendments stimulate biological control by endemic or introduced nematophagous fungi. Determine whether amendments with a high carbon:nitrogen ratio stimulate trapping by the fungus Arthrobotrys oligospora. Determine susceptibility of bacterial-feeding nematodes to nematophagous fungi. Determine whether population densities of nematophagous fungi correlate with biological control of nematodes Determine whether soil pH correlates with biological control by Hirsutella rhossiliensis in a range of soils.
Soil cages were used to determine whether the population density of nematode-trapping fungi, as measured by most probable number procedures, was correlated with trapping of nematodes. The fungi studied produce adhesive knobs (Dactylellinia ellipsospora and D. haptotyla), adhesive networks (Arthrobotrys oligospora and A. eudermata), or constricting rings (A. dactyloides). The fungi were added to field soil as dried alginate pellets containing assimilative hyphae. The soil was packed into segments of PVC pipe, which were covered on one end with mesh (480-

micrometer pore size). Two segments were taped together to form one cage containing 80 cubic centimeter of soil and 0 - 16 pellets, with mesh covering the outer ends. The cages were buried in vineyards and recovered after 15 - 61 days. One segment of each cage was used to determine fungus population density and the other segment was used to estimate trapping activity. For all five fungi, population density was correlated with the number of pellets added, but population densities were largest for A. oligospora and D. haptotyla, intermediate for D. ellipsospora and A. eudermata, and smallest for A. dactyloides. The correlation between population density and trapping was relatively strong for D. haptotyla and D. ellipsospora but weak for A. dactyloides. In the cases of A. oligospora and A. eudermata, there was no correlation between population density and trapping because these fungi trapped few if any nematodes in soil.
Impact: Nematode-trapping fungi are common but relatively little is known about their population biology in soil. To understand the potential of these fungi as control agents of nematodes that attack plant roots, we need methods to quantify their numbers or biomass in soil. The most probable number method provided data that predicted trapping activity of three of five fungi. Concerning biological control of plant-parasitic nematodes, the data for D. haptotyla and D. ellipsospora were encouraging because the most probable number procedure seems useful for predicting trapping and because large numbers and activities were obtained by adding fungal inoculum to field soil in a near field environment. Field soil is generally considered resistant to the introduction of nematode-trapping and other fungi, but establishing large numbers and high levels of activity is clearly possible.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Population Dynamics and Genetics of Cyst and Root-Knot Nematodes in Sustainable Cropping Systems
Description: Objectives: 1. Quantify the effect of poor hosts and resistant plants on nematode population dynamics. 2. Measure the population dynamics of H. schachtii (SBCN) and Meloidogyne spp. (RKN) after selection on resistant plants. 3. Assess the genetic variation in field populations of SBCN and RKN. 4. Compare genetic markers in resistance-selected populations of SBCN and RKN with parent field isolates. Experiments continued during the year to assess the efficacy of broccoli mulch as a biofumigant to manage the plant-parasitic nematode Heterodera schachtii. Field trials were conducted to assess the efficacy of broccoli biomass to reduce nematode populations. Experiments are conducted as randomized complete blocks with 4 replications per treatment. Each harvestable plot consists of 10 feet of a single row (with 5 foot buffers on all sides of each plot to avoid edge effects and effects caused by soil movement during tillage). Treatments are: 1) control (no broccoli soil amendment, although roots of previous broccoli crop remain in place), 2) No broccoli with tarp; 3) 2x broccoli shoot residue; 4) 1X broccoli shoot residue; 5) 1x broccoli shoot residue with tarp; 6) 2x broccoli shoot residue with tarp; 7) 1x broccoli plus Telone (rate of 9 GPA-current standard practice). The basic experimental protocols are as follows: (1) The broccoli crop is planted, grown, and harvested according to commercial scheduling; (2) Following harvest, the crop remains are mechanically chopped in situ with commercial equipment; (3) The crop residue is moved by hand among plot units as necessary to achieve appropriate treatment rates for residue (0x or 2x the biomass per unit area in the biomass production areas - 1x is normal residue and does not require movement); (4) Plots are disced and bedded with commercial scale equipment, and soil samples are collected for nematodes; (5) Fumigant and tarp are applied by hand to appropriate treatments; (6) After three weeks the tarps are pulled, soil samples collected for each treatment, and the entire area

planted to broccoli; (7) At the appropriate time (depending on the time of year, the length of time to maturation will vary) the crop is harvested, yield data recorded from ten feet of a single row, and post-harvest nematode soil samples taken. This research is ongoing. We also assessed the influence of the potential biological control bacterium L. enzymogenes strain C3 on the bacterial-feeding nematode Caenorhabditis elegans and the plant-parasitic nematodes Heterodera schachtii and Meloidogyne javanica. Exposure of C. elegans to commercial chitinase resulted in five times fewer progeny juveniles than without chitinase. Exposure of C. elegans to L. enzymogenes strain C3 on agar gave almost complete elimination of egg production and the death of 94 percent of hatched juveniles after two days. The hatch of H. schachtii eggs placed on L. enzymogenes growing on agar was about 50 percent as compared to 80 percent hatch of eggs placed on E. coli growing on agar, and hatched juveniles died as the cuticle and body contents disintegrated. Exposure of Meloidogyne javanica juveniles to a seven-day old broth culture of L. enzymogenes for four days resulted in the death of juveniles. The death and disintegration of juvenile nematodes suggests that the proteases and lipases previously reported for this strain have activity against plant-parasitic nematodes.
Impact: Approximately 25 percent of nematicides in California are for reduction of cyst nematode in Cole crops. This research may reduce pesticide use by defining biofumigation with plant biomass, or biological control possibilities. These may be alternatives to chemical control, but the nematode control reductions will likely be less than with nematicides.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Precision Technology, Institutional Change, Productivity, and Environmental Quality in Agriculture
Description: Objective: Develop a modeling framework to analyze the economics of precision technologies at the farm level, analyze the diffusion of precision technologies, and design policy interventions to meet the environmental policy objective in a cost-effective manner through adoption of precision technologies. This work developed optimal crop barrier strategies to control pest problems (Pierce's Disease) that are transmitted by vectors. We showed that selection of barrier crops and their size have to adjust to differences and prices of vulnerable crops, the revenues from the barrier crops, and the dynamics of the pest movement.
Impact: The results of this project developed a strategy that enabled growers to more effectively control Pierce's Disease in Napa Valley. This effort also provided government agencies with information necessary to assess programs such as EQIP (Environmental Quality Incentives Program) that subsidized environmentally friendly practices.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Proper weed identification is essential for control
Description: Weeds play a major role in California crop production, costing growers millions of dollars annually. More than 250 plants are considered weeds, each with its own particular life cycle, growth habit, mode of reproduction, competitiveness and susceptibility to chemical or mechanical control. With so many crops grown in the state and the vast number of weed types, it is obvious that no one control program will work for all growers or in all situations. This means that farmers, pest control advisors (PCAs), managers and others involved in weed control must be able to identify the weeds that are present before deciding which management or control

strategies to use. A workshop at UC's Kearney Agricultural Center trained growers, PCAs and others on weed identification and how to devise strategies for control. UCCE farm advisors and a specialist shared information in a way that encouraged interaction between the more than 120 participants and the instructors, promoting a high level of participation.
The event included a weed identification quiz and discussion on how to correctly identify weeds according to specific characteristics, growth habits and life cycles. Cost-effective modes of control for various orchard and vineyard settings were also discussed.
Impact: Understanding the importance of being able to properly identify weeds before deciding on methods of control is the essential first step in effective weed management. Numerous positive comments confirming this fact were received from the participants during the day. A survey showed the hands-on weed identification part of the workshop was rated as very valuable. Due to the success of this event, future weed workshops will be held on both the east and west side of the valley, covering both annual and perennial crops.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Reduced Use of Fungicides in Vineyards of the San Joaquin Valley
Description: Powdery mildew is the number one grape disease in California. The most common fungicide used to control it has been sulfur. Typically, growers have applied sulfur and/or other fungicides on a calendar schedule--meaning that every seven, 10 or 14 days something is applied to control the fungus. Since the early 80's new fungicides have become available to growers every few years. However, we learned in the mid 80's that new materials also can bring new challenges such as fungal resistance. The first of the new fungicides lost its efficacy against grapevine powdery mildew within three years. Growers went back to using sulfur, exclusively or in combination with other new chemicals, on a calendar schedule. Growers like sulfur because of its low cost, ease of application and lack of powdery mildew resistance. But the exclusive use of sulfur also has downsides such as shorter application intervals, phytotoxicity, eye and throat irritation, and air quality and drift issues. Most of the problems associated with sulfur can be remedied by implementing the UC Davis Powdery Mildew Risk Index (PMI). The PMI, based on optimal temperatures for powdery mildew growth, helps growers determine the best time to apply fungicides. It has been used extensively in most California grape growing regions, except for the San Joaquin Valley where growers have been slow to integrate PMI into their powdery mildew control programs due to lack of available data. This year, Fresno and Madera County farm advisors held a series of meetings for San Joaquin Valley grape growers, focusing on powdery mildew biology, chemical control methods, fungicide resistance, sulfur drift issues and the PMI. Growers were shown how to access, organize and calculate the PMI, using weather data from the Fresno-Madera Weather Network. They developed spray programs using fungicides of their choice and weather data from the 2002 season.
Impact: San Joaquin Valley grape growers implemented the PMI into their 2003 fungicide spray programs. Most compared a spray program using the PMI to a normal calendar spray program, using a small section of their vineyard. Others have committed entire vineyards. (A grower farming 40 acres of grapes can save $128, $263, or $667 by eliminating a single application of dusting sulfur, wettable sulfur or sterol inhibitor (fenarimol), respectively.) Many growers have already eliminated three sprays during the 2003 growing season, with substantial savings in time and money besides improving air quality and reducing spray drift.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Refinement of Arthropod Economic Thresholds on Field Crops California
Description: Objectives: 1. To investigate the utility of and the optimal fit of reduced risk insecticides in arthropod pest management of field and vegetable crops. 2. To investigate the influence of crop production practices on arthropod pest populations and the feasibility of optimizing some of these practices as cultural controls; the influence of the practices on the arthropod population densities and on the plant response will be studied. 3. To characterize the effects of arthropod-induced injury on plant gas exchange parameters such as photosynthetic rate, stomatal conductance, intercellular CO2 concentration, respiration, hydraulic conductance, water potential, leaf temperature, light response and assimilation-CO2 concentration response. Research was conducted in 2002 on damage and treatment thresholds for beet armyworms in sugarbeets and spider mites in field corn. Seven treatments replicated in sugarbeet plots included an undamaged control plus complete plant defoliation one, two, three, and four months before fall harvest; three additional treatments were multiple defoliations. Artificially defoliated treatments had lower tonnage and sucrose percentage than the control. Multiple defoliations led to reduced yields compared to plots receiving single defoliations. The later the defoliation, the less effect it had on yield. Sucrose percentage was lower in plots defoliated 2 or 3 months before harvest than in plots treated 1 or 4 months before harvest. Yield losses were the result of increased root rot incidence and smaller beets. Harvest data on tonnage and sucrose percentage were collected from 7 different field trials in 2001 and 2002 utilizing natural defoliation from BAW. Each trial had plots with BAW suppression, untreated plots, and some had plots with insecticide-induced BAW outbreaks. Insecticides for BAW suppression did not cause a statistical increase in tonnage or sucrose percentage when compared to the untreated control. In 2001, there was a positive relationship showing that increased BAW densities resulted in increased root rot incidence. Root rot incidence in 2002 was very low, resulting in no such relationship. Management of BAW under the conditions at the West Side REC in 2001 and 2002 was unnecessary. However, BAW densities in commercial sugarbeet fields in 2001 and 2002 were higher than those in these research plots. In cases where larval control is needed, Successr reduced the population to the greatest degree. Lorsban and Lannate provided suppression through the 2nd BAW flight, but resulted in higher BAW densities than the control after the 3rd BAW flight. Applications of Asana resulted in BAW densities consistently higher than the control. On field corn, under California conditions, silage yield is fairly tolerant of spider mite injury. For instance for the Yolo Co.-Davis site, the early-season mite days ranged from 350 for the avermectin-treated plot to 3900 for the plots infested with mite contaminated leaves. This was a moderately heavy infestation and the treatments altered the mite population as desired. Silage yields (39.2 to 43.6 tons/A) and grain weight (0.18 to 0.2 oz./50 ears) did not differ significantly among the treatments.
Impact: Decision threshold are a critical component of integrated pest management systems. These values are dynamic and vary with changing agricultural practices, such as improved varieties, production practices, management options, etc. Therefore, it is imperative that these thresholds be updated in order to optimize management strategies and cost:benefit relationships.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Reflective Mulch Enables Fall Vegetable Production Without Pesticides

Description: In the San Joaquin Valley, production of fall vegetables, particularly squash, cucumbers and pumpkins, is severely hampered by several aphid-transmitted virus diseases and also by the silverleaf whitefly. Attempts to control the virus disease vectors with insecticides have proven unsatisfactory. Silverleaf whitefly management with chemicals also has not been very effective and the whitefly can rapidly develop resistance to all classes of insecticides.
UC scientists took advantage of the fact that both aphids and whiteflies are repelled by ultraviolet light. At the Kearney Agricultural Center, two researchers used reflective mulches (polyethylene covered with a thin layer of aluminum) to reflect incoming ultraviolet light back toward the sky, thus repelling aphids and whiteflies attempting to land on plants. When plant foliage finally covers 60-70% of its surface, the mulch ceases to be effective. At this point, however, many plants have reached maturity and can better tolerate disease. In most situations, yields are nearly as high as in non-diseased plants. In addition to reducing aphid and whitefly numbers and the incidence of virus diseases, plastic mulches retard weed growth, conserve soil moisture and promote improved soil nutrient absorption.
Impact: Reflective mulches have decreased the incidence of non-persistent, aphid-borne viruses in cantaloupe, squash, cucumber and pumpkin by 75-85%. In addition, the initiation of disease symptoms is delayed up to four weeks. The buildup of whitefly numbers has been significantly delayed in these crops as well. On pumpkins and cucumbers, whitefly density on plants growing over reflective mulch was reduced 10 to 14-fold compared to plants growing over bare soil. Thus, the use of reflective mulch permits the production of disease- and whitefly-susceptible crops during late summer and fall without using insecticides.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Research and Video Explain Husk-Fly Control To State's Walnut Growers
Description: California walnut growers were having increasing difficulty both monitoring walnut husk fly and controlling it with chemical treatments. Walnut husk fly damage was causing high off-grade on many deliveries despite up to three chemical treatments in a season. Local growers requested help on how to better monitor this pest, how to time chemical treatments and how to achieve control with a minimum number of applications.
A research team including the Butte County UCCE walnut farm advisor, an area UCCE IPM advisor and a Cal-State, Hayward, professor investigated the problem. Through replicated trials, the team and four UC field assistants discovered a better trap for monitoring the flies and an improved technique for timing treatments. In further replicated trials, chemicals were evaluated by applying treatments only when needed according to the new timing information.
All chemicals tested did an adequate job of pest control with no more than two applications. These research findings were validated across the state in 15 orchards in cooperation with seven UCCE farm advisors and three UCCE Area IPM advisors. A peer-reviewed, educational video of the new findings and biology of the pest was made by UC Communication Services, using a script developed by the Butte County farm advisor and Area IPM advisor. A quiz and a "Frequently asked Questions" brochure were also developed as handouts. Each farm advisor with walnut responsibility received a video to use in his/her walnut program. Seven field days attended by 200 growers featured the new research results. In addition, the video was shown at 11 local meetings to 1,500 producers and to hundreds of pest control advisors. Each attendee received a brochure. Project information also is included in "UC IPM Pest Management Guidelines: Walnuts."

Impact: This UCCE project has resulted in satisfactory control of the walnut husk fly with fewer pesticide applications than in the past. Growers now have a better understanding of the fly's biology and why and when it needs to be controlled. They also have an improved, commercially available trap for monitoring flies, and information on how to best time treatments and keep them at a minimum. The trap, "Pherocon AM Trap", is now the standard walnut husk fly trap and is used by virtually every grower monitoring this pest.
Quiz scores after viewing the video have improved 80%. UC Communication Services has sold nearly 100 copies of the video.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: The Role of Biological Control in Urban Pest Management Systems
Description: Objective: To continue development of biological control methods for the eugenia psyllid, especially in cooler coastal locations in California, To develop and implement an integrated pest management program for elm leaf beetle in a large urban area with many elms (Sacramento), To determine food stress interactions between the Argentine ant and urban tree dwelling Homopterans in relationship to home invasions, and develop integrated pest management techniques for reducing home invasions by Argentine ants. Eugenia psyllid biological and cultural control: Sampling continues at 4 plots in a coastal area of Alameda County. Peak eugenia psyllid adult levels in 2002 again increased from 2001 in sticky trap catches in 3 of our 4 plots. The plot with the highest increase was heavily pruned in the 2000-2001 period, resulting in much new foliage that this psyllid favors. Parasitoid levels lagged psyllid levels until mid-June, and then parasitoids appeared to control the psyllid from July-December. We continued sampling foliage to determine how parasitism is affecting populations in these plots. Six additional plots were established in Alameda County to test the effect on psyllid leaf curl damage of pruning time and not removing pruned leaves to conserve natural enemy populations. Preliminary 2002 results show high rates of parasitoid emergence from pruned foliage for 6 weeks and confirm the low survival rate of psyllids on prunings. If successful, the proposed method could save landscapers time and money while mitigating damage. We continue to monitor plants to quantify the damage reduction. Red gum lerp psyllid: Weekly monitoring for adults using sticky traps continued on 29 sites in 17 counties throughout the state. Spot checks continued at sites with releases and other sites. We have released more than 43,000 Psyllaephagus bliteus parasitoids in 57 sites throughout California. Recoveries of the parasitoid in traps, confirming establishment, were made in all release sites with traps, and parasitoids have been detected in 30 counties. At all sample sites where long-term data is available, psyllid female adult counts have dropped in 2002 by 37.1 percent from average counts in the year before the parasitoid was established. Most of the areas with improvement are near the coast, with the southern California coast having the largest improvement (2002 average psyllid level was 21 percent of 2000 level). In inland sites the parasitoids are just becoming established, and are not yet significantly affecting psyllid populations. The spotted gum psyllid and lemon gum psyllid: We are continuing cooperation with Disney Corp. and the city of Anaheim, CA to monitor these psyllid populations in 5 plots, using sticky traps weekly and foliage sampling every three weeks for immature stages. We expanded sampling to plots in Lakewood, Los Angeles County, and Buena Vista, San Diego County. We explored in Australia in early 2002 for biological control agents, and identified one potential candidate, Psyllaephagus hirtus, however it has not been successfully been reared for release. A return trip to Australia in early 2003 will collect more of this promising biological control agent.

Impact: Biological control of red gum lerp psyllid in coastal California areas is reducing tree mortality and use of pesticides. Use of this biological control strategy will continue to reduce pesticide load on the environment, costs for pesticide, and costs for removing and replacing dying and dead trees.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Signaling Pathways that Control Virulence in Fungal Plant Pathogens
Description: Objectives: 1. Obtain cosmid or bacterial artificial chromosome (bac) DNA clones for six novel G protein coupled receptors (GPCR's) from N. crassa, and use these clones to create gene replacement (null) mutants. 2. Analyze defects of GPCR null mutants. 3. Create N. crassa strains deleted for multiple GPCR's and analyze for defects. 4. Determine the G protein(s) downstream of each receptor. 5. Identify target genes regulated by GPCR's using transcriptional profiling. Previous work from our laboratory and others has implicated heterotrimeric G protein signaling pathways in fungal development and virulence. Our project is focused on the identification and characterization of cell surface G protein coupled receptors (GPCRs) in the filamentous fungus Neurospora crassa. Our progress during the past year for each objective is detailed below. Objective 1) We have identified cosmid clones for the two pheromone receptors, a putative carbon sensor and three novel GPCRs that share limited similarity with cAMP receptors from the protist slime mold Dictyostelium discoideum using sequence and clone information at the Whitehead Institute Center for Genome Research website (http://www-genome.wi.mit.edu/annotation/fungi/neurospora/). We designed primers for amplification of 5' and 3' flanking regions in order to create gene replacement/deletion constructs for each of the six genes. We have now obtained deletion mutants for four of the genes (one pheromone receptor, the carbon sensor and two of the putative cAMP receptors) by transformation of wild type with the deletion construct. Objective 2) We have performed phenotypic analysis on the four gene replacement mutants. The pheromone receptor (pre-1) mutants are normal during vegetative growth, but exhibit mating type-specific female sterility during the sexual cycle. Strains lacking the putative carbon sensor gene (gpr-4) have defects in conidiation. Analysis of these mutants is ongoing. Mutants lacking one of the putative cAMP receptors (gpr-1) have defects in perithecial (fruiting body) formation that follows fertilization and meiosis. Strains mutated for another putative cAMP sensor (gpr-2) are phenotypically indistinguishable from wild type. However, defects similar to those observed for gpr-1 single mutants are observed in gpr-2 null strains after introduction of a mutation in the adenylyl cyclase gene, cr-1. These results suggest that GPR-2 and CR-1 regulate distinct signaling pathways, both of which are impacted by GPR-1. Objective 3) We have created strains mutated for both the gpr-1 and gpr-2 genes. These mutants have more severe perithecial defects than gpr-1 or gpr-2 cr-1 strains and are unable to shoot ascospores. Objective 4) Female fertility can not be restored to pre-1 pheromone receptor null mutants by introduction of a constitutively-activate allele of the G-alpha subunit required for female fertility in N. crassa, GNA-1. Thus, activation of the G-alpha subunit is not enough to trigger perithecial formation in a receptor null mutant.
Impact: Fungi are important pathogens of plants, and it is of fundamental importance to understand how pathogenic fungi recognize and then damage plant tissues. We are characterizing cell surface proteins in fungi that are important for fungal development and that have also been implicated in mediating early responses of fungi to plants. Once the proteins and the molecules that bind to them are identified, it should be possible to develop novel inhibitors that would

block the ability of the fungus to detect and/or invade plant tissue, thus combating disease and increasing crop yield.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Stink Bug Pheromone to Reduce Reliance on Orgonophosphates in Progessing Tomatoes
Description: Objectives: 1. Expand knowledge of consperse strink bug biology and host plan associations over a calendar year. 2. Incorporate pheromone technology with sampling as a mitigation measure to reduce grower reliance on orgonophosphates. 3. Evaluate reduced risk insecticides for efficacy against consprtse stinkbug nymphs in processing tomatoes. 4. Promote implemenation of a phermone-based stink bug management approach through education and research. We completed one year-round consperse stink bug EUSCHISTUS CONSPERSUS habitat survey, September 2001-December 2002, with concurrent dissection of adults to determine reproductive status and migratory capability over this period. Results show this species to be in reproductive diapause October-March with brown venter coloration, unmated spermatheca and immature ovarioles. Bugs are migratory displaying green venter coloration and reproductive activity from March through September. Pheromone traps attract reproductively mature, ovipositing females throughout the tomato season, June-September. Female trap catch is higher than male catch during this period, particularly early season when trap peaks occur in June. Field collection and dissection results support using early season trap peaks as a biofix from which to accumulate degree-days and forecast subsequent nymphal development within the crop. Collaboration with the California Tomato Research Institute and Heinz and Morning Star processing companies led to selection of cooperating growers who provided two commercial fields for our research. These fields were monitored weekly during the 2002 growing season by canopy shake sampling and pheromone trap catch methods. Weekly canopy shake sampling and pheromone trap data were correlated with weather station data near our field sites to accumulate degree-days (DD) from the early season trap peak recorded in each field and forecast small nymph development within the crop. Shake sampling data confirmed small nymph peaks within each field approximately 558 DD F. from the early season trap biofix date. These results validated our E. CONSPERSUS phenology model under commercial conditions. A reduced-risk insecticide trial for stink bug control compared the chloronicotinyl (Actara) plus pyrethroid (Warrior T) tank mix, a pyrethroid (Warrior T), and an organophosphate grower standard (Monitor) to an untreated control. Treatment levels were replicated 4 times in large scale trials at our two commercial field sites, with treatments timed relative to the early season pheromone trap peak biofix in each field. One field site received an early spray timing at 407 DD, 151 DD ahead of the 558 DD benchmark for small nymph development. Our second field received optimal spray timing at 589 DD from its early season trap peak, within 31 DD of the 558 DD benchmark. Percent fruit damage was significantly lower at the optimal spray timing corresponding to small nymph development within the field. There were no significant differences between the two organophosphate timings and the chloronicotinyl plus pyrethroid tank mix or the pyrethroid applications applied optimally from the pheromone trap biofix date. The reduced-risk chloronicotinyl plus pyrethroid tank mix performed as well as the organophosphate for stink bug nymphal control in processing tomatoes. We participated in Cooperative Extension outreach meetings January 8 and 17, 2003 to present project results to tomato growers, pest control advisers and processing company representatives.
Impact: This project addresses FQPA regulatory constraints associated with stink bug management in California processing tomatoes by incorporating stink bug pheromone

monitoring with a phenology model for this species to time insecticide treatments to the more susceptible nymphal stages. This approach is permitting growers to utilize reduced-risk materials other than the current organophosphate standard in a successful control strategy. This is reducing pesticide applications, resulting in improved economic viability and reduced environmental impacts.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Studies of Natural and Synthetic Chemicals Useful in Control of Phytophathogens
Description: Objectives: a) Explore Natural Products Chemistry of fungi, bacteria, plants and selected animals,in some cases using bioassay guided separations. b) Test new compounds found for biological activity. c) Investigate various problems related to organic chemistry as they appear.
Work continues on Methyl Iodide as a soil fumigant. We are currently testing the efficacy of planting mustard after fumigation with methyl iodide to remediate possible iodide residues in the soil. Projects from last year continue: bacterial quorum sensing molecules and antifungal compounds from grapefruit.
Impact: This project attempts to find chemicals, natural or synthetic, that can be used in the control of plant diseases.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Systematics and Evolution of Scale Insects (Hemiptera: Coccoidea)
Description: Objectives: 1. Phylogenetic analysis of molecular and morphological data to estimate evolutionary relationships of scale insects (superfamily Coccoidea). 2. Preparation of taxonomic revisions of scale insect genera, especially of the families Coccidae, Eriococcidae and Margarodidae. 3. Description of species of scale insects found in California, with emphasis on taxonomic variability and immature stages 4. Provision of accurate and rapid identifications of scale insect specimens. Active research on the systematics and evolution of scale insects (order Hemiptera, superfamily Coccoidea) continued during 2002, with the aims of facilitating identification, improving classifications and providing biological data on this important pest group. One major paper (Cook et al. 2002) on the relationships and classification of scale insect families was published (listed below), and another significant paper (Thao et al. 2002) was published on mealybugs (family Pseudococcidae) and their associated endosymbiont bacteria. The latter research demonstrated the coevolution of the primary endosymbionts with their mealybug hosts and the multiple infection of the primary with the secondary endosymbionts. The presence of the primary bacteria is essential to the health of the host mealybugs. Taxonomic and phylogenetic research also continued on the mealybug genus Ferrisia. The new pest Ferrisia species that was recognized last year from pistachio trees in southern California is being formally described in all life stages and molecular data have been acquired to support the status of this species as new and distinct from described species. In July 2002, a visit was made to the Coccoidea Collection of the US National Museum in Beltsville, Maryland, to study museum specimens of other Ferrisia species for comparative purposes. Also determinations were made of a number of scale insect samples, mostly for scientists from UCD, other universities and government agencies. Slide preparation and identification of each specimen/sample takes a total

of about 3 hours because of the technical procedures involved. Additional photographs of scale insects have been taken for the digital database of images of live Coccoidea.
Impact: Taxonomic and phylogenetic work on scale insects is essential for the accurate identification of pests and potential pests, and also allows the association of biological data with names. Research on mealybugs (family Pseudococcidae) is especially important because this large family (about 2,000 species) includes many significant pests of agriculture.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Taxonomy of Parasitoids Aids Biological Control
Description: Aphytis rank among the most important parasites of armored scale, which in the past have threatened both citrus and olive in California. Foreign exploration for and the introduction of wasps have been regarded as the best defenses against scale. Most species of Aphytis are extremely difficult to identify based on existing keys. Often the adults are identical or separated by only marginal features, and only information from other life stages or behavior can be used to reliably recognize a species. This has, and will continue to be, a major impediment to using Aphytis in biological control programs. The Entomology Research Museum at the University of California, Riverside recently obtained funds to curate its vast Aphytis collection, which, at approximately 25,000 specimens, is the largest in the world and represents critical material collected from mostly citrus in more than 73 countries. Current efforts are focused on the characterization of species using both morphological and molecular data. This information will allow us to assess geographic variability, look for fixed sites to develop molecular markers for the identification of species, and assess the relationships of species within Aphytis.
Impact: In California, species of Aphytis imported from other countries have been instrumental in protecting citrus, olives, and other important crops from armored scales. Using biological control with these insects has resulted in the reduction or elimination of pesticides used in the crops and the environment. The Entomological Research Museum supports the biological control efforts by providing means to identify species.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: UC Finds Solution to Serious Pest of Artichokes
Description: Meadow voles, small rodents that live throughout California, are in most situations a natural and harmless part of the environment, but in artichoke fields and some other agricultural crops they feed on and damage the crops. In perennial artichoke fields, primarily in the Monterey area, voles are the most serious pest and controlling them is essential for production. Recently, the only method available to reduce this damage, a rodenticide, was cancelled by the manufacturer. With a potential crisis looming, the artichoke growers turned to UC for help. In consultation with with the California Artichoke Advisory Board, Monterey County agricultural commissioner, California Department of Food and Agriculture and the rodenticide manufacturer, UCCE specialists set to work. After extensive review of the current pest management practices, they began intensive laboratory tests to evaluate alternative materials and procedures. After just a few months, the UC researchers began field trials to test a newly developed rodenticide. Their laboratory findings were borne out in the field where good control

of the vole pest population was achieved. The UC data were submitted to pesticide regulators as part of the proposed change in the rodent bait registration.
Impact: Word has just been received that UC's data have been accepted by the pesticide regulators and the changes have been approved. Thus, artichoke growers, who were facing a potential disaster, can begin using the new material in time to smoothly transition from the remaining stocks of the old rodenticide.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: UC Research Helps Deal With New Lettuce Threat
Description: In the fall of 1998, a new pest of lettuce, the lettuce aphid, was discovered in Central Coast lettuce fields. It spread rapidly. In 1998, only 100 acres or so were affected but one year later 100,000 acres, nearly 70% of Central Coast lettuce fields, had some level of infestation. In the most severely impacted fields, growers did not harvest a single head of lettuce. The aphid infests the inner portion of the lettuce plant that should be destined for market. Infested lettuce is unfit for sale, causing complete economic loss to producers. With the pest unchecked, the billion-dollar lettuce industry would have faced many millions of dollars in loss. A CE Farm Advisor and other UC researchers have cooperated to find methods of managing this pest. Research, funded by UC and the growers themselves, has shown that appropriate pesticide strategies can reduce the losses. Non-chemical approaches also have been studied, including the use of lettuce varieties that resist the aphid. He has worked with USDA and private industry lettuce breeders in testing these resistant varieties, which were first developed in Europe. He has also worked with organic growers to develop means of increasing populations of naturally-occurring biological control agents of the lettuce aphid on their farms.
Impact: By using appropriate insecticide programs tested by UC, pest control professionals have been largely successful in avoiding the severe economic losses that this pest could have caused. Organic growers, for whom fewer effective control techniques are available, have seen their production limited by the aphid. Some have shifted significant acreage out of California to areas where this pest is not present. If similar shifts had occured in conventional production, the economic impact would have been in the millions of dollars. Although organic growers continue to be the hardest hit, UC research has helped them reduce their losses through techniques such as insectary plantings (non-crop plants in or near crop fields to attact benficial insects) and the use of botanical insecticides. Both organic and conventional growers are looking to resistant plant varieties for long term management of this pest. Plant breeders from UC, USDA and private seed companies are all working toward development of resistant varieties.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: UC's Crop Detectives
Description: A myriad of problems plague crops, including biotic pests such insects, plant diseases, weeds, vertebrate animals and nematodes. In addition there are potential problems from non-biological factors such as adverse temperatures, salinity, fertilizer injury, phytotoxicity and wind. When something goes wrong with a crop, who does the farmer call to help investigate? One logical answer is the pest control advisor, fertilizer dealer, the seed salesperson and perhaps other farmers. But if the problem still is not solved, then who can the farmer turn to?

UC has a strong core of experienced advisors scattered throughout counties of California. Some reside at agricultural centers such as UC's Desert Research and Extension Center. Others are located in county-supported offices. Still others occupy an outpost office in a remote agricultural region. The advisors have solid backgrounds in crop sciences such as entomology, plant pathology, weed control, soil science, vegetable crops and agronomy. Experienced advisors are professional troubleshooters. They visit a farmer's field, ask the appropriate questions, collect samples and evaluate the situation. Often they recognize the cause of the problem in less than an hour. They can follow up the diagnosis with laboratory tests as needed. Their recommendations, based on scientific principles and methods that incorporate the values of sustainable agriculture and environmentally sound integrated pest management, save farmers many hundreds of thousands of dollars annually.

Impact: Examples:

- A farmer shows the advisor a field of lettuce, yellow and scorched on the leaf-margins. He plans to apply more nitrogen fertilizer. The advisor runs a quick soil test and finds extremely high levels of nitrogen. (The previous crop, onions, had been heavily fertilized.) The advisor recommends sprinkler irrigation to flush the excess nitrogen from the root zone. The crop yield was normal. Saving to the farmer about $40,000.
- Another lettuce grower plans to treat his field for powdery mildew. The farm advisor determines that the infection is another pest, downy mildew. The treatment would have been useless and the crop destroyed by the disease. In a 40-acre field, the grower would have lost $76,000.
- A field of watermelons is wilting and dying. A plant pathologist farm advisor determines that the problem is a soil-borne fungal disease. The melons are lost, but the advisor provides a crucial warning: Do not, as planned, grow cantaloupes as a rotation crop--they're susceptible. The grower switches to broccoli and saves an estimated $30,000.

Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Use of Mulches to Control Avocado and Citrus Root Rot
Description: Phytophthora root rot of avocado and citrus is a worldwide problem, causing the potential destruction of avocado orchards and reducing fruit quality and yield for citrus. It is estimated that some 60 percent of California avocado orchards are affected by the disease.
A Professor of Plant Pathology of the University of California, Riverside began a series of field trials in 1999 to evaluate the effects of yardwaste mulches on citrus and avocado. Results indicated that avocado yields and growth increased by as much as 43 percent in Phytophthora-infested orchards when the mulches were applied. In addition, the mulches helped reduce the need for water, fertilizer, and weed-control agents. Some benefits were seen for citrus, but they were not as dramatic. He was able to determine that mulches are effective because they produce enzymes that decompose the cell walls of Phytophthora. Another major area of his work involves developing disease-resistant rootstocks aided by genetic tools such as microsatellite analysis to determine the parentage of natural crosses. Some 50 new rootstocks have been developed with excellent root-rot resistance, and extensive field tests of these new varieties are ongoing. One new rootstock, the Merensky II, has been released to growers.
Impact: Virtually all Phytophthora-infected avocado orchards planted today use yardwaste mulches due to the research conducted by the researcher. Avocado growers are finding that through a combination of control methods--including resistant rootstocks, mulches, and fungicides--they are able to replant in orchards where almost all the trees had died. Municipal

and country governments also have benefited from his research. Previously local officials were paying as much as $100 a ton to dispose of yardwaste. Now citrus and avocado growers purchase the yardwaste for their orchards, enabling cities and counties to earn a profit and to reduce the solid waste they deliver to landfills.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Vector Specificity and Semipersistent Closterovirus Transmission by Whiteflies
Description: Our objectives are determine the specific feeding behavior that result in acquisition and inoculation of two closteroviruses, tomato infectious chlorosis virus (TICV) and lettuce chlorosis virus (LCV), by their whitefly vectors (Trialeurodes vaporariorum and Bemisia argentifolii, respectively); determine if vector specificity of TICV and LCV is due to differences in feeding behavior between vector and non-vector whitefly species; and determine if vector specificity of TICV and LCV is due to differences in the binding of virus to the alimentary canal of vector and non-vector whitefly species, or, if vector specificity is due to differences in the release rate of bound virions by vector and non-vector whiteflies. The electrical penetration graph (EPG) technique was used to determine what part of stylet penetration behavior by the whitefly vector, Bemisia argentifolii Bellows & Perring (Homoptera: Aleyrodidae), is lettuce chlorosis virus (LCV) inoculated in the host plant Malva parviflora L. LCV is a semipersistently-transmitted closterovirus. Since closteroviruses generally are found in the phloem of their plant hosts, this study tested the hypothesis that virus inoculation occurs during the phloem phase of stylet penetration behavior. Virus-exposed whiteflies were allowed to feed on uninfected host plants, and the whiteflies were divided into two experimental groups: group 1 attained phloem phase on the uninfected plants, and group 2 did not attain phloem phase. Two series of tests were conducted, one where whiteflies were manipulated so that the amount of time spent in non-phloem phase stylet penetration behaviors was similar between group 1 and group 2, and a second series of tests where whiteflies were manipulated so that the number of intracellular punctures made during stylet penetration was similar between group 1 and group 2. Both series of tests indicated that virus inoculation took place primarily during phloem phase. Considering only individual whiteflies shown to be capable of transmitting virus, 11 of 23 whiteflies (48%) in the phloem phase treatment successfully inoculated the virus whereas only one of 19 whiteflies (5%) in the non-phloem phase treatment successfully inoculated the virus ($P = 0.00008$).
Impact: Understanding the mechanisms of transmission of closterovirus viruses may enhance development of control strategies aimed at disrupting the intricate process of virus transmission. For example, prior to this year, our results indicate that mechanisms of plant resistance to whiteflies should be more effective at slowing the spread of closteroviruses if the host plant resistance factors occur in the plant surface, epidermis, or mesophyll rather than in the phloem. Resistance factors localized in the phloem may not repel whitefly vectors until after the virus is transmitted.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Vine Mealybug Identification Posters
Description: Infestations of the Vine Mealybug (Planococcus ficus), an imported insect pest of grapevines, are now being found in many of California's major grape-producing counties. The mealybug can cause a great deal of damage. It excretes a sugary honeydew which rots on the

vine, causing defoliation and lowering yields and fruit quality. As it feeds, the pest also spreads viral diseases between vines. The vine mealybug has the potential to become our most damaging and expensive insect pest in California vineyards. At this time, the most important task is to find the infestations that exist and treat them promptly. Field workers are in the best position to do this, since they literally see and touch each individual vine. If an infestation occurs, they likely will be the first to notice it. However, if they do not realize the urgent need, this vital information may never reach the vineyard manager. A bilingual English-Spanish identification poster,("Wanted: Vine Mealybug/Se Busca: El Piojo Harinoso de la Vid")was developed by a San Luis Obispo viticulture and soils farm advisor. It contains a detailed picture to show workers what a mealybug infestation looks like and instructions to notify their supervisor if they see the pest in the field. The poster is printed as an 11x17 inch full-color print on photographic paper, and laminated. During the past three months, nearly 2,000 copies of the poster have been distributed throughout the state. Over 250 have gone to local clientele. Other Cooperative Extension farm advisors have distributed the poster in the counties of Sonoma, Napa, Madera, San Joaquin, Sacramento, El Dorado, etc.
Impact: It is crucial to find new infestations of the mealybug as early as possible when they can still be treated effectively. This educational effort has created an opportunity for prompt and informed action to greatly reduce treatment costs for the vineyard industry, decrease the amount of pesticides used, and maintain the yields and quality of the grape harvest.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.12 Integrated Pest Management
Title: Whitefly-Plant Interactions and Host Plant Resistance to Whiteflies
Description: Objectives: 1. Determine how whiteflies differentially respond to host and non-host plant species. 2. Quantify the level of whitefly resistance in selected clonal lines of alfalfa and determine the mechanisms of whitefly resistance in the resistant genotypes 3. Evaluate different cotton varieties and different non-commercial cotton species for resistance to whiteflies 4. Develop techniques for studying feeding and stylet penetration behavior of whiteflies.
We have begun to examine the mechanism of resistance in clonal lines of alfalfa that we had previously identified as resistant against silverleaf whitefly, BEMISIA ARGENTIFOLII. Resistance in these clonal lines is expressed primarily as very high first instar mortality, so we tested the hypothesis that first instars had a low success rate of locating phloem sieve elements on the resistant clonal lines. Experiments using three different techniques (electrical penetration graphs, honeydew clocks, and histology) all indicate that first instar nymphs successfully locate and penetrate sieve elements on the resistant clonal lines. Therefore, we conclude that the resistance resulting in high first instar mortality is compartmentalized in the phloem; mortality is not expressed until after sieve elements are penetrated. Future research is planned to determine what factors in the phloem of the resistant clones are causing high first instar mortality. We have identified three electrical penetration graph waveforms produced by the nymphal stage of silverleaf whitefly, thus permitting this valuable technique to be used to study feeding behavior of silverleaf whitefly immatures. Pathway phase, which occurs as the whitefly's stylets penetrate from the leaf surface to the sieve element, is represented by a high amplitude waveform similar to that produced during pathway phase in adult silverleaf whiteflies. Phloem phase, which occurs when the tips of the whitefly's stylets are inserted in a sieve element is represented by two waveforms named 'high frequency' and 'low frequency' based on their relative frequencies of voltage fluctuation. The high frequency waveform was correlated with honeydew excretion indicating that the high frequency waveform represents ingestion of phloem sap. The low

frequency waveform alternates regularly with the high frequency waveform, but presently, we have not correlated it with a biological behavior. We suspect that the low frequency waveform is produced during salivation into the sieve element, but this hypothesis needs testing. As in the previous two years, in a season-long field test, GOSSYPIUM THURBERI, a wild relative of commercial upland cotton (G. HIRSUTUM), exhibited very high levels of resistance against silverleaf whitefly. In contrast to three consistent years of field data showing G. THURBERI to be highly resistant, last year's greenhouse tests on seedlings showed slightly higher survival of silverleaf whitefly nymphs on G. THURBERI than on commercial upland cotton, and this year's greenhouse tests of whitefly oviposition preference on seedlings indicated that G. THURBERI was just as preferred for oviposition as commercial cotton in both choice and no-choice tests. The reasons for these contradictory findings will be explored.
Impact: Four highly resistant alfalfa clones and three moderately resistant clones have been identified that can be used in the ongoing breeding program for whitefly resistant alfalfa. Also, the stage specific survival study indicated that we can expect resistance to be expressed primarily in the first instar. Measuring nymphal survival through completion of the first instar is much less laborious than measuring survival from egg to adult. This will make screening alfalfa clones for resistance more efficient. Consequently, we will soon screen over 200 additional clonal lines. This method also is more efficient means than the expensive field trials that have been done in the past. Our results indicate that a high percentage of plants deemed resistant in the field had low whitefly densities more as a result of chance than resistance. Thus, the method developed in this project should be less expensive and more accurate. Detection of high levels of whitefly resistance in the cotton relative, G. THURBERI, is encouraging, because this species has been used in the past to incorporate new genes into commercial upland cotton, G. HIRSUTUM. Our results indicating that whitefly susceptibility is not correlated with vascular bundle depth was disappointing, yet valuable in order to avoid wasting effort selecting for ineffective traits in cotton breeding. The advances that we made in developing the EPG technique for studying feeding behavior will be very useful in determining the mechanism of resistance which in turn will facilitate selection of whitefly resistant plants.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: 3 Year Study Examines Most Efficient Sprinkler Spacing
Description: Questions about water and fertilizer use efficiency are major economic and environmental issues for California agriculture. Excess nitrate is an important concern for San Joaquin Valley communities that depend on groundwater for drinking. Vegetable crops such as carrots, onions and potatoes typically require high amounts of nitrogen fertilizer and frequent irrigation, usually by sprinkler. Although sprinkler lateral spacings vary from 30 to 50 feet, no season-long field study had determined the impact of these different spacings on efficiency of water and nitrogen use. A three year study funded by the statewide Fertilizer Research and Education Program compared seven different sprinkler lateral spacings from 33 to 48 feet for impacts on irrigation uniformity, nitrogen leaching and yield. Yield and quality were statistically unaffected by spacing. With set times of 12 hours, more traditional lateral spacings (42 to 46 feet) achieved the same seasonal uniformities and carrot yields as 33 to 40 foot spacings. However, the 40-foot spacing was the most consistent over the season for water and nitrogen use efficiency. When wind speed is greater than 12 mph the 40 to 42 foot spacing has a definite advantage over wider spacings. Narrower spacings did not give additional improvement. A full "season-long average" sprinkler uniformity was found to be about 10% higher than the reported

statewide average. Sprinkler age made no difference in uniformity, except when set duration dropped below six hours. Short sets decreased uniformity by 10 to 20%. Carrot yields were statistically the same where sprinkler precipitation was from 80 to 120% of crop ET.
Impact: Most carrots, onions and potatoes in Kern County are now irrigated at 40 or 42-foot lateral spacings with six to 12 hour sets. With this system, this study shows that water use effiency in the 50,000 acres of carrots grown in Kern County is closer to 90% than the 75-80% estimate normally used for hand-move sprinkler irrigation. This high level of efficiency also means that less water is available through "ag conservation savings" than is typically estimated by California water policy makers for these types of systems.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: An Evaluation of the Effectiveness of Livestock Distribution Practices in Grazed Watersheds
Description: The objectives of this project can be summarized as four sequential, interlocking items: 1. Measure the responses of plants to variable flooding regimes. 2. Determine the interactions of other variables to flooding and local hydrology. 3. Develop simulation modles of rhizosphere processes. 4. Conduct field experiments and tests of predictions regarding the vegetation under manipulated hydrology and associated variables. Develop a Windows based Animal Distribution Modeler for predicting areas on the landscape that will receive more intensive or less intensive use by domestic grazing animals. Develop a set of algorithms that predict the pattern of livestock distribution on the landscape when livestock distribution tools are employed. Conduct on-ranch demonstrations of the effectiveness of distribution practices refined in this project to solve livestock impact problems on riparian/stream systems and domestic water sources. Through extension education and university classroom education improve rancher, range manager, regulatory agency, student and general public understanding of animal behavior and livestock distribution. In 2002 we conducted two pot experiments and a field experiment on water depth, light, and fertility effects on water grass-rice interactions. These experiments were intended to assess the potential of fertility delay as a manipulative tool for weed control. The first pot experiment, conducted in Davis, used late watergrass (Echinochloa phyllopogon) and rice (Oryza sativa cv. M-202) in a dual target design with seven rice plants in the neighborhood. All plants were germinated simultaneously, but the targets (one rice and one watergrass) were subjected to some level of light or fertility deprivation for a week. The pots were then planted and allowed to mature. The results are highly variable and do not support the hypothesis that either short-term light or fertility deprivation had a significant effect on the outcome. The second pot experiment was also conducted in Davis. This experiment used the same target design (seven neighbors, two targets), expanded to include both late and early (E. oryzoides) watergrass. The main treatment variables were water depth (two levels) and fertility delay (three levels). This experiment revealed that water depth and fertility had significant effects on late watergrass growth and reproduction (the interaction effects remain to be tested). However, early watergrass was unaffected by either treatment and was so competitively superior to rice that water depth and fertility delay do not appear to offer hope as management variables. The field experiment was conducted at the Rice Experiment Station at Biggs. This experiment was intended to mimic the second pot experiment, but had only a single main effect (fertility delay) when the water treatment proved impossible to implement. M-202 rice was planted into 3 x 7 m plots, with watergrass seed coming only from the seedbank. All watergrass was E. phyllopogon. The results of this experiment showed that delayed fertility had a significant effect on the watergrass (delay

reduced the watergrass stand and limited its seed production), but rice production did not recover to peak levels with delayed fertilization.Together, these results suggest that delayed fertilization can be an important factor in watergrass control in rice, but cannot be the sole or major factor. When watergrass is the weed of major interest, preplant fertilization increases the competitive advantage of the watergrass, making early control by herbicide essential. A practical alternative to herbicides will require early weed suppression such as weed seed bank reduction in combination with delayed fertilization; these will be examined in the next round of experiments. The first pot experiment showed that short-term disadvantages can generally be made up in watergrass, which reemphasizes the importance of delaying watergrass entry into the rice stand if cultural control is to be effective. The suppression of late watergrass in the field experiment would seem to be inconsistent with the second pot experiment, but we believe the apparent inconsistency can be explained by density effects compounding per-plant competitiveness.
This three state project is progressing on field livestock distribution studies and on modeling/data analysis components of the project. Modeling: As part of the modeling component of the project we have met with Paul Provenza and his staff who have similar modeling objectives in their USDA IFAS grant. We are considering the feasibility of collaborating on an animal distribution model. We met twice in Logan, Utah developing a conceptual model. Landscape Temperature: During livestock distribution studies we have collected landscape temperature data from multiple locations in study pastures in Montana, California, Idaho and Oregon. These data will be used to determine the influence of landscape temperature on livestock distribution and to parameterize models for predicting livestock distribution. We are working with atmospheric scientists at OSU to develop equations that relate the landscape temperature data to solar isolation. Montana Herding Study: We initiated a study to quantify the effectiveness of herding to protect riparian areas at the Bair Ranch near White Sulfur Springs, MT. Strategic placement of supplement complemented the herding in this first year of the study. An additional 2-year study was initiated on the Thackeray and Ross Ranches to evaluate the effectiveness of supplement placement without herding on cattle grazing. Effectiveness of treatments in this study cannot be estimated until the end of the field season next year. Oregon Supplementation Study: The field work portion of the 3 year study investigating the performance and behavior of cattle receiving daily supplementation, supplement once every six days, and no supplement while grazing low quality summer/fall northern great basin forage were completed 1 November, 2002. Analyses of the distribution and behavioral data are just beginning. California Distribution Study: We completed cow tracking studies in four pastures at the University of California Sierra Foothill Research and Extension Center during four seasons this year. We are currently analyzing the vegetation data, forage quality data and the cow position data from this study. California Supplement Attraction Study: We conducted one supplement attraction study on a private ranch in Madera County. Preliminary observations indicate that the supplement was an effective attractant. However while the supplement sites were strong attractants cattle often moved to other locations to graze. These data require extensive analysis and we will run similar studies at other ranches during 2003.
Impact: The 2002 experiments have refined our understanding of the role of fertilization on rice-watergrass interactions. Farmers have realized that early fertilization may do more harm than good by increasing weed impact, so the use of fertilization timing as a weed control technique is increasing, reducing herbicide applications and thus, protecting soil and water quality.
Improved application of livestock distribution practices so that livestock can be attracted away from environmentally critical areas and attracted into areas where grazing is being used as a tool to manipulate vegetation. Use of this strategy is protecting critical riparian habitats on annual rangeland.
Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: Carbon, Water Vapor and Energy Exchange over Grassland and Tree/Grass Ecosystems
Description: The complex mixed grass/oak system possesses multiple functional types, has rates of carbon uptake and water loss limited by soil water deficits, is normally grazed and burned, and grows on non-ideal terrain. These characteristics challenge Biometerologists. Better information on the fluxes of carbon and water is needed for management and to predict effects of climtae and enviornmental change. This project will: 1) measure and model carbon, water and energy fluxes of grassland and mixed grass/oak ecosystems; 2) study how sloping terrain affects the interpretation and measurement of carbon and water fluxes over grass; and 3) examine theories on the coordinated use of water for the assimilation of carbon. For the past two years we have been conducting a comparative study on the carbon and water exchange over a deciduous oak/grass savanna and annual grassland. These two ecosystems are located in northern California, coexist in the same climate and on similar soils, but possess unique and contrasting structural and functional attributes. Net carbon exchange of the grassland experienced much seasonal dynamics and considerable year-to-year variability. Winter frost events limit canopy photosynthesis of the annual grassland during winter growing seasons. Rapid growth occurs after the last frosts and ceases when the soil water profile is depleted and the plants die. During the spring growth period, photosynthesis is a non-linear function of available light and the sensitivity term is a function of leaf area index. The timing of the cessation of winter rains delays the end of the growing season and determines whether the grassland is a sink or source of carbon. Late spring rains, after the grass died, allows soil moisture to be retained in the soil profile over the course of the summer. This occurrence enables microbes to respire at greater rates than the year when the grass depleted moisture from the root zone and causes the grassland to be a source of carbon. Net carbon uptake by the oak savanna occurs during the winter when the trees are dormant, but the grass is active and during the summer when the grass is dead, but the trees are photosynthesizing. Photosynthetic rates of blue oak leaves experience very unique behavior in the time course of photosynthetic capacity during the summer drought period. For a short period during the spring, when soil moisture is amble, leaves achieve extremely high rates of photosynthesis, exceeding rates of temperate oaks by a factor of two. As the summer drought progresses, stomata regulate water loss and carbon gain and photosynthetic capacity declines, in parallel with decreases in leaf nitrogen. CO2 efflux measurements, made at the savanna site, with chambers, soil CO2 profiles and an understory eddy covariance system reveal that soil respiration is a continuous function of temperature, soil moisture and photosynthesis. But episodic rain pulses stimulate huge short-term rates of respiration, by activating microbial activity until the surface moisture dries.
Impact: Field measurements of carbon and water exchange are being contributed to the AmeriFlux and FLUXNET project data archives, for access and use by the world wide research community, educators and students. Biophysical models, such as CANOAK, will implement algorithms, being produced from our field measurements. This is translated into information that quantifies surface boundary fluxes of hydrological, weather, biogeochemical and climate models. Information on carbon and water exchange of an oak savanna provides information that has been needed to improve management of oak savanna and predict how this ecosystem will respond to climate change.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: Coexistence of Honey Bees and Solitary Bees in California and Costa Rican Wildlands and Croplands
Description: Objectives: 1. Determine floral preferences and nonpreferences of honey bees and solitary bees at specific sites in California and Costa Rica with the main goal of evaluating the potential for competition and/or coexistence between these two groups of bees. 2. Continue long-term monitoring studies of selected trap-nesting bees in modified wildlands of California and Costa Rica. 3. Monitor mortality in trap-nesting bees (same ones as Objective 2) with reference to natural enemies and annual weather patterns, especially those that depart substantially from normal (e.g. El Nino and La Nina years). 4. Develop methods for monitoring honey bees and solitary bees in agricultural lands and adjacent wildlands in California. In 2002, the Africanized honey bee began moving slowly into northern California, with reports of its presence in cities such as Visalia and Santa Barbara. In anticipation of its greater spread and establishment in northern urban CA, a survey of host plants of AHB and native bees in two S.F. East Bay cities, Albany and Berkeley, was initiated. One of the goals of this survey was to quantify visitation frequencies of all bee species on commonly used ornamental plants to better advise homeowners about the use of bee-attractive plants around their home environment. Based on the earlier work in Costa Rican and California wildlands, we developed a new quantitative method for recording bee visitation frequencies on ornamental plants. To date, we have recorded measurable bee visitations/preferences on 105 ornamentals in Albany and Berkeley. As expected, honey bees and native bee taxa are variously distributed among urban host plants, with no evidence of interference competition of honey bees versus native bees. Other findings included: 1) an unexpected high diversity of native bee species (approx. 75) were found in urban gardens; 2) honey bee populations were relatively low; 3) native bees were unevenly distributed on their host plants with greatest diversity found in gardens with several bee-attractive plants flowering at the same time; 4) many avid gardeners (home and community) wanted more information on how to encourage native bees. The urban bee work will be continued in 2003. Two papers on urban bees are already in press.
Impact: One important environmental impact of our overall work is the recognition that bees may be used as bioindicators of environmental health of an area. We now have a wealth of quantified information that can be used to assess an area's health in terms of plant reproduction. We also are beginning to use this information as a larger contribution to a developing network of researchers who are monitoring pollinator decline across the U.S., Canada, and Mexico.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: Developing a Fuzzy Classification System for Accurate Land Cover Classification
Description: The goal of this project is to further develop fuzzy classification theory to advance our ability to accurately classify earth land cover - land use classes derived from satellite data. The proposed theoretical fuzzy classification system will be applied to the highest spatial and spectral resolution satellite data available for California (EO-1). The classification accuracies of the fuzzy system will be tested with existing intensively measured commercial forest and hardwood rangeland sites from northern California and the Central Valley as ground truth. GSY = 2. We developed methods for estimating crown closure using digital surface and digital elevation models. We developed a correction method for improving canopy boundary locations using shadow and boundary information derived from the imagery. This allowed us to achieve improved estimates of locations of points in the canopy with resultant more accurate estimates of

crown closure. We also introduced a 3D model-based tree interpreter for measurement from high-resolution aerial images. Trees are modeled as 3D hemi-ellipsoids. Multi-angular images are used to build the optimal tree model for individual trees. An overall accuracy of 90% was achieved for tree height and crown radius measurements. Thus, this method shows promise for dramatically reducing the costs relative to traditional field-based forest measurement systems. Models of tree crowns are important in many aspects of ecology because the crown contains the photosynthetically active portion of the tree. The amount of carbohydrates produced depends on the size of the crown and the capacity of the roots to absorb water and nutrients. In one study we model the crown profile of California conifers using a time-series autoregressive moving average (ARMA) approach. We first predict the trend line and then model the residuals around the trend were fir using ARMA models. It was found that 70% of the trees could be modeled using first order models. In a related study of hardwood trees it was found that 80% of the trees could be modeled using first order models. However, the trend for hardwoods often was more complex - requiring a cubic or quartic trend thirty percent of the time. These models can be used to improve models of forest growth dynamics and also for describing wildlife habitat.
Impact: This project seeks to improve our ability to use satellites for monitoring forest and natural systems. Satellites simply record the amount of reflected radiation from a target. We then need to take this information and decide what the object is. We use classification algorithms to make these decisions. Improving the classification algorithms is important so that we can make more accurate maps and hence have more accurate data for making more intelligent management decisions. In addition we are developing algorithms to allow us to measure trees (size, species) using high-resolution digital images. This holds the potential to dramatically decrease the cost relative to field-based forest inventory needed for forest management decision making.
Funding Source: McIntire Stennis and State
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: Effects of Logging and Prescribed Burning on Ectomycorrhizal Fungal Community Associated with Abies concolor
Description: Our overall goal is to understand the spatio-temporal patterns of symbiotic fungal communities associated with the roots of Abies concolor, and to determine if, or how, thinning and fire affect them. This goal will be addressed in the context of the following six hypotheses: i) Thinning or fire reduces species richness; ii) Thinning has a similar short-term effect to prescribed burning on the below ground EM community structure. iii) Thinning or fire causes a shift toward EM species present in the resistant propagule community (RPC). iv) the RPC for white fir is lower in species diversity and more spatially homogeneous than the mature forest community (MFC); v) Peak soil temperature and ash deposition either stimulate or reduce individual component species of the resistant propagule community (RPC). vi) Between-year temporal variation in community composition is not significant. In the second year of this project we are still processing pre-treatment samples and analyzing data, but preliminary results show that: 1) the diversity of ectomycorrhizal fungi is extraordinarily high in ABIES dominated mixed conifer forests, with the first 29 most abundant fungal species accounting for just over half of the total ectomycorrhizal abundance. 2) Hypogeous fungi, those producing truffles and false-truffles, collectively account for over one third of this community. 3) biasing the below-ground sampling to ABIES, by targeting locations where the over story is dominated by fir yielded root tips that were over 80% ABIES. In unbiased samples, all tree species in the overstory within 10 m were typically retrieved. The prescribed fire treatment were disappointing within our Teakettle site in that many of our plots were essentially not burned. In addition, many of the trees that we

expected to survive the thinning treatments did not. As a result we will likely concentrate our post-treatment work on the Blodgett forest site, in which the treatments were more successful in achieving the above-ground goals.
Impact: The high diversity of fungi means that these forests are extremely species rich even at relatively small spatial scales. The high percentage of fungi that form truffles and false-truffles shows that this diversity is directly linked to animal food webs, as these are typically a huge component of the diet of flying squirrels and other rodents. Both findings will be important to land managers.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
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 proposed strategies for reducing PM10 dust emissions from the Owens (dry) Lake, California playa. The goals of this project are to define methods for establishment of native desert vegetation on saline playa soils, and to achieve a sand-stabilizing level of vegetation development within a short time frame. Program objectives are divided into two phases: VegPhase I (Objectives 1-3, below) will be conducted on natural stands of native plants and VegPhase II (Objectives 4-6, below) will be in new experimental plantings. 1. Assess seed and transplant availability of Sarcobatus vermiculatus and Atriplex parryi in the Owens Basin. 2. Assess fertilizer and irrigation requirements for improving growth rate, vigor, and seed production of established mature plants of these two species and growth of interplanted seedlings of these species. 3. Assess long-term performance of these native plant species with fertilizer and irrigation. 4. Define the design criteria (leaching, irrigation, fertilizer, organic matter, plant materials) for establishment of these native plants on Owens Lake playa soils. 5. Evaluate potential for increasing natural establishment of native species in the playa with seed trapping and amendments. 6. Evaluate planting performance and define criteria for long-term monitoring including toxic element accumulation, sand stabilization, and plant population persistence. Since initiation of this project in fall 2000 we have established two large-scale drip-irrigation systems and numerous experiments on the Owens (dry) Lake playa. At each of the two irrigation locations we have conducted replicated experiments to test effectiveness of leaching regime, planting procedures, fertilizer and amendment regimes, and various irrigation rates on establishment, growth, survival, flowering, and seed production of three native, salt-tolerant shrubs (Atriplex parryi, Suaeda moquinii, Sarcobatus vermiculatus) and one native, salt-tolerant grass (Distichlis spicata). In addition, experiments testing effects on establishment and growth by competition among these species were established and are being monitored. During the 2002 growing season we planted an additional 2400 shrubs to expand and repeat the experiments with new plant materials grown from locally collected seed. Survival, growth, flowering, and seed production have been monitored throughout the growing season. Exclosures were constructed around the experimental plots to prevent herbivore damage, which is particularly severe for Sarcobatus vermiculatus. This may partially explain the lack of natural establishment of this species in the Owens Lake playa. The experiments will continue through the 2003 growing season, at least. Analysis of leaf nutrients and growth responses of Atriplex parryi indicated sequential macro-nutrient limitations, first by N, then P, then Mg. No evidence of Na or B toxicity was detected in the irrigated plants. Irrigation alone resulted in no increase in growth of the three shrub species indicating that nutrient availability, rather than water limitation, was most important in

determining successful establishment and growth of the shrubs. In the shrubs, seed production and seed quality were both increased many fold by nutrient addition, an effect that again was not caused by irrigation alone. Furthermore, the larger, higher quality seed produced by the experimentally fertilized shrubs was more successful in establishment in the field. Establishment from seed is a potentially feasible way to augment stands of planted, fertilized shrubs on the Owens (dry) Lake playa. Large areas of Distichlis spicata have already been planted as part of dust mitigation efforts on the playa. Our experiments show clearly that shrub establishment and growth are strongly inhibited within existing stands of this grass. Improving diversity of the plant community by introducing shrubs will require elimination of saltgrass in the microsites (~1 meter square area) where shrubs will be planted or seeded. This information will be used to improve establishment and growth of native halophytic shrubs as part of sustainable fine particulate dust (PM-10) mitigation efforts at the Owens (dry) Lake playa.
Impact: Sustainable reduction of particulate dust pollution (PM-10) in the Owens Basin, Inyo County, California requires establishment and growth of native plant cover on stressful saline, alkaline soils. This research is determining soil leaching, irrigation, and fertilization requirements for establishment, growth, and persistence of native, salt-tolerant shrubs and a grass useful for dust mitigation.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: Residual Dry Matter Management on Annual Rangelands
Description: In the early 1980's, managers of grazing on California's annual rangelands were beset with a host of problems exacerbated by drought. Needed was a simple and yet scientifically defensible method for determining grazing capacity and regulating grazing intensity. The available science was primarily based on work by federal agencies outside of the state and on perennial-dominated grasslands. Beginning in the 70's studies were conducted investigating the relationship between residual dry matter (mulch), the local environment, grass growth, and grazing. A CNR-UC Berkeley Professor initiated additional research, with Cooperative Extension Advisors and Specialists, in 2000 to further investigate the relationship of residual dry matter with net primary production, species diversity and water quality parameters.
Impact: Recommendations based on this work have been disseminated by UC Cooperative Extension, adopted by state and federal agencies, and incorporated into guidelines for managing annual-type ranges. This method of managing grazing, called "management of residual dry matter" or "RDM", is now the standard for determining the degree of grazing use and was recently issued as a revised and updated ANR publication. The RDM approach has been combined with use of modern remote sensing and geographic information systems, allowing several San Joaquin Valley Counties to save millions of dollars in assessment expenses. Adopted by the US Fish and Wildlife Service, the Bureau of Land Management, the US Forest Service, the National Park Service, and many state and local land management agencies, the RDM approach has protected millions of acres of annual rangeland by improving water quality, protecting wildlife habitat, and enhancing forage quality and quantity.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: Restoration of Native Oak Woodlands

Description: For a century, there has been concern in California that several species of native oaks are not regenerating adequately. Poor regeneration not only threatens the oak forests themselves, but also the wildlife that utilize oak resources. It could also impact recreation, water quality and quantity, the state's visual landscape and lead to the spread of noxious weeds. This was was one the principal reasons for the establishment of the Integrated Hardwood Range Management Program (IHRMP) in 1986. Since then, the IHRMP has conducted extensive research on the causes of poor oak regeneration and practical, low-cost methods of establishing young oaks. Much of the applied research has been conducted at UC's Sierra Foothill Research and Extension Center in Yuba County, focusing on all aspects of regeneration from collecting and storing acorns to protecting seedlings in the field from damaging animals. One of the 10 current projects is evaluating the effectiveness of "treeshelters" (individual tree protectors) on oak establishment. Beginning in 1989, the IHRMP began hosting a series of Oak Regeneration Field Days at the Sierra Foothill Center. These events, with a total attendance of 700, have contributed greatly to educating practitioners--restorationists, arborists, nursery operators, landscapers and registered professional foresters--about the most up-to-date practices on all aspects of oak regeneration. This past year the IHRMP published a 62-page "how to" brochure titled "Regenerating Rangeland Oaks in California" that provides easy-to-understand instructions on how to plant and grow oaks. More than 700 copies have been purchased.
Impact: The information developed by the IHRMP has been used to successfully establish oaks in plantings throughout the state. Utilizing this information, The Nature Conservancy has restored hundreds of acres along the Sacramento and Cosumnes Rivers with woody plants, including valley oaks. Along state highways and intersections, California Department of Transportation has planted numerous native oaks during the last decade The success rate of these planting efforts have continually improved as they have adopted the UC-IHRMP methodologies.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: Spring-ecosystem structure and function on California's oak woodlands
Description: Objectives: 1. Assess cattle grazing effects on spring-ecosystem function by estimating energy flow and nutrient cycling among plant, litter, and soil pools. 2. Assess spring-ecosystem nitrate interception and transformation potential at the terrestrial-aquatic interface to determine the relative importance of these ecosystems to the oak woodland matrix and downstream aquatic ecosystems. 3. Test differential vegetation canopy effects on spring-ecosystem water quality. 4. Continue monitoring channel morphology at original nine spring sites.
GSY = 3. This research to study the effects of various grazing treatments on spring-fed wetlands of the Sierra Nevada foothills has found that in some cases plant composition can be manipulated with grazing where lightly grazed sites maintained a greater diversity and evenness of species. Total plant cover did not differ among the sites after 7 years, but after 10, moderately grazed sites showed significant decreases in cover (indicating the importance of long-term monitoring). The effect on water quality varied, but in certain wetlands the removal of grazing resulted in increased nitrate concentrations in waters flowing out of the spring. On the other hand, removal of grazing also resulted in lesser emissions of methane, a potent greenhouse gas. Channel morphology did not vary with treatment, but the species richness of aquatic insects tended to decrease with increasing grazing.
Impact: The effect of grazing on spring-fed wetlands is complex, but in a broad sense, these studies indicate that some level of grazing is probably desirable, particularly from the standpoint

of species diversity. In addition, removal of grazing can have a negative impact on water quality by increasing the concentration of nitrates that are released into the springs. However the results also suggest that high levels of grazing can damage these systems and that grazing in general may increase greenhouse gas emissions. Therefore, appropriate management, including adjustments to the timing and intensity of the grazing, should be used to maximize the health of these wetlands and their benefit to the larger landscape. In general, these studies have, and will continue, to inform how we manage these important systems in the years ahead.
Funding Source: Mcintire Stennis and State
Scope of Impact: State Specific

Theme: 4.14 Natural Resources Management
Title: Taxonomic and Biological Investigations on Microlepidoptera
Description: Objectives: 1) To develop a tribal and generic classification of tortricine moths (Tortricidae: Tortricinae) for the New World. 2) Inventory of Lepidoptera diversity, emphasizing larval biology of microlepidoptera. My goals are to document the diversity and plant relationships sufficiently such that a framework of the community can be constructed: species present, which are resident, and why. Comparison of several such studies should enable development of predictive criteria based on the plant community, in relation to conservation: what we can project about Lepidoptera, the major herbivore group (and therefore the insect community as a whole), and how much sampling will be needed to achieve data that enable predicting overall biodiversity with confidence. Emphasis of research during the coming five years will continue to focus on these questions. 3) To develop knowledge of comparative behavior and biology (oviposition patterns, larval habits, diapause strategies etc.), as an integral element of biosystematics of these moths, at both higher (family, subfamily, tribe) and lower (genus, species) taxonomic levels. Research focus continued on biodiversity inventory in relation to conservation, on hybrid viability tests between populations of the Argyrotaenia franciscana complex (Tortricidae), and molecular systematics of Syndemis (Tortricidae). We carried out field research in 10 California counties and in OR, WA, NC, SC, TN, and Costa Rica, on 77 dates, including faunal surveys at 4 reserves in CA: Inverness Ridge, Marin Co.(NPS); Big Creek and Hastings Reserves, Monterey Co. (UCNRS); and San Clemente Island, Los Angeles Co.(USN). On San Clemente I. in May and Sept.-Oct. we recorded about 155 species of Lepidoptera (69% of the total known fauna), of which 55 were new to the island list, a 32% increase. Included were 32 species based on larvae or leaf mines. We conducted 35 intra- and inter-populational hybrid trials involving 5 populations of the A. franciscana/citrana complex, with emphasis on A. isolatissima. In collaboration with D. Rubinoff (U. Hawaii), we trapped Syndemis males using pheromone baits at 3 isolated populations of Monterey pine and Coast Redwood and have begun analysis of the samples for molecular characteristics. Altogether we processed 153 oviposition, mating, and larval collections (33% female Tortricinae confined for eggs) and reared adults of 63 species (83% Microlepidoptera).
Impact: This project discovers, organizes, and puts into database form biodiversity inventory of Lepidoptera (moths and butterflies) and their larval host plant relationships in natural reserves and parks (federal, state, county, The Nature Conservancy, and University of California), providing baseline data for conservation efforts.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.15 Nutrient Management
Title: Leaf Color Chart: A Cost-Effective Tool for Nitrogen Management

Description: Precise application of nitrogen (N) fertilizer based on plant need and location in the field greatly improves fertilizer use efficiency in rice growing. This maintains yield while helping to reduce nitrogen runoff into surface and ground water. Moreover, higher energy costs have increased fertilizer prices. One way to improve the economics of rice production is to estimate tissue N status at critical points in the plant's life cycle. To do this effectively, a rice grower must evaluate large acreages and make management decisions quickly.
A UCCE farm advisor has developed an easy-to-use, inexpensive and accurate tool for determining nitrogen status in rice plants--the Leaf Color Chart. The LCC is a series of panels with colors based on the wavelength characteristics of rice leaves. The spectral data were transferred into color-matching computer software and pigment formulations were developed utilizing light and heat-stable colorants. The color panels are constructed of acrylic plastic that withstands high temperatures. Ribbing was added to the individual color panels to reduce glare. The resulting color chart is durable and ready for use in the field. On-farm studies have demonstrated that the LCC accurately predicts leaf N levels in major California rice varieties at growth stages when N status is most critical for high yields. UCCE maintains a list of growers using the LCC so new calibration data can be sent via mail.
Impact: In the Sacramento Valley, over 300 Leaf Color Charts are in use as it has become an integral part of the fertility management program for farm managers and private consultants. The LCC evaluates nitrogen status of a rice crop cost-effectively, avoiding leaf sampling, laboratory analysis costs and time delays in receiving the results. (UC's Office of Technology Transfer has filed for a patent on the LCC concept and the technological innovations used to produce it.)
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.18 Recycling
Title: Grasscycling for Green Waste Reduction
Description: Responding to a statewide shortage of landfill space, in 1990 the California Assembly passed AB939, which required California municipalities to reduce solid waste by 50% within 10 years. The California Integrated Waste Management Board (CIWMB) staff asked an environmental horticulture advisor in Alameda County, to do research and develop educational materials for municipalities and the public about reducing green waste, which comprises a large portion of California's waste stream. With his technical assistance, the CIWMB developed the first comprehensive brochure on the practice of "grasscycling", the natural recycling of grass by leaving clippings on the lawn when mowing. He also initiated a two-year research project at the UC Bay Area Research and Extension Center. The project, results of which have been widely published, quantified both the volume of grass clippings being disposed of as green waste and the amount of nitrogen lost as a consequence. The CIWMB and California municipalities used these figures to educate the public. In 1999 he helped CIWMB develop a video on the subject of grasscycling. Both the video and related printed material have been distributed throughut the state.
Impact: By 2000, a majority of California's municipalities reached the 50% waste reduction goal. Although data are not available on how much of that reduction was green waste, indications are that this relatively easy and environmentally beneficial technique played a significant role in reducing the waste steam. Rough estimates by CIWMB staff indicate a significant downward trend in the total amount of green waste (leaves, grass clippings, branches, prunings, trimmings, etc.) disposed of in landfills. In 1990, 6.2 million tons of yard waste was 14.6% of total waste going to California landfills. In 1999, 3.9 million tons of yard waste was 10.3% of the total.

Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.19 Riparian Management
Title: Hydrogeomorphic Restoration of Riparian Agricultural Land
Description: This study aims to determine the geomorphic and hydrologic potential of northern California's riparian agricultural lands to revert back to healthy ecosystems that reduce financial losses from floods. The geomorphic potential is defined as the elevational, stratigraphic, and sedimentary conditions necessary for riparian habitats to exist at all. The hydrologic potential interacts with the geomorphic conditions and is defined as the flow magnitude, duration, frequency, timing, and flashiness, which together drive many ecological processes and functions in riparian systems. Specific objectives with respect to a northern California riparian agricultural system include the quantification of the relative proportion of vertical accretion due to alluvial influx of inorganic sediment versus in situ biomass accumulation, the characterization of the spatio-temporal distributions of habitats, the determination of the amount and direction of energy driving changes in sediment patterns, the assessment of historical and pre-historical physical stability, and the simulation of the natural flow regime resulting in a hydrogeomorphically viable restoration. Processing and analysis of sediment cores from agricultural floodplains continued throughout the year. My group has now processed all 12 cores that were collected. 4 cores have been analyzed in great detail using multi-proxy analysis while the remaining 8 cores have been inspected and analyzed for a subset of characteristics. Also, seismic-reflection surveys have been performed using our new state-of-the-art system. The comprehensive dataset that has been generated is unprecedented in floodplain studies in terms of its spatial resolution, its balance of temporal resolution and depth of coring, and the number of environmental variables that have been measured. The cores contain a 40,000-year record of floodplain processes, including significant information on pre- and post- American land use impacts on the floodplain at the junction of the Cosumnes, Mokelumne, and Sacramento Rivers. Now that the dataset is complete, I have turned my attention to scientific publication and to outreach. My data has been used by other UC Davis researchers and by agricultural landowners to aid computer modeling of alternative land use scenarios that balance environmental and agricultural goals. The first of many scientific papers based on this data is now in peer review and several others are in various stages of preparation. Field studies of floodplain hydrogeomorphology have continued despite the dry conditions that have persisted since this project began. Data from sensors that monitored flow conditions during the 2002 flood season were obtained and analyzed as well as sediment data from the floodplain surface. The amount of data collected in 2002 greatly exceed that for 2001 and confirmed that our monitoring approach is working. An aerial photogrammetric survey of the floodplain was performed and this yielded a topographic map of the monitoring region with a 20-cm vertical resolution. Co-analyses of my floodplain hydrological data with other scientists' ecological and watershed data have revealed important interconnections but have also identified needs for improvement in monitoring. In response to this finding and in anticipation of a wetter year for 2003 based on climate models, I have added several more velocity and depth sensors to the field site using funds from a recently obtained $750,000 multi-investigator award from the Packard Foundation.
Impact: Riparian agricultural lands in California face the dual problem of high exposure to flood risk and low availability of natural habitats to sustain a healthy ecosystem. In this project the pre-historic, historic, and on-going environmental conditions present at a representative area are being studied. Data generated is being used for water resource planning and sustainable land-use that both restore nature and protect land from flood damages.

Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.21 Soil Quality
Title: Alternative Straw Management Practices on Available Soil Resources in Flooded Rice Fields
Description: Objectives: 1. Determine the effect of residue incorporation and winter flooding on rice residue decomposition, pest pressure and waterfowl use. 2. Determine the impact of waterfowl use on rice residue decomposition, pest pressure and yield on farms with alternative residue and water management practices. 3. Develop new long-term management strategies that promote waterfowl use and maintain or improve economic profitability. The agronomic benefits of foraging waterfowl in winter flooded rice fields in the Sacramento Valley of California (U.S.A.) was quantified. Fifteen winter flooded rice fields along a 105 km long transect, each with 5 pairs of waterfowl exclosures and control plots were used to measure residue decomposition in spring, and weed biomass and grain yield at harvest. Experimental exclusion of waterfowl resulted in a significant increase in remaining residue from 1014 to 1233 kg ha-1 across the transect At seven sites with high waterfowl activity, remaining residue increased from 836 to 1549 kg ha-1 when waterfowl were excluded from the plot. Grassy weed biomass increased from 44 to 91 kg ha-1 over the whole transect in absence of waterfowl. At seven sites with high waterfowl activity the grassy weed biomass more than doubled in the absence of waterfowl from 89 to 204 kg ha-1. No significant yield effect could be detected. Winter flooding rice fields resulted in mutual benefits for waterfowl and agriculture that could be of particular significance in organic farming systems.
Impact: Rice farmers winter flood their fields to promote straw decomposition. Winter flooded fields also provides winter habitat for migrating waterfowl. By growing a crop and converting the land into wetland, a dual purpose of the land is achieved: agricultural production and wildlife habitat creation. Straw incorporation also increases soil organic matter and provides nutrients to the following crop.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Animal Manure and Waste Utilization, Treatment, and Nuisance Avoidance for a Sustainable Agriculture
Description: Objective 3. Develop and refine physical, chemical, and biological treatment processes and engineering systems for management of manures and other wastes.
The system was designed to handle 0.056 m3 (2 cu ft) of manure per cow per day. Two adjacent structures were each 134 m (440 ft) long and 16.5 m (54 ft) wide. The depth of the structure was 2.1 m (7 ft). The floor and inlet wall were made of concrete. Additionally, concrete pillars were set 1.5 m (5 ft) on center to support tri-bar flooring. The spacing in the flooring was 6 mm (0.25 in). The flush water and manure flowed in a sump prior to being pumped into the gravity basin. The basin used weeping walls that allowed the water to drain into the retention structure. Each structure was filled for approximately eight weeks and then allowed to dry as the alternate structure was filled. During the last week of drying, the structure was cleaned using a front end loader. Manure was land applied using conventional spreaders. Samples were taken for TS and FS at various increments from the inlet prior to cleaning a structure. An excavator was used to remove the samples. Samples were placed in ziplock bags, stored on ice and transported to the laboratory. Samples were weighed into pre-weighed aluminum dishes and dried at 100 Degrees

C (212 Degrees F) oven for 24 hr, reweighed, and ashed at 540 Degrees C (1000 Degrees F) for 4 hr. Samples were collected on four dates during spring/summer, 2001. Samples were taken from 2, 3, 3, and 12 flushes. Influent samples were taken at 15 to 30 second intervals initially, and at minute increments after eight minutes. Samples were collected as water dropped into the weeping wall system into 250 ml nalgene bottles. Effluent samples were taken at the outfall pipe to the retention pond. Bottles were stored on ice and transported, refrigerated prior to laboratory analyses. Samples were acclimated to room temperature, mixed thoroughly, and replicate 20 g samples were weighed. Beakers were placed in a 180 C drying oven for 4 hr and then in a 100 C oven. Total solids were calculated by the difference in the dry beaker weight with the sample and the dry weight of the beaker. Beakers were then ashed at 540 C for 4 hr. Fixed solids were calculated. Beakers were washed thoroughly, rinsed three times, and dried in a 100 C oven. One sample per batch was emptied to calculate cv for estimating TS using the shake and pour method. This served as an internal reference. Replicate samples with cv greater than 7.5% were re-analyzed. Data were used to calculate mean TS and FS. The average (n=338) TS concentration was 1.52% +/- 0.53 and coefficient of variation of 34.7%. The effluent TS concentration averaged 0.62% +/- 0.14 and coefficient of variation 23.0%. The TS concentration of influent samples was not normally distributed. . Average percent TS removal for each sampling trip were 63.4, 53.5, 63.1 and 49.3 %. Average percent FS removal for each sampling trip were 11.2, 0.9, 10.5, and -4.1%. This method of solid separation was superior and more consistent than previously analyzed mechanical separators or gravity flow settling basins.
Impact: The weeping wall system was far more consistent and effective at removing solids from dilute liquid waste streams. This approach is reducing maintenance (less than with mechanical screens) and the labor and equipment needed for clean-out is periodic and more desirable with this system.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AL, AR, CA, FL, GA, HI, IL, IN, IA, KY, LA, MI, MN, MS, NC, OH, PA, SC, TN, TX, VA, WI, CO, NON-SAES: USDA/NRCS, USDA/ARS, SOUTHERN RESEARCH & OUTREACH CTR. (MN).

Theme: 4.23 Water Quality
Title: Applied Limnology of Clear Lake, California
Description: This project has two objectives. The first is to continue to provide the best possible applied science for the agencies managing this complex, multiply stressed ecosystem. The second is to continue to develop methods for the assessment of stresses to aquatic ecosystems. The focus of work during this project period will be the assessment of the impact of acidity, sulfate, and mercury on the Clear Lake ecosystem. The findings will be widely applicable to other lakes with similar problems. During this reporting period, our main effort has been the writing up of our accumulated data on Clear Lake for a special Issue of Ecological Applications. Some twenty manuscripts are being written on all phases of the investigation over the past year. We have also taken short cores to sample the upper layers of the sediments to resolve problems encountered in interpreting the tops of cores that may have over-penetrated. Mercury contamination persists right to the top of course, indicating that EPA's 1992 remediation efforts were unsuccessful.
Impact: Our data and advice continue to be utilized by EPA, the Regional Water Quality Control Board, and to Lake County regarding contamination problems in Clear Lake. Project results have been used in the TMDL decision process for mercury discharges into the lake, the first step in successfully reducing mercury contamination in Clear Lake..
Funding Source: Hatch and State

Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Aquatic Invertebrates in Assessments of Anthropogenic Impacts in Calif Streams, Rivers and Wetlands
Description: The research plan for the next five years will include basic ecological studies of aquatic ecosystems directed towards the following applied questions and issues: (1) investigation of the life history and population dynamics of the Chinese mitten crab in the San Francisco Estuary; (2) evaluation of the effects of prescribed burning on aquatic and riparian habitats; (3) analysis of ecological processes in intermittent waters by determining how landscape and changes in land use affect dispersal between vernal pool habitats; (4) examination of how the integration of landscape scale attributes with local scale habitat features improves the ability to explain biological community variation, and (5) development and evaluation of new biomonitoring tools, including species traits characteristics and the Reference Condition Concept as applied to multiple floral and faunal assemblages. Stream restoration projects have become increasingly common in California. From review of these studies, it is apparent that the need for systematic post-project evaluation, particularly for small-scale projects, is a critical omission in most restoration projects. A 70-m restored reach of a small urban stream, Baxter Creek (in Poinsett Park, El Cerrito, California) was used as an example of how restoration projects can be quickly and inexpensively evaluated using habitat, biological, and resident-attitude assessments. The restoration involved opening a previously culverted channel, planting riparian vegetation, and adding in-stream step-pool sequences and sinuosity. Replicated benthic macroinvertebrate samples from the restored site and an upstream unrestored site were compared using several metrics, including taxa richness and a biotic index. Both biological and habitat quality improved in the restored compared with the unrestored section. However, when compared with a creek restored 12 years before, habitat condition was of lower quality in the recently restored creek. A survey of the neighborhood residents indicated that, overall, they were pleased with the restored creek site. The approach used in this demonstration project is applicable to other small-scale evaluations of urban stream restorations. Furthermore, it demonstrates the value of benthic macroinvertebrates as indicators of environmental health in aquatic habitats of California.
Impact: Throughout the industrialized and developing world, water quality monitoring approaches are being based on benthic macroinvertebrate assemblages. This model uses the largest data set available for North America to evaluate the accuracy and usefulness of these multivariate modeling approaches.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Benefits and Costs of Resource Policies Affecting Public and Private Land
Description: Objectives: 1. To elucidate the biological, physical and chemical processes that control the efficiency of constructed wetlands in the cleanup of toxic trace elements from agricultural and industrial wastewater. 2. To determine the role of microbes and plant rhizosphere interactions in determining trace element availability to plants in uplands and wetlands. 3. To improve the efficiency of phytoremediation by elucidating and genetically manipulating mechanisms of trace element sequestration, accumulation, and volatilization in plants. 1. Valuing changes in Recreational Access 2. Benefits and Costs of Agro-environmental Policies 3. Benefits Transfer for Groundwater Quality Programs 4. Valuing Ecosystem Management of Forests and Watersheds The Terry 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. Recent developments in ecology, plant physiology, and molecular biology are summarized below. Ecology research: Clean water is currently the most important factor limiting agriculture in the western United States. However, agricultural irrigation water leaches salts and trace element contaminants, such as Se, from the soil, and quickly becomes unusable for irrigation of many crops. The integrated on-farm drainage management system, or IFDM, is an innovative solution to this problem being used at the Red Rock Ranch, CA. Clean water is used to irrigate non-salt tolerant crops. The drainage water from these fields are then used to irrigate successively more salt-tolerant crops, until only a small amount is deposited into a solar evaporation pond. Before this approach can be applied on a more widespread scale, it must first be determined if the IFDM system poses an ecotoxic risk to wildlife with respect to Se. We have earlier found high concentrations of Se in plant tissue and soil from the halophyte fields of the IFDM system. Determination of Se ecotoxicity requires not only the quantitation of total Se present but also a thorough and complete speciation of Se, particularly organic Se, in different compartments of the ecosystem. This is because Se toxicity and bioavailability are strongly dependent on Se chemical form. In 2002, we have conducted three sampling trips at the IFDM system in Red Rock Ranch, collecting plant roots, shoots, seeds, soil, and insects from areas of different salinity. We have used X-ray absorption spectroscopy during two trips at the Stanford Synchrotron Radiation Laboratory to speciate inorganic Se forms. Additionally, we have developed HPLC methods to identify and quantitate selenoamino acids from plant tissue and are now analyzing samples. Plant Biochemistry, Molecular Biology, and Physiology: We have developed double homozygous Indian mustard plants overexpressing both ATP sulfurylase (APS), from Arabidopsis thaliana, and selenocysteine methyltransferase (SMT), from the Se-hyperaccumulator, Astragalus bisulcatus and Indian mustard expressing both gamma-glutamyl cysteine synthetase (ECS) and glutathione synthetase (GS). We expect that the double transgenic plants will combine the traits of their single transgenic parents and, therefore, have even further increased phytoremediation potential. We have completed the molecular characterization of the APSXSMT plants and have begun their physiological characterization. In seedling tolerance experiments, we have shown that the APSXSMT seedlings tolerate selenate and selenite better than wildtype and single transgenic plants. We expect that the double transgenics overexpressing GS and ECS will have increased tolerance to heavy metals because they overproduce phytochelatins, which act as metal detoxifiers. Agencies have a critical need for economic value estimates associated with resources they manage. In work closely coordinated with the California Department of Transportation, the Beneficial Use Values Database (BUVD), a data base of beneficial use values of water, was assembled; this information was used by Caltrans contractors in an evaluation of stormwater retrofits for the San Francisco Bay Bridge; a benefit-cost evaluation tool, the Beneficial Use Values Calculator (BUVC), was developed and methods for reducing or eliminating one source of bias in contingent valuation estimates of environmental values were developed. The State Water Resources Control Board is planning to use the BUVD and BUVC; the willingness to pay by California households for removal of impairments to beneficial uses of water bodies was estimated. The demand for recreational fishing in Oregon coastal counties and the value of fishing opportunities were analyzed for the Pacific States Marine Fishery Commission and the Southwest Fishery Science Center of the National Marine Fisheries Service. The demand for beach visits by San Diego county residents and the value of those trips and beach attributes were estimated as part of work for Caltrans. New conceptual advances include a model of demand systems for recreation that occurs at multiple sites, which generates estimates of the value of each site under a wider range of demand conditions than do existing flexible

models. This was used to estimate the value of whalewatching recreation at three Northern California sites. A model of inverse demands for travel to a site separately from time spent on site was developed and applied to salmon fishing in Alaska. This model is important because it relaxes the assumption that travel has no value, which is made in virtually all current models. As part of a national team of researchers, a data base on values of sport fishing nationwide was assembled from estimates in the existing literature. A data base on the economic values of water was assembled from estimates available in the existing literature. Assessing the value of time spent in recreation and other activites related to the environment is the most seriously underdeveloped area of the nonmarket valuation literature. The correct way of specifying recreation demands when time is an important cost was discovered, and it was shown how this can be used to jointly estimate the value of time with other activities that are observed. Applications of this approach include joint estimation of recreation demand and the value of time, and joint estimation of willingess to pay for environmental programs in time and in money. A parallel analysis identified the household shadow value of grain in Namibian households from their willingness to pay money and grain stocks for environmental programs. A method for identifying multiple values of time people have for different activities was developed, and when implemented the approach identified several key values of time that are relevant to research problems in several distinct literatures, the valuation of life and limb, the evaluation of transportation projects, and in recreation demand.
Impact: The multi-disciplinary research in the Terry lab provides a fundamental understanding of the assimilation of selenium and other trace elements by plants and microbes. Results of this work is being used to efficiently and economically clean up trace element-contaminated environments. This research is utilized by the California Department of Transportation and other public agencies charged with maintaining and improving California water quality by providing information on economic values affected. It has also improved methods of assessing the economic values of nonmarket activities. The research on benefits transfer in water pollution control is being used by the California Department of Transportation in its stormwater quality program, significantly improving the allocation of scarce resources to effect the greatest possible improvements in stormwater quality.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Farm Water Quality Planning
Description: Irrigated agriculture has been identified as one of the potential sources of pollutants in watersheds throughout California. Regional Water Quality Control Boards regulate water quality through their Total Maximum Daily Load program and permit programs for agricultural runoff. However, growers can avoid external regulation by managing their own land to meet water quality standards. Voluntary use of these management practices also is a positive opportunity for farmers to demonstrate environmental stewardship of their land.
A working group of 25 Cooperative Extension farm advisors and specialists have developed the Farm Water Quality Planning short course, in partnership with the USDA Natural Resources Conservation Service. This short course provides a template for irrigated agriculture producers to describe their ongoing efforts to protect water quality. An individual management plan produced during the course assesses their operations for potential sources of nonpoint pollution, including sediments, pesticides, nutrients, and salinity. In the plan, they can document practices they already have in place that protect water quality, and select practices that may address potential

sources of pollution identified in a site assessment. Methods to evaluate the efficacy of selected water quality management practices are also included.
Impact: Water quality management plans help growers organize their efforts both individually and within watershed groups. The current audience includes irrigated agriculture producers in Santa Barbara, San Luis Obispo, Monterey, San Benito, Santa Cruz, Santa Clara, and San Mateo counties. To date, six watershed groups have completed the short course, with a total of 100 growers receiving training and over 60 completed plans. Additionally there has been interest in extending the Farm Water Quality Planning short course to irrigated ag producers in the Sacramento and San Joaquin Valleys and on the North Coast.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Microirrigation Technologies for Protection of Natural Resources and Optimum Production
Description: Objective #1: To evaluate and refine microirrigation management strategies to promote natural resource protection and optimal crop production. Objective #3: To assess and develop decision criteria for adoption of microirrigation technologies. Objective #4: To promote appropriate microirrigation technologies through formal and informal educational activities. Regulated deficit irrigation (RDI) was managed using the plant-based method of midday stem water potential (SWP) in a number of prune and almond demonstration orchards. After 4 to 5 years of experience with this program in prunes, most of the grower cooperators have switched to SWP-based RDI as the standard method of irrigation. In a number of these orchards, we have also reduced the number of monitored trees from 10 to 5, with the same apparent ability to effectively manage the RDI regime, making the method more attractive to growers. After 2 years of demonstrating that RDI can reduce hull rot and improve nut harvestability in almonds, we have found no negative consequences to almond nut yields, and have in fact found some evidence of a slightly positive effect of RDI on the number of nuts (+2%), compensating for a slight decrease (-3%) in average nut size. In one almond orchard, it was possible to reduce irrigation by about 50% where the soil had good water holding characteristics, allowing a substantial savings in water, in addition to improving the orchard floor conditions for the drying of the harvested nuts.
Impact: Compared to the currently recommended levels of irrigation for prune, the substantial water savings that are generated (57% - 70%) are of great benefit to the states' water supply, as more prune growers adopt midday SWP for the management of RDI. The cultural benefits experienced by almond growers provide for a more efficient nut harvest, in addition to savings in water that also approach 50%, under some soil conditions.
Funding Source: Hatch Multistate Research and State
Scope of Impact: AZ, CA, FL, GU, HI, ID, IA, KS, MN, TX, VA, WA, WY, USDA/CPRL, USDA/CPSWPRC, USDA/WMRL, VI

Theme: 4.23 Water Quality
Title: The National Atmospheric Deposition Program (NADP), UC PI #1
Description: Provide a national framework for collecting and disseminating quality assured atmospheric deposition data to: (1) characterize geographic patterns and temporal trends in biologically important chemical deposition, and to (2) support research activities related to: (a) productivity of managed and natural ecosystems; (b) the chemistry of surface and ground waters including estuaries; (c) the health of domestic animals, wildlife, and fish; (d) human health; (e)

the effects of atmospheric deposition on visibility and materials; and (f) discern source-receptor relationships. There were two main foci for our Experiment Station research in the past year. The first focus was a continued characterization of organic nitrogen in fog waters and atmospheric fine particles (PM2.5) from the Davis NADP site (CA88). This work was described in detail in our last AD-421 report, but the papers describing our results were published in the past year. There are several major findings described in these papers: 1) Although it is rarely measured, we found that organic nitrogen (ON) accounted for a significant portion, typically 15 - 20%, of the total N in fine particles and fog waters. This indicates that ON needs to be accounted for in budgets of nitrogen deposition. 2) Amino compounds, primarily in combined forms such as proteins and peptides, represented approximately 20% of the ON in the fog waters and PM2.5. This is significant since amino compounds are generally quite bioavailable. 3) In conjunction with departmental colleagues we found that dissolved organic N (DON) and amino compounds are even more important in soils collected from the north California coast. DON dominated the nitrogen pool in soil extracts, accounting for 77 to 99% of the total dissolved nitrogen. Furthermore, combined amino acids were the dominant component of organic nitrogen, accounting for 48 to 74% of the total DON. Free and combined amino compounds accounted for 59 to 78% of the DON. Because amino acids can be an important nitrogen source for some plants, soil DON may play an important role in plant nutrition and ecosystem function. The second focus of our work in the past year was on characterizing the concentrations of gaseous and particulate nitrogen (N) and phosphorus (P) in the air in and around Lake Tahoe. Atmospheric deposition of N and P has been a major factor responsible for loss of clarity in the lake. To characterize atmospheric nitrogen and phosphorus we collected summertime aircraft samples from two locations in the Sierra-Nevada mountains west of Lake Tahoe ("low-Sierra" and "mid-Sierra" sites) and in the Tahoe Basin. The average total gaseous and particulate N concentrations (10) measured over the low- and mid-Sierra were 660 (270) and 630 (350) nmol N / m3-air, respectively. Total airborne N concentrations in the Tahoe samples were one-half to one-fifth of these values. We were also able to collect samples from a forest fire burning just outside the Tahoe Basin. The forest fire plume had the highest concentration of atmospheric N (860 nmol N / m3-air) and a greater contribution of organic N (ON) to the total N compared to non-smoky conditions. Airborne P was rarely observed over the low- and mid-Sierra but was consistently present at low concentrations over Lake Tahoe. Phosphorus in the forest fire plume was present at concentrations ~ 10 times greater than over the Tahoe Basin. Overall, our results suggest that out-of-basin emissions (i.e., those from the Central Valley) could be significant sources of nitrogen to Lake Tahoe during the summer and that forest fires could be important sources of both N and P.

Impact: Our work this period has two main environmental impacts: 1) Organic forms of nitrogen are an important part of the atmospheric nitrogen budget and need to be considered when determining the effects of N deposition. 2) In the summer, both forest fires and air transported from the Central Valley can be significant sources of nutrient pollution to Lake Tahoe, which contributes to the loss of lake clarity. This latter finding has significantly changed the approach to reducing the eutrophication of Lake Tahoe, focusing management measures on locally controllable sources of P input into the lake. This has significantly improved the management strategies.

Funding Source: Hatch Multistate Research and State

Scope of Impact: CA, CO, FL, GA, IL, IN, KS, KY, LA, MA, ME, MI, MN, MT, NC, NE, NYC, OH, OR, PA, TX, UT, VA

Theme: 4.23 Water Quality

Title: The National Atmospheric Deposition Program (NADP), UC PI #2
Description: Provide a national framework for collecting and disseminating quality assured atmospheric deposition data to: (1) characterize geographic patterns and temporal trends in biologically important chemical deposition, and to (2) support research activities related to: (a) productivity of managed and natural ecosystems; (b) the chemistry of surface and ground waters including estuaries; (c) the health of domestic animals, wildlife, and fish; (d) human health; (e) the effects of atmospheric deposition on visibility and materials; and (f) discern source-receptor relationships. Our major focus has been aircraft sampling of meteorological conditions and air quality in several areas of central California: the San Francisco bay area, the northern San Joaquin Valley, the southern Sacramento valley, the Sierra Nevada east of Sacramento and the Lake Tahoe Basin. We have participated in large, multi-investigator regional studies (such as Central California Ozone Study - 2000, Lake Tahoe Atmospheric Deposition Project) as well as individual projects with funding from the US EPA, California Air Resources Board, The San Joaquin Valley Research Consortium, and the UC division of Agricultural and Natural Resources. Analysis and interpretation of these measurements have provided significant insight into the chemical composition of air pollutants in these areas and their transport and dispersion to rural areas. In addition to flying instruments which measure standard meteorological variables, we flew several real time pollutant monitors (ozone, oxides of nitrogen, particle concentrations) and a filter-denuder system to collect "grab" samples of gases and particles for laboratory analysis. From our studies and those conducted by others it appears that in summer, the Bay area has only a minor impact on the air quality in the Sacramento valley and northern Sierra. Conversely, a significant fraction of air pollutants are transported to the San Joaquin Valley in summer and impact the southern Sierra appear to originate in the Bay area. High concentrations of photochemical smog constituents frequently reach elevations of 5000 to 6000 feet in the Sierra, but either stop their eastward travel about these altitudes or become vertically mixed such that high concentrations of these pollutants infrequently reach the high Sierra. In the High Sierra, a general decline in the regional air quality is seen but rarely the highly polluted air attributable to a plume from a specific urban source. Results from the filter-denuder sampling include documenting concentrations of ammonia, nitric acid, phosphorous, total gaseous and water soluble particulate inorganic and organic nitrogen in the Sierras east of the Central Valley and in the Tahoe basin. We find high concentrations of these in both areas but concentrations in the Tahoe basin are about one-forth those over the foothills. We have sampled forest fire smoke and find much higher proportions of ammonia, phosphorus and organic nitrogen than in non-smoky conditions. Nitrogen and phosphorus containing pollutants are depositing into Lake Tahoe, fertilizing algae growth and reducing lake clarity. Sources of nitrogen appear to be combustion and agricultural emissions from the Central Valley plus emissions from biomass burning.
Impact: These studies document the degree to which non-urban areas downwind of pollution sources are affected by the ensemble of emissions from urban, transportation and agricultural sources. In particular how these areas often experience concentrations greater than those found in the urban areas themselves as they are exposed to the accumulation of all emissions along the traveled trajectory. Greater knowledge of the sources of these pollutants, their transformations and dispersion as they travel and their deposition into sensitive ecosystems is being used in developing viable plans to reduce these impacts.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA, CO, FL, GA, IL, IN, KS, KY, LA, MA, ME, MI, MN, MT, NC, NE, NYC, OH, OR, PA, TX, UT, VA

Theme: 4.23 Water Quality

Title: Natural Attenuation of Cryptosporidium Parvum during transport in watersheds
Description: The overall objective of the proposed work is to understand the natural attenuation of viable Cryptosporidium parvum (C. parvum) during transport from agricultural source areas to surface water supplies. The working hypothesis is that both background water quality conditions and association with natural sediments mediate the rates of C. parvum transport and inactivation in surface waters. Animal operations have been implicated as one of the primary sources of the human pathogen Cryptosporidium parvum (C. parvum) in streams. As a result, agricultural operations have been increasingly forced to implement strategies to control pathogen delivery to surface waters. Requirements for best management practices (BMPs) such as buffer stripes are based on the assumption that pathogens may be readily transported to downstream water supply intakes once runoff reaches a stream. However, recent evidence suggests that pathogen transport in streams is mediated by interactions with suspended and bed sediments. This implies that there may be a significant in-stream attenuation of C. parvum concentrations before agriculturally-derived waters enter downstream water supply systems. In this project, we examine the in-stream attenuation and net downstream transport of viable C. parvum oocysts in surface waters. Our innovative laboratory experiments specifically examine: 1. C. parvum association with natural sediments, 2. deposition in streambed sediments, 3. downstream C. parvum transport, and 4. the effect of suspended particle interactions on C. parvum viability in streams. On the basis of these experiments, tools will be developed to predict the net attenuation of viable C. parvum oocysts between upstream agricultural discharge points and downstream surface water supplies. Our work supports efforts by the dairy, swine, and livestock industry, by agricultural and urban planners, and by decision makers providing them with improved tools for assessing and managing C. parvum transport in watersheds. The research work involves separate examinations of the oocyst surface properties, of interactions with suspended solids in streams, of interactions with stream bed sediments, and of the overall transport behavior and viability in streams. During the first year, we setup the oocyst collection, purification and delivery system for the various experiments at University of California, Davis (UCD) and at Northwestern University in Chicago (NWU). All oocysts used in the experiments are obtained fresh from fecal samples at dairies in Tulare County, California. We also created the capacity for C. parvum analysis in water samples at NWU (in addition to the existing analytical lab at UCD) so that samples could be analyzed at the location of the experiments. Once in place, we began a suite of experiments that will continue throughout the second and into the third year of this project.
Impact: The results of our project are greatly improving our ability to understand the natural filtering ability of smaller streams that receive Cryptosporidium parvum, a potentially deadly waterborne pathogen. Currently, the natural filtering ability of streams is not taken into consideration when designing buffer zones for rangeland farming. Our work has improved the design of these buffer zones and the design of small stream restorations providing significantly better pathogen removal.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Oak Management Impacts on Water Yield and Nutrient Cycling in Annual Rangeland
Description: The first objective is to continue watershed monitoring. This involves collecting stage height and precipitation records and water quality samples. The work from this project will be integrated with that from other projects at the Sierra and Hopland field stations. A second objective is to learn more about the nutrient dynamics in the watershed. This includes developing more data on the characteristics of the suspended sediment. A third objective of the project is to

develop an understanding of the source of baseflow. Previous work indicates that we do not have a full understanding of the source of base flow (the flow when it is not raining) in the watershed. Base flow has a significantly different chemistry than storm flow. A final objective is to provide more of a teaching component to the watershed research. Annual rangelands occupy three million hectares in California, and represent the landscape where California's urban-wild land-agricultural interface is most pronounced. Grazing and prescribed fire are critical vegetation management tools allowing managers to maintain economically feasible agricultural enterprises, reduce fuel loads, improve wildlife habitat and manage weed infestations. However, the watershed-scale impacts of grazing and prescribed fire on watershed processes are not known. To address these issues, we have developed a project that has two primary goals: i) use a paired watershed design to determine the watershed-scale effects of fire and grazing intensity on water quality, hydrology, nutrient cycling and plant community dynamics on annual rangelands and ii) use the experimental watersheds as field classrooms for extension education and university classroom education. The study simultaneously examines sediment, nutrients and microbial pathogens, the primary water quality concerns on California's rangelands. We are completing the pre-treatment calibration phase on four watersheds each at sites in the Sierra Nevada foothills and Coast Ranges. The following treatments will be examined: i) non-managed reference, ii) grazed to 800-1000 kg/ha residual vegetative dry matter (RDM), iii) grazed to 300-500 kg/ha RDM, and iv) moderate intensity prescribed fire. We find that stream water concentrations of nutrients, sediments and pathogens vary dramatically at the storm-event, seasonal and annual time steps. During storm events, sediment and pathogen concentrations increase while nitrate concentrations decrease. Nutrient concentrations also display a distinct seasonal pattern with the highest concentrations at the start of the water year. This pattern results from a temporal decoupling of the nitrogen cycle that occurs in the Mediterranean climate due to distinct wet and dry seasons. There is also considerable variability in the magnitude of constituents exported from watersheds on an annual time step. An 18-yr record at one of our watersheds shows that nitrogen and suspended sediment loadings vary by more than an order of magnitude (total N = 0.2 to 4.0 kg/ha/yr; suspended sediments = 25 to 465 kg/ha/yr). Loadings appear to be related more to total runoff, seasonal distribution of the rainfall, and rainfall intensities than differences in rangeland management practices.
Impact: These studies have provided important information linking rangeland management practice effects to water quality. This information has led to changes in rangeland management approaches reducing impacts to water quality across California's annual rangeland.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Optimization and Design of Vegetative Buffer Strips for Removal of Waterborne Cryptosporidium parvum from Animal Agricultural Runoff
Description: Objectives: Develop practical guidelines for the construction of vegetative buffer strips that effectively reduce by several logs (99 to 99.9%) the concentration of C. parvum oocysts in animal agricultural runoff. Determine the effect of percent vegetative cover on a buffer's filtration efficiency, and how this relationship between percent cover and filtration varies for agricultural soils of differing properties (infiltration rate, organic matter, bulk density), different slopes, and different rainstorm intensities. Approximately 2.3 years of this 3-year project have been completed to date. We are on schedule to complete our assessment of 108 soilboxes around April 2003, with an approximate 4 to 6 additional months for statistical modeling. Analysis of preliminary data suggests that 100 cm of vegetated buffer with >85%

cover, 5 to 20% slope, comprised of silty clay loam, loam, or sandy loam, and precipitation rates of 1.5 or 4.0 cm/hr, produces a 1.0 to 3.1 log10 reduction in waterborne C. parvum oocysts. This strategy should be able to function as a practical beneficial management practice for animal agricultural operators across the USA. On-farm risk factors appear to exist for protozoal diseases such as C. parvum in farm animals, suggesting that the prevalence of infection can be reduced by livestock owners and animal health professionals if management practices are appropriately modified. To supplement this herd health approach, strategic placement of vegetative buffer strips between areas of high fecal deposition and critical source water supplies should further reduce the risk of microbial contamination from livestock production systems.
Impact: Science-based recommendations currently do not exist for recommended set-back distances for microbial water quality. This project provides general quidelines for the necessary width of vegetated buffer to achieve a 90% to 99.9% reduction in waterborne C. parvum in runoff. Implementation of these buffers will significantly improve water quality in terms of reduced pathogen loads.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Predicting Impacts of Non-Point Source Pollution on Ground-Water Quality
Description: The ultimate objective is to develop improved conceptual and quantitative models of migration on non-point source contaminants in complex alluvial aquifer systems so that ultimate consequences of past and future land management strategies can be ascertained. Specific objectives are as follows: #Use our new geostatistical modeling tools to create more accurate characterizations of alluvial aquifer systems. Advance the state of the art In geologic conceptualization and modeling. # Investigate the role of matrix diffusion in regional, subsurface solute transport. #Investigate long-term respknse of water quality in a ground-water system to (a) typical levels of non-point source pollution and (b) reductions in those levels as a result of changes in land management practice. Produce recommendations for land and water management options that will reduce groundwater contamination. #Investigate long-term response of water quality in a groundwater system to irrigation and salinization. Assess sustainability of irrigated agriculture with respect to groundwater quality.
Building on results of my previous research, my 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 shows 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. Our recent 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. An NSF-funded project to perform a field test of age dispersion is underway. Furthermore, we continue to move our developed modeling tools out into the public and private sectors. TProGS, our geostatistical software for modeling heterogeneous subsurface systems has been adopted by the popular groundwater modeling software package, GMS. Further, our random walk computer code for accurately modeling transport of non-point source and point source pollution is being adopted 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 are

leading 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 identifies land-management strategies that will preserve rather than damage groundwater quality.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Purification of Agricultural Drainage Salt and Its Value-Added Applications in Textile Processing
Description: Recovery of sodium sulfate from agricultural drainage wastewater; direct application of agricultural drainage salt in textile dyeing and finishing; utilization of the salt in value-added applications such as detergents. In the study of utilization of agricultural wastes in textile processing, a drainage by-product, drainage salt, has been found usable for 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, this research explored feasibility of producing a value-added product, sodium sulfate, from the waste and utilizing the product in textile dyeing. The results indicated that sodium sulfate could be produced from the salt and could be purified by a recrystalization method in a temperature range within the highest and lowest daily temperatures in summer in the valley. In the past year, we have tested salt samples produced in Rainbow Ranch, Bakersfield, for dyeing cotton fabrics and also worked with a California textile company, U.S. Dyeing and Finishing, Inc. in Southern California to run pilot scale application of the salt. Although the dyed cotton fabrics were not in high quality, we have found the major problem-purity of the salt. The company is still open for our next run of test. We are looking at economic and practical method for purification of the salt.
Impact: We have studied the feasibility of utilizing an agriculture waste, drainage salt, in textile dyeing in laboratory and in a textile dyeing company. Sodium sulfate, as a value-added product, is produced from agricultural drainage salt in California center valley, and can be used in reactive dyeing of cotton fabrics if its purity is improved. Use of the salt in textile dyeing will reduce impacts to water quality.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Rangeland Water Quality Management
Description: Livestock grazing and associated ranch practices may pollute surface water if not properly managed, a great concern to downstream water users and state regulatory agencies. Increased sediment from grazing induced soil erosion; increased stream temperature from removal of streamside vegetation and nutrient loading have the potential to degrade aquatic habitat that is important to several endangered species. Improper management of livestock may result in pathogen loading that can impact domestic water sources.
In 1989, the range livestock industry identified water quality as a high priority issue and in 1990 began discussions with the State Water Resources Control Board, UC Cooperative Extension, USDA NRCS and the California Association of Resource Conservation Districts about a voluntary program through which ranchers address clean water issues on their own propery. These discussions led to the development of the California Rangeland Water Quality

Management Plan (CRWQMP). Approved by California's State Water Resources Control Board in 1995, CRWQMP provides for voluntary development and implementation of ranch water quality plans. Under the leadership of UC Cooperative Extension rangeland specialists, UCCE and USDA NRCS developed a short course curriculum that facilitates development of ranch water quality plans. Ranchers learn about nonpoint source pollution associated with ranching through the Ranch Water Quality Planning Short Course. They become familiar with basin plans and assessments, including the impaired waterbody list and the TMDL priority list. Plans developed during the short course include: property information, ranch goals, ranch facilities and resources, ranch maps, ranch operations and land use, ranch management practices, basin water quality status, nonpoint source self-assessment, planned management practices and monitoring procedures.
Impact: As a result of the Ranch Water Quality Planning Short Course, more than 400 ranchers voluntarily developed water quality plans since 1997 for more than 1,350,000 acres of privately owned rangeland. Based on a survey, 67 percent of these ranchers implemented practices to protect water quality. The most prevalent practices implemented included improved management of dirt roads, installation of riparian fencing and improved livestock distribution. The short course has been a catalyst for the development of several landowner watershed management groups and is being used as a model to address farm water quality on California's central coast.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Reduce Pollution with Proper Fertilizer Timing
Description: Applying nitrogen and phosphorous with irrigation water is a common practice in the Imperial Valley. If the fertilizers are applied incorrectly, the nutrients end up in the drains rather than in the crop. Nitrogen and phosphorous are the two main nutrients that cause eutrophic conditions (high algal biomass and low dissolved oxygen concentrations that cause massive fish kills) in the Salton Sea. Current and proposed federal water quality standards for California require growers to improve the quality of drainage waters. To achieve both federal and state water quality objectives, growers will have to reduce the amount of phosphorous that rearches the drains and the Salton Sea.
Impact: The UCCE advisor's recommendations (Best Management Techniques or BMTs) are being adopted by growers. This is improving fertilizer use efficiency and reducing the nonpoint point source pollution in the Salton Sea watershed. Our educational materials also are used to implement plans to meet the TMDL (Total Maximum Daily Load) regulations.
Our BMTs were included in the Regional Water Quality Control Board (Region 7) silt/sediment TMDL standards. For additional information, please visit our water quality website http://tmdl.ucdavis.edu.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: The Role of Plants in Wetland Ecosystems: Applications for Wastewater Treatment and Bioremediation
Description: Objectives: To determine 1) Carbon budget for emergent macrophytes growing in natural vs. constructed wetlands. 2) Mechanisms by which different wetland species cope with increased levels of salinity. 3) Role of wetland macrophytes in biochemical transformations of selenium and other pollutants. This project focused on elucidating functions of macrophytes in

wetland ecosystems. We studied species growth and decomposition, nutrient uptake and resorption, and tolerance of selected species to increased levels of salinity. Ecosystem processes were explained in terms of life history strategies. Species Selection The species selection concentrated on the emergent macrophytes, tules, cattails and rushes, for the following reasons: 1) These species have previously been suggested as suitable for wastewater treatment. 2) They are robust, highly productive, herbaceous perennials with a strong tendency to dominate wetland systems. 3) All the species are known to deal well with anoxic conditions in the sediments. In addition, these species differ in their nutrient resorption efficiency and proficiency. Wastewater Treatment The growth and decomposition were studied for Scirpus acutus, S. californicus, and Typha spp. at the South Sacramento Wastewater Treatment Experimental wetland in Sacramento. Based on the results of this competition study, the procedure for replacement of a less desirable Typha spp. with Scirpus spp. has been suggested and implemented. Tahoe Basin Wetlands Distribution and response of wetland plant communities in Tahoe Basin to drought was evaluated. Communities dominated by matrix species (Carex, Juncus) were resistant to drought, while those dominated by Nuphar and Scirpus were replaced by terrestrial ruderals. Information on nutrient uptake and nutrient resorption efficiency resulted in delineation of several simple indicators of current and (recent) past conditions of sediments in particular marshes. This then provided information on N and P input from the watersheds draining into these wetlands, and potential output of nutrients into the lake. Salinity and Nutrient Addition Responses The response of several species to increasing salinity was studied in the field and in a greenhouse experiment. The amount of salts taken up by plants and allocated to different plant parts was measured and the production of organic solutes evaluated. A fertilization experiment studying the effect of phosphorus addition on the nutrient-poor Eleocharis cellulosa community was conducted. The experiment was simulating the effect of agricultural runoff on freshwater marshes. An additional component to the study on nutrient cycling in these marshes was the assessment of nitrogen fixation by cyanobacterial mats. Life History Strategies of Wetland Species from the Central Valley Comprehensive information and functional assessment of representative native and exotic wetland plants from inland wetlands of northern California was obtained. Information on biomass of mature plants together with data on tissue nutrient concentration, species cover, species richness, and soil properties was collected for a set of 22 species throughout twelve Central Valley wetlands. This information is available for managers of Wildlife refuges and any potential wetland restoration projects. Succession of wetland vegetation was monitored as a part of the Cache Slough Ecosystem program. The results of this monitoring were utilized by the US Army Corps of Engineers.
Impact: Knowledge of functional role of wetland macrophytes is critical for understanding their role in both natural and man-made wetland ecosystems. The response of wetland macrophytes to nutrient enrichment and changes in salinity provides the necessary information for the use of these plants in wastewater treatment and wetland restoration projects. Results generated in the course of this project has been utilized by various agencies such as US Army Corps of Engineers in developing successful wetland mitigation projects, and Wildlife Refugees managers for proper selection of wetland species in the development of quality waterfowl habitats.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.23 Water Quality
Title: Water Quality Protection on San Francisco's Watershed
Description: The San Francisco Public Utility Commission challenged the presence of grazing livestock in the Alameda Creek watershed, which provides drinking water to 2.5 million people

in the San Francisco Bay Area. The Commission assumed that cattle posed an unacceptable risk to water quality and human health by shedding Cryptosporidium parvum in their feces. Since annual grasses dominate this watershed, elimination of grazing would significantly add to the risk of wildfire. Increased erosion following a wildfire is one of the greatest potential sources of surface water contamination in California's annual grasslands. The absence of livestock grazing also could change the current ecological balance in the watershed, which includes a variety of wildlife including feral pigs, bald eagles, mountain lions, tule elk, black-tailed deer and a variety of small mammals. Watershed lands owned and managed by the City and County of San Francisco support 17 livestock operations covering 38,000 acres. UC specialists working in the dairy industry provided information on a risk management strategy used to ensure food safety known as HACCP (Hazard Analysis Critical Control Points). A Farm Advisor working with the Alameda County Resource Conservation District(RCD), adapted the HACCP strategy to water quality protection. Science-based information was provided by a CE specialist of UC Vet-Med Extension, who had recently worked with livestock/range advisors throughout the state studying the prevalence and risk factors for shedding of C. parvum in rangeland cow-calf herds. This research found that the risk is primarily limited to calves under four months of age.
Impact: The San Francisco Public Utilities Commission directed the Alameda County RCD and the livestock industry to develop a best management practices plan designed specifically to guard against C.parvum and other waterborne pathogens. After UC ANR provided information to develop a HACCP-based water quality protection plan, a grazing accord was signed by California Cattlemen's Association, UC Vet Med, UC Rangeland Hydrology Specialist, USDA Natural Resources Conservation Service, Alameda County RCD, Alice B. Toklas Lesbian and Gay Democratic Club, and the SF Public Utilities Commission. The grazing resource plan to assure safe drinking water for 2.5 million residents of the San Francisco Bay Area recognized that properly managed livestock grazing is compatible with watershed protection and provided for continued grazing on 38,000 acres of San Francisco owned-land in Alameda and Santa Clara Counties.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.24 Weather and Climate
Title: Studies of Short-Term Climate Variability
Description: To provide a better understanding of the physical processes foverning the atmospheric circulation at middle latitudes, with particular emphasis on regional short term climate variability. To determine to what extent changes in stratospheric ozone affect weather patterns and climate in the lower atmosphere. To improve the accuracy of atmospheric weather prediction, with emphasis on forecoasting extreme weather events such as drought, frost, and flooding. During the past year we have shown that the midlatitude jet stream can have an important impact on the dynamics of long-lived circulation patterns in the atmosphere (Hodyss and Nathan 2002). We also have shown that stratospheric ozone anomalies may be driven internally by the quasi-biennial oscillation (Cordero and Nathan 2002). These studies provide new understanding of how the jet stream and stratospheric ozone affect regional and global climate variability.
Impact: The vagaries of weather and climate affect many important aspects of the California economy, including, for example, agricultural production, power generation by public utilities, air quality, and the recreational industry. Our research has increased our understanding of the physical and dynamical processes that affect short-term climate variability. Such understanding

is improving long-range weather forecasts, thus benefiting California's economy and the quality of life of its citizens.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.26 Wildfire Science and Management
Title: Photo-Ecometrics for Natural Resources Monitoring
Description: There are two primary objectives of this project: (1) develop canopy modeling techniques and associated software for canopy modeling and crown delineation from high spatial resolution (1-4 m) satellite data, digital camera data and large-scale aerial photographs. (2) develop hyperspectral data analysis algorithms for Yellow Starthistle and salt cedar mapping in selected sites of California and monitoring their speading and control. The first objective would lead to techniques that will significantly improve our ability to economically assess the accuracy of thematic vegetation maps. The second objective would lead to techniques that allow for wall to wall mapping and monitoring of the two invasive species in the US. We have been continuing our work on the development of photo-ecometrics. DSMs (digital surface models) automatically derived with digital photogrammetric systems are useful in land surface change monitoring including forest growth monitoring. Major efforts have been made to improve the automatic generation of orthophotographs of the forested canopy. Traditional orthophoto-making does not include the orthoprojection of forest canopy and therefore they are not truly orthophotos over forested and urban areas. Our procedure can produce high quality large scale orthophotos (up to 1:2,400 experimented). Such results have not been reported elsewhere. We developed an internet based fire emission estimation system. The system can estimate wildland fire, agricultural burning and residential wood burning based on fuel maps, burnt areas, and socio-economic and climate conditions for residential areas. The system is useful in prescribed burning and for postfire estimation. It has been implemented for the state of California. We also mapped hotspots of North America for 1989-2000 using daily Advanced Very High Resolution Radiometer (AVHRR) on board the NOAA satellite series. Burn scar mapping and validation are underway. We continued to make progress in estimating forest biochemical constituents using in situ field spectral measurement data. At a Giant Sequoia plantation site, our results indicate that spectrally derived vegetation indices and linearly combined spectral data are correlated to total potassium, total phosphorus and total nitrogen of foliage. We also worked on spatio-temporal modeling of microbial contamination on grazed land in New Zealand. We built a grid-based and stream networked model to predict the fecal contaminants in a hilly land catchment extensively used for grazing. Experimental results indicate that our model captures the key features that control the population dynamics of the fecal contaminants. Through international collaboration we expanded our forest leaf area index estimation work to Argentina and the carbon balance work to China. Our carbon balance work involved the use of NOAA AVHRR data from 1982-1998 for calculating the net primary productivity. For the first time, we estimated the carbon balance over the terrestrial ecosystems of China during 1982-1998.
Impact: Our results along the line of developing the field of photo-ecometrics will considerably improve accuracy and efficiency in forest inventory. The algorithms developed in our research can potentially be widely commercialized. Our North America burnt area map between 1989-2000 is highly demanded in the global ecosystem science community for the study of global carbon circulation.
Funding Source: McIntire Stennis and State
Scope of Impact: State Specific

Theme: 4.27 Wildlife Management
Title: Demography of Threatened and Exploited Birds
Description: A five-year study to combine field and modeling approaches to examine the demography of contrasting case studies of threatened and exploited birds. One species, the Marbled Murrelet, is extremely difficult to study but is threatened and thought to be declining rapidly. The other species, the Green-rumped Parrotlet, is easily studied, which makes it ideal for investigating population processes that are postulated to be common but difficult to document. The first objective is to determine why the central California Marbled Murrelet population is in decline. We will conduct mark-recapture and radio-telemetry studies to determine whether murrelets are declining because of high rates of nest failure or because many individuals fail to nest. The second objective is to continue long-term studies of the Green-rumped Parrotlet in Venezuela to link social system, dispersal and demography to source-sink population dynamics. Work will be conducted on two populations of a small box-nesting parrot, which will act as a model for other parrots that are less easily studied and are heavily exploited for the international trade. GSY = 4 Work continued on demography and population trends of Marbled Murrelets (Brachyramphus marmoratus) that we have been conducting in central California since 1995 to understand the factors that threaten this population. We captured 65 individuals to bring the total number of individuals marked to 291 since 1997. Mark-recapture analyses in progress suggest adult survival is about what would be expected for a seabird of this size. Results from 15 at-sea surveys indicate that 500-600 birds are in this population and no clear trend can be discerned over the past four years. Likewise, applications of mark-recapture models suggest population size changed little. Yet direct estimates of reproduction from telemetry studies and estimates based on the ratio of juveniles-to-after hatch year birds indicate very little successful reproduction. We hypothesize that the central California population may be sustained by immigration from populations further north and may be a demographic sink. We radio tagged 25 murrelets in September 2002 and followed their postbreeding season movements from airplanes.
Impact: Results from our murrelet studies are providing the basis for the application of forest restoration management strategies in old growth forests in California. These strategies are proving successful in maintaining and enhancing murrelet habitat and populations.
Funding Source: McIntire Stennis and State
Scope of Impact: State Specific

Theme: 4.27 Wildlife Management
Title: Development and Application of Age, Size-Specific Population Models
Description: The general objective of this study remains the development of modeling and analysis techniques based on age, size and spatially structured models to solve practical problems in California's fish and wildlife populations. The focus for the next five years will be on : (1) effects of ocean and river conditions on California salmon population dynamics and (2) effects of varying ocean conditions on biological productivity in California's coastal ocean. This will continue to be a modeling study, with field sampling in support of that, and the focus on understanding dynamic behavior. We used mathematical population models to show that the differences in responses of coho and Chinook salmon to a shift in the ocean environment in the mid-1970s were not simply due to differences in spawning age distribution as previously thought. We also showed that the low rates of straying between salmon populations can make them much more persistent and less likely to collapse in response to a deleterious shift in the environment. We used the biogeochemical marine ecosystem model we had developed to show how primary and secondary productivity during the upwelling season depend on wind strength.

We extended our model of the persistence of populations in marine reserves to include different levels of fishing between reserves, and a finite coastline.
Impact: Our results regarding salmon and marine productivity provide the basis for understanding how salmon populations and catch vary from year to year and for managing both fisheries and water resources accordingly. Results have been applied in the the design of effective marine reserves along the California coast.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.27 Wildlife Management
Title: Population Genetics and Phylogeography of Declining Amphibians and Reptiles in California
Description: Objectives: 1. To collect mitochondrial DNA (mtDNA) sequence data for three species of native California amphibians and one reptile to measure population differentiation. 2. To use these mtDNA data, in conjunction with field information of population declines, to determine Evolutionarily Significant Units (ESUs) and Management Units (MUs) for all four species. 3. To collect nuclear DNA data from 10-15 rapidly-evolving microsatellite loci for two species to determine levels of migration and gene flow over a fine-grained spatial scale. 4. To make recommendations to the US Fish and Wildlife Service and the California Department of Fish and Game on management directions for all four of these species, particularly in landscapes that have been severely affected by California agriculture. My work in California examines the influence of agriculture and urban land use on native amphibians and reptiles, particularly in the Great Central Valley. During the review period, we completed three projects, and made substantial progress on others. Major projects which are now complete include: 1) completion of a project on the effects of agrochemicals on 8 sensitive species of amphibians in the state and 2) completion of a long-term study on threats and recovery strategies for native pond turtles in an urban, Central Valley location, and 3) completion of a study of the effects of exotic species introductions on a native salamander in the Salinas Valley. We have continued to collect material for genetic analyses of four species of threatened amphibians and reptiles in the Central Valley, including the foothill yellow-legged frog, California tiger salamander (CTS), western Spadefoot and western pond turtle. Our work on the CTS is now complete, and demonstrates that at least three, and possibly six very differentiated lineages exist within the Central Valley and require separate protection. Our completed work also demonstrates that windborne agrochemicals and habitat loss are the two major factors driving amphibian declines in California, and that introduced exotic salamanders from the fish bait industry are a major threat to native CTS. Four relevant publications were accepted during this review period, several talks at major universities were given, and four major grants were funded/continued based on this work.
Impact: Our work on population genetics defines Distinct Population Segments (DPS) of several sensitive species of amphibians. We provided US Fish and Wildlife Service critical data on DPS of the endangered CTS which is guiding successful management. We demonstrated that agrochemicals can profoundly influence some amphibian species while others are primarily effected by habitat loss due to agriculture and urbanization, effectively broadening the scope of management plans.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.27 Wildlife Management
Title: Population Models for Improving Management of Ground Squirrels in California

Description: To develop mathematical models for squirrel populations, for determining the effectiveness of current and potential management strategies. Populations of California ground squirrels were indexed at sites where control measures were implemented in 2001. This data will provide information on the resilience of ground squirrels to lethal control measures. Results from the 2001 field studies of the response of California ground squirrel populations to control measures were analyzed. Other techniques (eg. fertility control) reported in the literature were reviewed for their potential use in ground squirrel management strategies. A mathematical model to describe the dynamics of California ground squirrel populations is currently being developed.
Impact: Information on the relative effectiveness of control techniques for California ground squirrels is important for ranchers and agriculturalists to develop cost-effective management strategies for this pest. Project results have developed baiting strategies that reduce the amount of bait applied and thereby reduce the potential for the poisoning of non-target species while maintaining effective ground squirrel control.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 4.27 Wildlife Management
Title: Smith River Chinook Spawning
Description: The Smith River (Del Norte County) is a nationally renowned salmon and steelhead river with Wild and Scenic River status. It is designated as a National Recreational Area and is the pristine watershed of the Redwood National Park system. However, the Smith River has had no long-term fishery database to help manage its valuable chinook salmon resource. In 1980, a UCCE research project was initiated to estimate the salmon spawning escapement and determine the age composition of the West Branch Mill Creek chinook population. A Del Norte County Sea Grant Extension Advisor conducted weekly spawning surveys in a defined study section of Mill Creek from November through March (1980-ongoing). Counts were made of adult spawners, salmon redds and carcasses. Scale samples were obtained from carcasses to determine the age composition of the chinook population. This 23-year study became the longest ongoing chinook population monitoring in California on a natural spawning stock. A final research report was completed documenting the research results. The long-term data revealed chinook growth and age fluctuations during three major El Niño events and documented natural variations in the population.
Impact: This research had several important biological and economic impacts. The database has been used by the California Department of Fish and Game, the National Marine Fisheries Service and California state parks as a natural index stream standard for northern California coastal chinoook populations. The research also caused California Department of Transportation to redesign a proposed 1993 realignment of Highway 101 through the Mill Creek watershed, saving the California taxpayers over $30 million in costs. In 2002, the Save the Redwoods League acquired the Mill Creek watershed (25,000 acres) from Stimson Lumber Company for $60 million. Almost $20 million of that purchase price was directly attributed to the fishery resource values in Mill Creek, based on the UC Sea Grant Extension long-term research results. This acquisition of the Mill Creek watershed provided a continuous protected habitat zone connecting the existing Redwood National Park and state park lands.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 4.27 Wildlife Management
Title: Waterfowl Production and Conservation in the Agricultural Landscape

Description: Objectives: (1) Examine the effect of waterfowl foraging activity on rice straw degradation and nutrient incorporation in winter-flooded rice fields; (2) Evaluate survival, dispersal and reproduction of wood ducks in relation to agricultural land use patterns; (3) Examine the population genetic structure of wintering and breeding waterfowl in California and the Pacific Flyway to guide effective management practices; (4) Evaluate habitat needs for waterfowl and wetland-dependent wildlife in the Central Valley (5) Develop and evaluate moist soil management practices to maximize food production for waterbirds. (1) We have completed the first phase of a new study to determine the impact of waterfowl activity on decomposition of rice straw in winter-flooded fields. Our results indicate that waterfowl foraging activity can lead to a significant increase in the decomposition of rice straw and a significant reduction in weed seeds. An article on this work is in press. Follow-up studies will address the availability of waste grain as food for waterfowl in agricultural fields. (2) We have completed analysis of data on habitat selection and feeding ecology by waterfowl in the Suisun Marsh and an MS thesis is near completion. This study will help guide wetland restoration efforts in this important area of the Delta. (3) We have completed a new study to assess the availability of moist-soil seeds as food for waterfowl in wetlands of the Central Valley. We found that many wetland restoration projects are not meeting their goals with respect to providing high quality habitat. Our analysis has identified several management methods that can improve seed production and enhance restoration efforts. An MS thesis has been completed, four manuscripts are in preparation and one article has been published. (4) We have continued a long-term study on the effect of land use and agricultural practices on the population biology of wood ducks in California riparian systems. Several popular articles have been published and manuscript preparation is on-going. (5) We have completed several studies using molecular genetic techniques to evaluate the population structure and ecology of four species of waterfowl in the Pacific Flyway. These analyses will determine the appropriate units for the management of these species based on their biological and evolutionary histories, rather than on arbitrarily determined geographical boundaries. During the past year, one student has completed her Ph.D. thesis while a second will be finished in the spring. Several manuscripts are in preparation. (6) We have completed the first phase of a new study to determine the factors limiting production of mallards in California. This work will help develop sustainable harvest objectives for this important game species and will evaluate habitat restoration efforts for breeding waterfowl in California.
Impact: Our studies have demonstrated the compatibility of agricultural practices (particularly rice farming) and wildlife habitat objectives. We have demonstrated the potential for waterfowl to enhance the decomposition of rice straw residue and reduce weed pressure in winter flooded rice-fields, thereby providing a reciprocal benefit to farmers. Rice producers now effectively manage their fields to provide quality wildlife habitat while simultaneously reducing herbicide applications for weed control.
Funding Source: Hatch 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. The 2002 Jump$tart Coalition's Personal Financial Literacy's nationwide survey on personal financial knowledge of 12th grade students showed that only 50.2% of the questions were answered correctly. The average scores in the 2000 and 1997 surveys were 51.9% and 57.3% respectively. Unfortunately, California's 12th graders performed even worse at 47.1% of the questions answered correctly. 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: emerging models for positive youth development, land use conflict at the ag-urban interface, supporting elders, out-of-school programming, healthy child development, and life-skills education.

Work during this past year has resulted in the establishment of a new theory of chemical wet finishing of textiles that can dramatically improve protection on first responders and healthcare workers; found that economic mobility for many immigrant farm workers and their children will require geographic mobility in order to experience upward mobility; resulted in the continuation of earlier research on creative design of low-income housing projects and furnishings; helped designers more fully understand the role the physical environment plays for adolescents in creating a supportive environment—places that are responsive to the emotional and social development of adolescents; found that homeless people of Placer County are attracted to the rural area for many of the same reasons the housed population is attracted there—for the outdoor life, health amenities, etc.; found that migrant leaders' continued involvement in local politics in Mexico has not thus far diminished their involvement in citizen participation roles in U.S.; found that young children, in addition to using trial and error, often retrieve relevant prior experience such as procedural strategies and attempt to apply familiar approaches to solve novel problems; found that caregivers who were trained in nutrition, aging and health maintenance and resource management skills demonstrated a significantly positive change in knowledge, attitude, and behavior; participated in programs that help provide youth the opportunity to experience how society and economy function, preparing them to be informed citizens in the real "society;" found that the camping experience is an ideal setting for environmental educational community and social responsibility, building self-esteem, and the wise use of leisure time; provided the opportunity for youth to participate in a lobby for community issues based on the ideas, opinions,

hopes, and vision of the youth; provided a practical strategy for elementary educators to use in implementing hands-on science education to improve the practice of experiential education in California elementary schools; developed a project that provided the means to create networks and ongoing dialogues with the Latino community and previously unconnected organizations and agencies: and found that programs that simply label youth as victims or bullies and then seek to "fix" the bullies will not work.

CE advisors delivered 174 local extension programs in this area. In addition, 17 statewide collaborative workgroups composed of both AES and CE academics planned and conducted research and extension projects. In addition, UC ANR has one Statewide Special Program that brings together AES and CE resources and personnel that addressed critical issues in the state that are included within National Goal 5. California academics published 48 peer-reviewed articles and 21 extension publications to address Goal 5 last year.

UC-DANR's Human Resources Programs Covering:

- Human and Community Development
- Economically Viable Families and Communities

HUMAN AND COMMUNITY DEVELOPMENT

UC-DANR 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-DANR 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 2002-2003 Allocated Resources

Extension Federal Funds (Smith Lever	Extension State Match	Research Federal Funds	Research State Match
$1,057,480	$7,299,104 [52.03 FTE]	$151,585	$3,756,889 [16.23 FTE]

Theme: 5.05 Children, Youth, and Families at Risk
Title: Learning and Problem Solving in Young Children
Description: Studies of early cognitive functioning suggest that infants are capable of inventing strategies to solve novel problems and generalizing the strategies to unfamiliar problems. However, virtually nothing is known about how they accomplish these feats. To address these issues, I plan to obtain trial-by-trial assessments of infants' and toddlers' problem-solving strategies and examine how their strategies change with experience. A series of experiments, each involving multiple phases (exploration, training, and transfer), is proposed. The specific issues on which I will focus include: (1) identifying the strategies that infants/toddlers use to solve problems; (2) examining strategy changes with experience; (3) examining the transfer of strategies to novel problems; (4) documenting developmental differences in infants' and toddlers' learning and transfer; and (5) identifying individual differences in infants' and toddlers' learning. Exploring these important but neglected issues of young children's problem solving should yield theoretically significant information about the nature and characteristics of early representations and about the path, rate, breadth, variability and sources of early cognitive change. Thus, the studies could promote the development of more general theories of cognitive development. Studying young children's strategy discovery and generalization and cognitive processes involved in strategy use also has significant educational implications; findings from this research will provide a foundation for improving early education in preschool, daycare and home settings. The issue of how young children use strategies in problem solving is important but has not been explored. This project examines how infants' and toddlers' problem solving strategies change with experience.
Impact: A great deal of research has examined toddlers' and preschoolers' abilities to understand symbol-referent relations and use the information about the hiding locations of a source space

(e.g., a scale model, picture, or map) to guide searches in a target space (e.g., a room). Although young children have demonstrated impressive abilities, relatively little is known about how children come to accomplish such feats. We conducted two studies to examine whether and how young children acquire strategies involved in mapping spatial arrays with experience. With a microgenetic design and multiple analogous tasks, 2.5- to 5-year-old children were tested on their ability to discover new strategies for locating a hidden toy by mapping two spaces when no instruction concerning the relations between the analogous spaces was provided. The basic task of the present research involved the presentation of a pair of spatial arrays (a small model and a large model) that were perceptually similar but different in size and other details. Each model contained three locations where a toy could be hidden. On each trial, children were shown a hiding location in the small model and were asked to search for a target toy in the corresponding location in the larger space. Children were tested with multiple sets of spatial arrays in multiple trials, and in each trial their performance and strategy use in target search were observed. Thus, children's task was to recognize and abandon their own unproductive strategies and to develop a new way to map the spaces. In Experiment 1, the larger toy was hidden in a location of the larger space perceptually and spatially similar to a corresponding location in the smaller space in each trial. It was evident that with experience, 3.5- to 4-year-olds acquired the strategy for mapping corresponding locations that shared both perceptual and spatial similarities. Even without instruction and demonstration, young children showed the ability to discover a new strategy, using the hiding information in the source spaces to guide their searches in the target spaces (Figure 1). In Experiment 2, perceptual and spatial similarities between corresponding locations were placed in conflict and thus either perceptual or spatial mapping was possible. With experience only 4- to 5-year-olds (bottom panel of Figure 2) but not younger children (top panel of Figure 2) were fairly effective in detecting a new correspondence. Four- and five-year-olds proved more capable of discovering a new mapping strategy, increasing the frequency of correct responses (correct mapping strategy) and decreasing ineffective responses (incorrect mapping and perseverative mapping strategies), and generalizing the newly acquired strategy across tasks with experience. In both studies, processes that underlie children's acquisition of mapping strategies were examined. Three key components -- namely, encoding locations within each space, noticing the general relations between spaces, and detecting precise mapping correspondences --proved to contribute to children's proficient search in target spaces. Every day, even young children face the challenge of various problems that need solutions. When encountering a novel problem-solving situation, young children, in addition to suing trial and error, often retrieve relevant prior experience such as procedural strategies and attempt to apply familiar approaches to solve novel problems. Findings from this research will provide a foundation for improving early education in preschool, daycare, and home settings.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 5.07 Community Development
Title: Analysis of Agricultural and Trade Policy and Migration Impacts in Rural Communities
Description: This project will employ agricultural household and micro economy wide modeling techniques to explore the economic impacts of agricultural and trade policy reforms on production, incomes and resource allocations in rural areas, and the interactions between these impacts and migration out of (e.g., Mexico) and into (e.g., California) rural communities. The models used in this research will integrate micro-economic, household-farm modeling into local general-equilibrium frameworks, making it possible to capture both direct and indirect impacts of policy changes on rural economies. Many of the applications will be in developing countries

with important trade and migration relationships with United States. Nevertheless, the modeling techniques potentially are equally applicable to rural areas in California, as well, and a major component of the research carried out under this project will focus on rural California. This research will involve extensive analysis of household-farm data, econometric estimation of model parameters, programming techniques, and policy analysis. The first applications will use micro economy wide modeling to explore the implications of NAFTA and Mexican agricultural policy reforms on incomes, production, and migration in major migrant-sending areas of Mexico and impacts of migration on rural California communities.
Impact: As rural economies increasingly become integrated with world markets through trade liberalization, understanding the ramifications for rural production, employment, poverty and migration is a priority for both the United States and less developed countries, including Mexico. Findings from this project are providing new insights into these ramifications and their implications for designing trade and rural development policies. This project examines impacts of trade and agricultural policy reforms and migration-development interactions in rural communities in the United States and abroad. Research using field survey data uncovered new interactions between migration and development, including negative lost-labor and positive remittance effects on agricultural productivity and the transition to non-farm activities in rural areas. Research in the United States indicates that there is a positive interaction between farm employment and immigration that increases rural poverty and welfare demands. It also produced evidence that certain types of public transfers "crowd in" remittances from U.S. immigrant households to households abroad.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 5.07 Community Development
Title: Household Demand Responses to Food Firms' Strategic Behavior Over Time
Description: We will investigate how food manufacturers' promotions and sales (temporary discount pricing) and the increasing penetration of generics brands affect consumers' demands. We will estimate household-level demands over all existing products within a food category taking account of past purchases. Our major purpose is to explain how consumers' reactions allow firms to price discriminate intertemporally. Using a data set that follows households over time, we will measure the demand elasticity biases from aggregating over households and over time. We will determine the demographic composition of households that engage in inventory behavior and hence can take advantage of promotional activities. We will ascertain how price sensitivity, use of coupons, and purchases of generics varies across households so that we can explain firms' ability to price discriminate. By so doing, we will determine which consumers benefit from and which are harmed by intertem- poral price discrimination. We will examine the degree to which sales activities depends on the perishability of the good.
We have examined the demand for dairy products and orange juice (in various forms). Although one might expect that any price is possible, we have found that firms set price primarily that end in "9" or "5" or "0". We are investigating whether demand curves are discontinuous or kinked at these mass points. We continue to investigate the demand response to sales.
Impact: We expect our results to be useful in better estimating demand functions taking into account sales, to explaining firms uses of sales, and to making policy statements about a variety of important government programs (milk marketing laws, taxes on fats and sugars, and others).
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 5.07 Community Development
Title: Toward a Modified Rural Focus for California Planning and Design
Description: To create stronger analytic models of the "new rurality" by means of a series of coordinated research projects. These projects include (1) a description of the social, natural and historic assets of the Central Valley; (2) Studies of emerging new rural social problems: e.g., homelessness; (3) Macro-level site surveys of the changing rural landscape. A Population increases in rural areas threaten to destroy the very amenities which attracted people in the first place. A This project recommends design solutions to new rural social arrangements. B The purpose of this study is to develop new policy for rural homelessness.
Impact: The main work of the New Rural Versus Urban Differences Project in 2002 was two comprehensive surveys of special populations in Placer and San Joaquin counties. In Placer county we conducted a survey of the homeless living in rural foothill areas and in the small cities along the I-80 corridor. In terms of breadth of scope, our survey instrument was more comprehensive (89 questions) than any other that has been used in research on homelessness, even in urban studies. Using graduate students from UC Davis, our goal was to interview every homeless individual in Placer county. We found 405 homeless people in Placer County including 109 women and 88 children. We have finished the census, done the analysis, and written our report. One of the more important findings of our census is that the homeless people of Placer county are attracted to the rural area for many of the same reasons the housed population is attracted there-i.e., for the outdoor life, health amenities, etc. They prefer ranch work to other kinds, and are an unusually stable population compared to urban-based homeless population. The average time that our respondents had resided in the town where they were interviewed is 7.8 years. This is a higher figure than the homeless of Yolo who lived in the county (not necessarily the town) for an average of five years, and it would be a remarkable figure for the housed population of the state of California as a whole. The Hmong health survey. In San Joaquin county we interviewed a random sample of 100 Hmong heads of household. Our survey instrument contained over 100 questions about health, health practices, health beliefs, use of health facilities, use of traditional shamanistic healers, etc. This was the first systematic survey of health problems and beliefs of the Hmong refugee population, and the public health response to their problems. We are currently in the process of coding the data and will begin analysis in January 2003. We anticipate completion of our report in March 2003. We continue to do work on the social impacts of tourism and the motivation to travel. The important work completed in this area during 2002 was our psychoanalytic study of the "ego factor in tourism." Our work with the homeless and the Hmong is being used by public and private (non-profit) agencies to improve their programming for these special populations, and to provide a factual base for their funding requests. Rural homeless and refugee populations do not have the same profiles as their more studied urban counterparts. Cooperating agencies include Sacramento BacViet Association, Placer county Social Services, Lao Family in Stockton.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 5.11 Family Resource Management
Title: Increasing Use of the Earned Income Tax Credit (EITC) by Low-Income Families
Description: The Earned Income Tax Credit has been described as the largest and most successful federal assistance program for low-income working families. Last year, the EITC was responsible for elevating the families of 5 million children above the federal poverty line. However, many eligible families do not take advantage of this valuable income supplement for various reasons, as indicated by the findings of Rural Families Speak.

Rural Families Speak is a longitudinal study assessing changes in the well-being of rural families in the wake of welfare reform and associated reductions in programs and services. In the first year of the study, only about one-third of the Latino participants who were eligible for the EITC had actually received the credit. The data indicated that lack of and/or inaccurate information were common reasons for non-receipt. Language and cultural barriers further diminished the likelihood that Latino families knew about and claimed the EITC. Recognizing the need to reach out to rural families about the EITC, Rural Families Speak distributed English and Spanish IRS materials explaining eligibility and the filing process to research participants between their first- and second-year interviews. County advisors were informed about the lack of rural families' use of the EITC and the need for education about the credit. EITC information is being included as part of EFNEP (Expanded Food Nutrition Education Program) and FSNEP (Food Stamp Nutrition Education Program) efforts. The University of California Cooperative Extension Spanish Broadcast and Media Services is disseminating written materials and radio announcements.
Impact: As a result of distributing educational materials about the credit to low-income Latino families living in rural communities, more than twice as many families received the credit the following tax year. The additional information provided by EFNEP and FSNEP and in public service announcements will further increase the number of families taking advantage of this valuable income supplement, contributing to their financial security and well-being.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 5.16 Impact of Change on Rural Communities
Title: New Immigrant Political Incorporation Patterns and Transnational Practices of Mexican Migrants in California
Description: The three main objectives of this study are: (a) To investigate the character of the trans-local ties forged by transnational Mexican migrants in Napa and Santa Rosa and their relationship to the transnational practices of political elites and policy-makers in their states of origin. b) To investigate the consequences of these trans-local and transnational connections and practices for local processes of Mexican immigrant incorporation in the two selected California communities in California's Wine Country, particularly with respect to acquisition of citizenship, rates of local civic and political participation; rates of electoral participation; and participation in local issue-oriented coalitions and state and local ethnic politics in California. (c) To develop analytical and policy criteria for evaluating the character and effectiveness of national, state and local public policies designed to promote citizenship, immigrant incorporation, and affiliation within a multicultural public sphere in the U.S. in the face of the ongoing pressures of transnational identity formation promoted by the nationalist projects of sending states.
Impact: Interviews were conducted with key transnational migrant leaders from the localities of Timbinal, Guanajuato and Jerez, Zacatecas to determine the types of their political activities in their communities of origin in Mexico as well as the extent of their incorporation into US citizenship roles in California. Papers based on this research were delivered at a Symposium on "Borders, Migration, and Trade" at the UC Davis Law School and an International Workshop on "Transnationalism" at Ruhr-University, Bochum, Germany. Articles stemming from this research are forthcoming in 2003 in the journals listed below. The research enables researchers and immigration policy makers to assess the impacts of transnational migrant communities vis-a-vis questions of dual-citizenship. The research reveals dynamics underlying new modes of transnational political and economic activism in Mexico and their relationship to emergent forms of political activity by Mexican migrants in California. Findings reveal that migrant leaders'

continued involvement in local politics in Mexico has not thus far diminished their involvement in citizen participation roles on the US side of the border. This informs policy makers involved in current U.S-Mexican migration policy debates.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 5.17 Jobs/Employment
Title: Immigation, Employment, Incomes and Poverty in Rural America
Description: Establish benchmarks for the process that has been termed the Latinization of rural America. Examine demographic changes in selected communities and involve local elected officials in an analysis of what the process means and how federal policy affects and might affect current trends. Help shade a rural dimension to what has been termed an emerging federal "immigrant policy," the policies and programs that deal with immigrants after their arrival and that foster economic development and poverty alleviation in rural towns impacted by immigration. Address the role of immigrant labor in economic development and local politics.
Impact: This project explored the challenges and opportunities posed by Mexican immigration into rural and agricultural areas to fill farm and farm-related jobs. The research was conducted by integrating census and administrative data and developing models that examined the interactions between farm employment, immigration, and rural poverty. The project was motivated by the hypothesis that the US risks the re-creation of rural poverty via immigration, encouraging or allowing the entry of immigrants from rural Mexico with little education to fill jobs in rural and agricultural areas. The research evaluated the benefits and costs of such migration, both cross sectionally and over time, concluding that the key to upward mobility for immigrants and their children was education-the average educational level of entry-level farm workers was six years in the late 1990s. For many immigrant farm workers and their children, economic mobility will require geographic mobility-migrants will have to leave the areas in which they had their first US jobs in order to experience upward mobility. This means that there may be rural-urban migration wave over the next decades, as experienced farm workers and their children leave for urban areas. Project findings have been the subject of legislative debate and media coverage.
Funding Source: State and Grant
Scope of Impact: State Specific

Theme: 5.22 Promoting Housing Programs
Title: Farmworker and Low-Income Rural Housing in California
Description: Continuation of earlier research on creative design of low-income housing projects and furnishings through professional architectural participation in low-income housing projects, design development of manufactured housing prototypes, and affordable furnishings, and furtherance of low-income housing policy and funding.
Impact: Four new housing projects were designed totaling 188 new, low-income dwelling units. Research is exploring development of housing on increasingly dense sites in the nonurban environment (#dwellings/acre) and the impact of this on community environments. Creation of affordable design proposals that can obtain community acceptance. Initial work on the Adams Street Site, a cooperative development of low-income housing, a family resource center, and hospital clinic in an upscale community. Working with community representatives to build strong social partnerships that span several economic classes. Projects provide opportunities for low-income individuals and families to dwell in stable housing environments and to gain access to supportive services that in turn enhance the economic, health, and educational well-being of

the project residents. Adams Street project is developing strong community cooperation for benefit of low-income residents.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 5.27 Workforce Safety
Title: Mediating Exposure to Environmental Hazards Through Textile Systems
Description: Objectives: 1. To improve protection and human factor performance of PPE through product development. 3. To develop performance specifications for protective clothing materials. Bioprotective functions will be incorporated on firefighters' uniforms to develop new materials, new finishes for materials, and prototype garments.
Impact: 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, Kevlar, and Kevlar/PBI blend fabrics were successfully treated with a hydantoin derivative, allylyl-dimethylhydantoin (ADMH), 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. 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. In addition, the same functional monomer was successfully employed in treatment of polyester, nylon, and polyethylene fabrics, the synthetic materials that are traditionally difficult to modify in textile treatments. These materials also demonstrated desire biocidal functions similar to the above materials. The results of this research demonstrated the establishment of a new theory of chemical wet finishing of textiles, biocidal functions of the textile materials. The new technology can dramatically improve protection on first responders and healthcare workers.
Funding Source: Hatch Multistate Research and State
Scope of Impact: CA, CO, IA, IL, MD, MI, NE, NYG, OK; NON-SAES: TX Tech U., NYC

Theme: 5.27 Workforce Safety
Title: Smaller Picking Tubs Reduce Back Injury Risk for Winegrape Pickers
Description: Hand harvest work in winegrape vineyards is physically demanding and exposes workers to ergonomics risks. Back injuries are the most common and most costly. With some 230 back injuries reported annually, the cost to the California vineyard industry is more than $2.3 million per year. In addition to uncalculated worker pain and lost income, these injuries reduce productivity and drive up worker's compensation insurance costs.
UCCE Viticulture Farm Advisors Ed Weber and Rhonda Smith in Napa and Sonoma Counties, together with a research team led by CE Specialist James Meyers and Experiment Station Professor John Miles, reviewed multiple vineyard jobs for ergonomics risk exposures. They worked with three wineries and one vineyard management company, involving more than 200 workers. They found that hand harvest is the most physically demanding job in winegrape vineyard work. When filled, standard-sized tubs weighed an average of 57 pounds. (Some weighed in at over 80 pounds!) Workers must stoop, grip, lift, carry and dump up to 20 times per hour, besides relocating the tub down the row. Smaller plastic tubs were evaluated with workers during the 1997-1999 winegrape harvests and ergonomics assessment showed large reductions in risk exposures. Workers fill the small tubs in less time, which means they lift more frequently. They also make more carries per hour to deliver the same tonnage. However, due to the smaller tubs' lighter weight, there was actually a slight decrease in energy demand. The smaller tub does

result in a 2.5% decrease in worker productivity as measured by pounds of grapes per shift. (This was not noted by either workers or managers, but by the researchers.)
Impact: The smaller picking tubs have resulted in a five-fold reduction in harvest workers' reported pain and symptoms for back injury and other musculoskeletal disorders. Workers are less tired and less likely to be injured using the smaller tubs. Equally important, the workers have accepted the use of the smaller tub. All of the vineyard companies cooperating in the project have permanently adopted the smaller picking tub. The tubs are commercially available and indications of worker preference suggest that they will be disseminated throughout vineyards in Napa and Sonoma Counties.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H
Title: 4-H Program Reaches Over 84,000 Students Since 1992
Description: Enhancing the elementary school classroom by bringing in outside resources helps children learn. Children's natural curiosity and interest in animals and plants creates learning moments, encourages agricultural literacy and provides opportunities for students to discuss and learn about life experiences. To affect the classroom, however, the program must be longer than a one-day exposure. The Fresno County 4-H School Enrichment Program provides a three to six week classroom presence, enhancing the atmosphere of elementary classrooms with a 4-H curriculum in avian embryology, plant science, nutrition and water rockets. Bringing animals, plants, rockets and nutrition information to the classroom provides a basis for students to learn about basic biology, health, agricultural literacy, basic physics and life skills. Dave Snell, 4-H youth development advisor in Fresno County, has developed the curriculum and 4-H staff train teachers and provide the necessary resources for classrooms presentation. The programs are self-contained to reduce effort on the part of the teachers. College interns deliver eggs and pick up incubators for the avian embryology program. Contact teachers in each school act as organizers of the program.
Impact: Interviews with many teachers have indicated that the 4-H School Enrichment Programs is an integral part of their overall strategy to keep their students in class and excited about learning. Having that egg or chick or plant in the classroom allows them to relate their other studies such as writing, math or biology to a real living object in their classroom. When something happens to the chick, such as dying or hatching handicapped, students have a chance to discuss life skills without the risk of talking about a real person. The Fresno County 4-H School Enrichment Program reaches over 7,000 students each year. About 350 elementary school teachers in over 40 elementary schools are inserviced and provided curriculum and supplies. The program has also expanded to Tulare, Kings and Kern counties, with their county 4-H staffs presenting it.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H
Title: Building Youth Resiliency Through Environmental Design
Description: Determine the relationship of the physical environment to resiliency-inducing environments. Establish a typology of physical design characteristics which contribute to resiliency-producing environments. Develop methods and policies for use by communities and designers for evaluating and improving the physical environments to produce more resiliency-inducing places.

Impact: This report follows the 5th year of this project and the following comments summarize the accomplishments of the project over its duration. The project has focused on adolescents in the landscape and has included examination into three primary areas: the cultural context, the physical environment, and design processes. The following paragraphs briefly describe the project results in each of these areas. Cultural Context. This examination included an analysis of the population demographics of the United States, particularly how population shifts (ethnicity and age) will effect the environments where adolescents live and where designers will work. The results were presented at several professional meetings and in an article published in American Society of Landscape Architects (ASLA) Annual Meeting Proceedings. A comparative study of two decades, 1950s & 1980s, examined popular press reporting of teen-related issues, design responses, and public policies. This article was published in Landscape & Urban Planning and was the start of a more in-depth study of the public policies effecting adolescents' use of places. It was found that several policies that restrict the use of public areas by adolescents have recently increased in popularity. The impact of these restrictions on adolescents' use of public places and on their emotional and social development was reported in several interim articles and in publication #2 listed below. The Physical Environment. Understanding adolescent preferences for particular environments was an important component of this project. The researcher conducted significant research prior to this project, but two additional studies were undertaken. The first, a study of teens in a rural community in West Virginia, included documenting the places important to these teens and also presented an in-depth comparison of other previous teen preference studies. The second, a study of community skateboard parks, examined the role these parks play in communities and with the skaters. This article was published in Urban Geography. Design Processes. An important component of the work of a design researcher is understanding how the information can be incorporated into design. This project included an examination of techniques to include youth in design decision-making. Through various community-based projects, several techniques for youth participation were identified. A review of these strategies was presented at conferences in Japan and Scotland. In addition, a workshop with teens was conducted to explore their desires for a community park and to evaluate the participation strategies. A video documenting this project was presented at a national professional conference and an international multi-disciplinary conference - the results were also published in the conference proceedings. Designers will more fully understand the role the physical environment plays for adolescents and thereby understand the characteristics necessary to create a supportive environment - places that are responsive to the emotional and social development of adolescents. These changes are likely to have a long-term effect on the individuals and ultimately to the society in general.
Funding Source: Hatch and State
Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H
Title: Latino Teen Pregnancy Prevention Project
Description: By 2025, Latino youth will account for 60 percent of the youth population in California (Clark, 2000; California Department of Finance, 1998). Considerable pressure has been placed on educational and health care systems to address the particular needs of this population. A major issue of concern is the high rate of teen births among Latino youth. This rate is higher than that of any other racial/ethnic group. Nationally, the birth rate for Latina teens is twice that of non-Latino whites. In California, Latina adolescents are four times as likely to become parents as whites. The research community has only recently focused its attention on the reasons for teen parenthood among Latino youth. Little is known about how to assist young

Latinos to delay parenthood, or to aid young parents to prevent or postpone additional teen births. The Latino Teen Pregnancy Prevention Project of the UC ANR Adolescence Workgroup has aimed to increase our knowledge of how to help Latino teen parents procure the assistance they need to improve their lives and the lives of their children. This project has also sought to learn what factors are crucial to increasing the odds that teens will delay the birth of a second child until they are better equipped to handle the additional responsibilities and burdens. Efforts have included a comprehensive review of the research literature on effective teen pregnancy prevention, surveys of 35 pregnancy prevention practitioners throughout the Bay Area and Central Valley, and visits to 12 local teen pregnancy prevention programs in the San Francisco Bay Area -- including schools, health care agencies, and community-based organizations.
Impact: Efforts of the Latino Teen Pregnancy Prevention Project have culminated in the development of a handbook for community practitioners which is designed to enhance program content and delivery. The Best Practices in Teen Pregnancy Prevention: Practitioner Handbook has been widely distributed to schools, community-based organizations, health agencies, and statewide partners through county-wide teen pregnancy prevention coalitions and national conferences. Over 230 copies of the handbook have been distributed throughout the nation. A vast proportion has been provided to California pregnancy prevention practitioners who work with Latino teens. The handbook's utility is evidenced in its use as criteria to award local grants by the San Mateo County Pregnancy Prevention Network. Workgroup members have also used the handbook to partner with and assist six teen pregnancy prevention programs in California to deliver improved services by incorporating these "best practices." In so doing, the Latino Teen Pregnancy Prevention Project has addressed ANR's historic responsibility to respond to contemporary needs in California with effective, science-based information.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H
Title: Money Talks: Program Improves Financial Literacy of Teens
Description: High school seniors have little knowledge of money management, savings, investments, income and spending. Although experts contend that children can grasp the concept of money as early as age 3, the American Savings Education Council study found that the majority (79%) of students ages 16 through 22 had never taken a class in personal finance. Two-thirds admitted that they could use more lessons on money management, and 9% were rolling over credit card debt each month. (Thirty-two percent had a credit card.)
Credit problems can start before young people are out of their teens. A Consumer Federation of America study found that "about 70% of undergraduates at four-year colleges possess at least one credit card." "Revolvers" carry debts on these cards that average more than $2,000, with one-fifth carrying debts of more than $10,000. Students with unsustainable debts may be forced to cut back on their course work or to drop out of school completely and work full time. The psychological problems resulting from unsustainable debts can range from anxiety to a severe emotional crisis and even suicide. A team of University of California Cooperative Extension Advisors created a curriculum appealing to teenagers that increases their financial literacy. The Money Talks: Should I Be Listening? curriculum, developed after surveying 323 Southern California teens, was designed to address the issues teens indicated were most important: simple ways to save, car buying, spending personality, and smart shopping. The purpose of the Money Talks curriculum is to create a multi-cultural curriculum that provides teens with accurate, non-biased information and hands-on experiences in financial management. The Money Talks curriculum consists of four upbeat and colorful newsletters; a video on savings, "Making Your

Dreams Come True"; and a bi-lingual Web site . The Web site contains downloadable versions of all the newsletters, interactive games, simple exercises, the savings video, and links to other financial sites. Teens can send questions to $am, our in-house financial advisor, and wait for an answer to be posted to the site. Teachers have access to a special section containing leader's guides for each newsletter with additional handouts, activities, and visuals to help engage students in the topic.
Impact: Nine sites in four counties pilot-tested the English version of the "Money Talks" newsletters. Pre- and post-test data were collected from 114 teens. Thirty items measured participants' financial attitudes and behaviors. Relative scores showed positive changes in behavior over time. Students seemed particularly to understand the intrinsic value of money and how personal values influence money decisions after using the "Money Talks" newsletters. The students also gained valuable information about car insurance. Participation in the program also had a positive influence on teens' knowledge. Nineteen true/false questions assessed knowledge on a variety of financial topics. Prior to participation in the program, participants answered an average of 56% of the questions correctly. On the post-test, teens answered about 70% correctly. The program is being expanded to include a newsletter series on banking and the addition of new games to the Web site. A second grant from the J.P. Morgan Chase Foundation will support developing materials on credit
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H
Title: Needs of Teen Parents and Their Children Identified by Local Consortium
Description: Teen parents throughout Solano County have not been receiving services available to low-income families. Health professionals and social services providers are concerned about the welfare of babies of teens and about the isolation and lack of opportunities for teen parents as they struggle to provide for their children. A consortium of community agencies received funding through a Prop 10 planning grant to assess the service support needs of teen parents and their children in Solano County, especially those who lack parent education programs and family support systems. A critical component of this effort was to make sure that the "voices" of the teen parents were evident in the final report. As a member of the coalition, the UCCE Solano County youth advisor was asked to design the process used. A UC Davis-based training program sponsored by Cooperative Extension offered participants the skills and knowledge to help their local communities work through critical issues, using the power of deliberative discussion in a forum setting. A combination of meeting facilitation and a decisionmaking discussion tool was constructed to share the "voice" of the teen parent participants. Sixteen teens and eight adults learned quickly the extent of their concern for their babies and themselves, and the worrisome conditions under which they are trying to raise their children. This forum set the stage for months of thoughtful discussion. The UCCE advisor met with the project coordinator prior to each meeting, provided feedback, suggested experiential team-building activities and used listening techniques to help identify the "teen voice." At the conclusion of the project, 10 specific strategies were identifed by the teen parents as most important for them and their children.
Impact: The report from the Teen Parent Consortium resulted in the establishment of two programs, each representing one of the teen identified top concerns. Approximately $870,000 was allocated for the programs, which will be conducted over three years. More personal payoffs resulted as well. Two teen parents were recruited into salaried positions, one as an administrative assistant for a teen pregnancy prevention program and the second as a outreach educator for a

newly formed teen-parent resource center. Also, one teen received a $25,000 scholarship to complete her college education.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H
Title: SLO Scientists: Families Having Fun with Science Clubs
Description: The SLO Scientists program was conceived and piloted in San Luis Obispo (SLO) County, California, to address the desire and need to involve youth and adults together in hands-on science. This helps improve science processing skills, science literacy and issues of family dynamics. The SLO Scientists Clubs utilize a new model of 4-H club structure that involves adults in a one-on-one (one adult/one youth) basis. Leader training explores scientific inquiry and critical thinking skills for the leaders/facilitators, which helps develop a high level of commitment and enthusiasm. High-quality experiential curricula, developed by the California 4-H Youth Development Program and ANR, have been used. The 4-H Center for Youth Development was involved in the initial design of the research and data analysis. The clubs were designed with these principles in mind: (1) The skills of scientific investigation would be taught in an enjoyable setting. (2)Activities would encourage youth/adult pairs to utilize critical thinking skills. (3)Participants would be encouraged to utilize their new skills and knowledge to better understand and to initiate action on science-related issues in their communities. (4) Clubs would provide a safe and fun environment for adults to learn from children and children from adults, and (5) family dynamics of mutual respect would be fostered for all participants so that involvement might allow a child to develop or strengthen an ongoing relationship with parent/guardians or other caring adults. To participate in SLO Scientists, children need to be in grades three, four or five. Each child has to have an adult willing to accompany her/him to all club meetings and be her or his partner during the meeting. Club meetings are held twice a month for 90 minutes in the evening, with occasional field trips. Each component has eight to ten sessions and participants may continue for another component.
Impact: Approximately 500 individuals have participated in the program since its inception in late 1995. A random sampling of participants (N=34 children & 34 adults) indicated that:

- Just over 50% of the children reported that they spent more time on such things as observing and experimenting after becoming involved in the SLO Scientists Program. Thirty-three percent of the adults reported an increase in this activity.
- Sixty-seven percent of the children reported that they "always" or "most of the time" talked with other family members about the activities after each meeting. Ninety-five percent of the adults reported doing this.
- Fifty percent of the children reported an increase in talking with her/his adult partner "about things other than science" since joining the program. Fifty percent of the adults also reported more talking with her/his child partner.
- Thirty-six percent of the children reported an increase in "family meetings to talk things over and solve problems" since starting the program. The adult participants reported a 25% increase in family meetings.

Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H
Title: Special Needs T.R.A.I.L. Program

Description: Research continues to document the success of animals as a means of therapy for children with special needs. Therapeutic horseback riding introduces children with special needs to freedom, confidence and the spiritual and physical therapy of riding a horse.
The T.R.A.I.L. Project (Teaching Riding as an Access to Independence and Learning) was developed by a group of youth in Mendocino County's 4-H Youth Development program. With the help of many adults and 4-H volunteers, young special riders are introduced to horses in a safe and positive atmosphere. Walkers accompany the riders, either leading the horse or steadying and supporting the rider. Most of the special riders have been referred to the program through local occupational therapists, by word of mouth or through other 4-H members and their families. Working through local children's service agencies, we learned that foster children also often have significant emotional and spiritual needs that can be met with the riding program.
Impact: Since the T.R.A.I.L. rides began in 1993, the program has aided therapy for over 100 riders. We have seen balance, language and other skills improve in many special riders. In addition, the motion of the horse and use of the hands on the reins increases blood flow and slowly but gently loosens contracted muscles. One blind child with cerebral palsy who at first required a "back rider" to keep her upright and secure on the horse is now riding on an English saddle by herself. The biggest payoff is the independence and trust that the riders develop. The foster children in our program benefit as well. Not only do they experience "pet" therapy, but they also learn responsibility and the self esteem that comes from working with horses and assisting other special riders as volunteers for the program.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H
Title: Teens Engage in Service Learning
Description: California schools increasingly include community engagement as part of their curriculum, and many high schools now list service projects as a graduation requirement. Through service-learning, communities benefit from the work and talent of young people, and youth gain valuable knowledge and skills. However, service-learning is complex. Too often teens end up with hollow assignments and the "learning" and the "service" are never fully connected. The process requires community partners who know how to incorporate youth into meaningful roles, embracing the energy and talents young people have to offer.
The 4-H Youth Development Program views teenagers not simply as program recipients but as promising resources. Teens provide unique ideas, energy and community connections. In Sacramento County, the 4-H Youth Development Program has provided dozens of teenagers with opportunities to address community issues and put their ideas into action.
Our programs empower teenagers, developing in them the tools and sense of responsibility to make a difference in things they feel important. Some teens have chosen to gather and refurbish bicycles for children. Others are trained to teach science to younger children in weekly after-school programs. Still other teens volunteer to plan and deliver environmental and camping programs. In each instance, young people partner with caring adults who coach, encourage and support them. The 4-H Youth Development Program is experiential education, which is the essence of service-learning. Youth are asked not only to engage in an activity, but to reflect upon their experience and apply what they have learned.
Impact: Teens as well as parents and adult project leaders were asked how they had grown through their experieces in teaching science to younger students. There were many answers to this question--becoming more organized, learning how to work with children, being responsible, teamwork. Ninety-two percent of the teens reported feeling more confident in public speaking as

a result of their service-learning experience. For some teenagers, these projects have opened doors to new opportunites and provided the chance to explore potential careers.
One thing teens agree on: they enjoy the responsiblity such programs offer...and being in charge. Long after the school service hour requirement is met, teens continue their involvement as planners, teachers, and do-ers.
Funding Source: Smith-Lever and State
Scope of Impact: State Specific

Theme: 5.28 Youth Development/4-H
Title: Worms and Snails and Teen Teacher Tales
Description: The desire for higher test scores, by emphasizing reading and math in elementary schools, is squeezing science from the curriculum, especially in low-income communities where school test scores often lag. The result is that young elementary school-aged children in these neighborhoods receive limited science education during the school day and few opportunities to enjoy the discovery, wonder, and learning of inquiry-based activities. In Sacramento County, UCCE partners with the Sacramento START after-school program, training teenage volunteers and program staff in the 4-H Youth Experiences in Science (YES) Project. Program staff coach the teens who deliver the program weekly at Sacramento START sites. Curriculum units include Snails, Worms, Bubbles, Recycling, Energy, Collections and Kitchen Science. The program promotes problem solving and thinking. Since September 1997, over 150 teens have delivered the semester-long program to more than 3,000 first to third grade children who attend the Sacramento START program. This partnership model has been successfully replicated in Monterey County.
Impact: Feedback from teens, coaches, parents and children themselves indicate that young program participants look forward to the YES Project sessions. Eighty-six percent of parents reported that their children wanted to continue in YES, and teens reiterate that finding. Ninety-two percent of teens reported feeling more confident in public speaking as a result of their YES experience. The program provides new experiences for teenagers, a chance to make a real difference in their communities and opportunities to explore potential career choices.
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.

Program Planning Advisory Committees (PPACs)
These committees are comprised of forty-five Division members representative of the diversity of UC ANR disciplines and program areas, from all Division-affiliated campuses and from county offices throughout the state. Fifteen individuals serve on each of three subject area committees, Agricultural Resources, Human Resources and Natural Resources.

The PPACs are charged with recommending Division-wide program priorities by identifying Critical Issues facing California that the Division can address and Target Issues, those Critical Issues where additional Division resources are most needed to address the problem. The three year planning cycle includes an "environmental scan" of stakeholders to determine the Critical Issues; assessment of current Division capabilities and resource commitments to the Critical Issues, and program evaluation to determine how effectively the Division has been able to address the Critical Issues.

During the fall of 2002, PPAC members conducted the "environmental scan" by surveying external and internal stakeholders through personal contact, written surveys, and web-based surveys to make an initial determination of the critical issues facing Californians. Over 200 organizations, agencies, institutions and other groups were contacted in this effort. In addition, input was solicited from the 1100 ANR academics. The resulting input was used to make an initial list of critical issues. Both ANR members and external stakeholders were then given the opportunity to comment on the draft lists and to indicate their top priorities. This information was then used by each PPAC to finalize the list of ANR Critical Issues for use in programmatic decision making by ANR leadership and individual members.

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. 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. 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. There were 88 Divisionwide workgroups with a total membership of over 3500. These workgroups involved nearly 600 external stakeholders in their program planning process and workgroup activities and projects. 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.

Workgroups requested funding for high priority research and extension projects identified by the internal and external workgroup members. Funds were allocated for specific research and extension projects collaboratively planned by the workgroup and conducted by workgroup members. Where appropriate, ANR workgroup funding was used as "seed money" to leverage or match other sources of support.

Agricultural, Human and Natural Resources Focus Groups

The Division conducted two Cooperative Extension Strategic Planning External Stakeholder Focus Groups in October 2002. One session was held with a group of individuals representing ANR's Human Resources program and another session with stakeholders from the Natural Resources program area. A session planned with Agricultural Resources program area stakeholders could not be conducted; instead individual interviews of fourteen stakeholders were conducted in the spring of 2003 to get the perspectives of Agricultural Resources constituents. The overall purpose of this exercise was to gather external stakeholders' views about the future, Cooperative Extension's role and their analysis of current organizational dilemmas that need to be addressed to ensure that Cooperative Extension stays engaged, relevant and effective in meeting critical clientele needs in the future.

External stakeholders from ANR's agricultural, human and natural resources program areas identified these growing trends for the future in California:

- Scarcity of "academic horsepower" and other professional human resources with a concurrent need to develop "pipelines" for new employees in private and public sectors.
- Competition for economic resources and continuing budget crises facing the state. Pressure on the environment and natural resources including agricultural lands to provide clean air, land and water for growing populations. Projected increase, almost doubling of California's population creating more pressure on land resources for agriculture.
- Threatened economic and overall viability in agriculture, farming, ranching and timber industries in California. Many firms are leaving the state to go to Arizona or Mexico or selling land to developers
- Lack of public understanding and environmental literacy so there is a need to increase public understanding and appreciation of how natural, agricultural and human systems are interdependent, including interrelationships of rural and urban populations
- There is a need for greater collaboration and partnerships among different stakeholders and disparate interest groups to solve complex and interdependent environmental, economic and social problems.
- CE's role is to "bridge, knit, and translate," providing objective scientifically based information and problem solving in local communities. CE is the University connection to the real world, facilitates dialogue and has knowledgeable people provide information that is science-based and non-biased so that people can make rational decisions.

In addition Agricultural Resources stakeholders identified these growing trends:

- Water, water, water and more water issues! Availability, cost, quality and regulation. Water is second most important agricultural input next to land and it is getting scarcer.

- Increasing government mandates, regulations and compliance leading to higher production costs – e.g. regional water control boards, wetland protection and air quality controls. Growers need someone to provide a road map so they can navigate through the regulations and meet them.
- Greater economic competition from other countries – e.g. China was mentioned several times as rapidly increasing production of several commodities with low labor costs and taking over California markets both at home and abroad.
- Growing agricultural/urban interface issues and challenges – existing land use policies constantly get challenged and thrown out because of a lack of knowledge about agriculture by elected officials.
- Big operations can do the applied research needed to implement the new research. Small operations can't do the applied research themselves. They need CE to do this. They need CE as the mechanism to transfer the basic information to the small businesses.
- Cost of labor has gone up dramatically - 90% of costs are in labor.

In addition Human Resources stakeholders identified these themes:
- Rural families have critical health and housing needs.
- Public schools and have new challenges.
- 4-H needs a new image and new direction to engage and serve diverse communities.
- Nutrition and health education is essential for healthy youth and adult populations.

In addition Natural Resources stakeholders identified these themes:
- Changing business paradigms for agriculture and natural resource based industries.
- More challenging and contentious public decision-making related to tensions related to natural resource policy, management and use.

The input received from these focus groups will be used in both programmatic and organizational planning by the Division's administrative leadership as decisions are made on determining the most effective organizational structure for ANR to serve California's needs and also to address the issues identified as priorities.

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 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 issues identified by California stakeholders:

Key Theme: 4.02 Air Quality/4.01 Agricultural Waste Management
Title: Alternate Uses for Agricultural Waste
Scope of Impact: State
Source of Funding: Smith Lever and State
Because burning of rice straw impairs air quality, state legislation charged the Air Resources Board with finding alternative uses for 50% of the straw by 2002. It was estimated in 1999 that only 3% was being baled for such uses. The rest was incorporated back into the ground and flooded. Meanwhile, rice straw had a reputation as poor cattle feed and even as a cause of death in some instances. For that reason, little rice straw was being fed despite the mounting pressure to increase utilization of straw. A key finding of this UCCE project was the large variation in feed quality of rice straw. Research with rice growers in Sutter, Yuba and Butte counties identified production practices to improve straw quality. At the same time, efforts with cattle feeders in Siskiyiou county identified ways of feeding rice straw that are nutritionally adequate and safe for cattle. Thus, the UC work led to increased understanding of the needs of both rice growers and cattle feeders. Once those needs were identified, the CE advisors were able to develop quality criteria for rice straw that facilitated marketing of straw that met cattlemen's needs.
Impact: The number of successful rice straw feeding operations has increased, which in turn has meant more straw marketed. The bottom line is more rice straw fed to cattle and less smoke from burning rice straw.

"Our newly-formed California Straw Supply Cooperative wanted to develop a marketing plan for rice straw as cattle feed. The Cooperative Extension program allowed us to kick-start our marketing of rice straw that met the cattlemen's needs. We sold 10,000 tons of rice straw for cattle feed in our first year of operation." Keith Shaw Manager of California Straw Supply Cooperative. "The Extension program has done an outstanding job of defining needs of the grower and cattle producers" Paul Buttner, Manager of Environmental Affairs for the California Rice Commission.

Key Theme: 4.22 Sustainable Agriculture
Title: Dairy Manure Water Nutrients for Forage Crop Production
Scope of Impact: State
Sources of Funding: Smith Lever and State

Growers have long known that dairy manure water pumped onto adjacent farmland contains useful plant nutrients. However, because it hasn't been easy to estimate the amounts of nitrogen and other nutrients in the water, farmers have added commercial fertilizer. Under the US EPA'a revised Clean Water Act requirements, most dairy farms will have to prepare management plans documenting all plant nutrients applied to fields. Eventually, the revised regulations will require producers to submit documents showing they are applying manure nutrients at appropriate rates. Final compliance with the regulations will be required by January, 2006. Growers are concerned about the complexity of complying with the new regulation. Data from the Biologically Integrated Farming Systems (BIFS) program and other UC research projects using flow meters and nitrogen "quick tests" have made it possible for farmers to measure nutrients in the lagoon water. This enables them to reduce or eliminate use of synthetic fertilizers. BIFS is administered by UC's Sustainable Agriculture Research and Education Program (SAREP). A CE specialist's project on the impact of dairy waste and nutrient management on groundwater quality was conducted in conjunction with an advisor's project on the use of dairy lagoon water in the production of forage crops. These projects laid the groundwork for the dairy BIFS project, involving farmers and pest control consultants as well as UC farm advisors, specialists and other researchers. Field days, workshops, grower surveys and other tools that directly link researchers with farmers have been used extensively in the project.

Impact: In one on-farm demonstration project, eight BIFS dairy farmers in partnership with UC farm advisors and researchers have optimized the use of animal manure on their forage crops, reducing the use of nitrogen, phosphorus and potassium and lessening the leaching of nitrates into the soil. Cost savings to the growers averaged $55/acre and went as high as $116/acre. In a related project, the specialist found an overall 25% decrease in average shallow groundwater nitrate concentration over four years where cooperating dairy farmers were managing the nutrients on their fields. "We cut our commercial fertilizer use way back and still managed to maintain our yields. My neighbor has begun to do the same thing. I think there has been a transition in the whole dairy industry." BIFS dairy farmer Steve Wilbur of SBS Ag, Tulare.

Key Theme: 4.23 Water Quality
Title: Mitigation of Contaminants in Surface Runoff from Nurseries
Scope of Impact: State
Source of Funding: Smith Lever and State

In the late 1980s, contamination of San Diego Creek and Newport Bay in Orange County resulted in the development of Total Maximum Daily Loads (TMDLs) for sediment, nutrients, pathogens, and several toxics. Since then, surface runoff from three nurseries operating in the San Diego Creek watershed has been regulated by the Santa Ana Regional Water Quality Board by issuing Waste Discharge Requirements (WDRs) permits. The permits have been updated regularly to reflect changes in water quality and to coincide with TMDL allocations. However, pollutant allocations have been expected to be reduced substantially in revised permits, thereby putting the nurseries at risk of consistently exceeding their daily load allocation.

Two California advisors developed and implemented a series of mitigation practices at one of the three permitted nurseries. The goal was to evaluate several low-cost practices for reducing pollutant loads in surface runoff. Campus researchers assisted the advisors and nursery

personnel in measuring the effectiveness of the various mitigation efforts by analyzing pollutants, especially pesticides. The project also involved several agencies, including the California Department of Pesticide Regulation, the Santa Ana Regional Water Quality Control Board and the Calfornia Department of Food and Agriculture. Surface runoff was treated with a series of mitigation practices, starting with the addition of polyacrylamides to flocculate soil particles, then settling these particles in sediment traps and a pond, and finally passing the runoff through a vegetative filter.

Impact: The result was a significant decrease in pollutant loading. During two years, water samples taken upstream and downstream of the mitigation practices showed reductions in nitrogen and phosphorus loads of 58% and 54%, respectively. Suspended solids were reduced 97-99%, while pesticides used to control Red Imported Fire Ant (bifenthrin and permethrin) were consistently reduced by more than 90%. The vegetative filter alone showed a 44% decrease in bifenthrin. Without these improvements in water quality, the nursery would potentially face serious fines and/or a cease and desist order. The pollutant reductions resulting from this project provided the nursery with a comfortable buffer.

Key Theme: 5.04 Child Care/Dependent Care
Title: Community Agency Learning (CAL) Series
Scope of Impact: State
Source of Funding: Smith Lever and State

Because over half (55%) of all California children ages 5 to 14 have both parents or a single parent working at least 30 hours per week, after-school programs are critically needed and play an important role in the lives of many children. The most important factor in the quality of this care, according to the RAND Corporation, is the quality of staff. However, maintaining staff quality is challenging due to factors such as funding uncertainty and short work hours. Although staff generally do not have teaching credentials, they are increasingly called upon to improve the academic work of low-achieving students. When that happens, traditional teaching methods that have failed the student during the school day are unlikely to succeed in after-school programs. The 4-H Youth Development staff in the San Francisco Bay Area developed 17 professional development workshops for after-school program staff: the Community Agency Learning (CAL) Series. These interactive workshops, based on expressed interests and needs and on the latest research information, cover youth development theory, after-school program management and after-school curricula. The 4-H staff team has trained more than 800 after-school program staff who in turn work with more than 8,000 children in Northern California. A similar program is being developed to serve Southern California communities.

Impact: Following the workshops, after-school staff consistently report improved knowledge and skills in working with children. Each of the workshops is evaluated, using a retrospective pre- and post-test. For example, 17 participants in the workshop titled Working with Challenging Children gave these responses:

--In regard to "ways to change the environment, curriculum/activities, teaching strategies, etc. to improve children's behaviors", respondents indicated a 41% improvement in knowledge.
--When asked if they "understand that staff has the strongest influence on children's behavior", respondents indicated 28% improvement.
--In regard to having "a rough plan to improve children's behavior", respondents indicated 67% improvement.

(*2) Did the planned programs address the needs of under-served and under-represented populations of the State(s)?* Listed below are several examples of California efforts to address the needs of under-served and under-represented populations in the state.

Key Theme: 1.03 Agricultural Profitability
Title: Small Business Enterprise Education Program
Scope of Impact: State
Source of Funding: Smith Lever and State
The government provides over fifty percent of employment in Trinity County and there are limited private sector job opportunities for the population. Additionally, there are a handful of manufacturing employers to provide employment to those who wish to create and market products. Consequently, those who wish to design and market products often do so as small business enterprises and these entrepreneurs need support to learn the skills and strategies of business planning. A California advisor conducted a project with the following objectives: Clients will: (1)explore the feasibility of marketing a product or service by writing a business plan, (2) use methods of analyzing markets and promotional strategies/materials, (3) meet with experts who can forward client business goals, and (4) identify financial and career skills needed for entrepreneurship, and (5) use group communication methods and organizational structures for the benefit of their business or non-profit organization. Clients will experience the value of writing a business plan prior to starting a business. Clients will use experts to enhance their entrepreneurial skills and chances for business success. The advisor participated in and taught small business development workshops, offered seminars in destination marketing and tourism market analysis and conducted workshops in non-profit organization management and grant writing. The educational/outreach results were the increased use of formal business plans in business start-up; increased bank financing of small businesses; increased grant funding to non-profit organizations; increased use of destination marketing strategies in tourism promotion and of market analysis in tracking tourist visits.
Impacts: In Spring 2003 five people completed a business plan, joined the Trinity County Chamber of Commerce, and will be fully operational by the end of the year. In 2002, a grant writing coalition of was formed (current membership is 53 people). The quality of proposals submitted were greatly improved over that which the writers could have done without coaching and without incorporation of feedback. There was a 30% approval rate of proposals submitted by coalition members. Membership donations to the Trinity County Chamber of Commerce increased after the announcement to develop a new marketing plan. Knowledge and skills gained through this project have been used by TCCC members in developing campaign materials for increase of the Trinity County Transient Occupancy Tax (a source of TCCC funding).

Key Theme: 1.32 Small Farm Viability
Title: Small Farm "Incubator Project"
Scope of Impact: State
Source of Funding: Smith Lever and State
Small farms and those with limited resources number well over 1,400 in Fresno County. The county's great diversity in ethnic makeup of small farmers makes for a unique and challenging opportunity to extend information. Many Hmong farmers also have difficulty understanding English. A Small Farms Advisor helped develop a 20-acre incubator farm where participants farm one to three acres and receive technical training during a two-year program. The programs are presented in various languages, including Hmong and Lao. The Center also serves as a one-stop-shop where farmers can attend computer classes, get information about loans and

recordkeeping or find out in the resource library about all of UC's programs. Cooperative Extension provides technical assistance for the farm production and the project is a collaboration between UCCE, Hmong American Community, American Farmland Trust and CV Small Business Development Center. Other participants include USDA-RMA, FSA, RD.
Impact: During 2002, more than 100 minority small farmers attended workshops at the Small Farm Incubator Project site in Fresno. Six, including three Hmong, two Lao and one African American, are participating in the two-year training and are farming between one and three acres. They also attend monthly workshops at the site, learning about IPM, soils, irrigation, fertilizers, marketing, postharvest, recordkeeping, budgets and finance.

Key Theme: 1.33 Small Farm Viability
Title: Assistance to Southeast Asian Strawberry Farmers
Scope of Impact: State
Source of Funding: Smith Lever and State
In the early 1990s, several Southeast Asian immigrants began planting strawberries in Sacramento County. They had very limited experience in farming, particularly with pest management, and they frequently lost entire crops to pests. They needed information, as did other Southeast Asian growers who joined them. There are currently about 40 Southeast Asian growers in Sacramento County. A UC horticulture advisor began working closely with the growers, conducting research and holding one or two meetings per year. He received a grant to provide each grower with a hand lens, an Integrated Pest Management manual and other useful information. He also encouraged the TV program "California Heartland" to film a segment on strawberry farming in Sacramento County, which they did in 2002. Several newspaper and magazine articles were written featuring these growers.
Impact: Through the advisor's efforts, these growers used safer and more effective production and pest management practices, and have received media attention to attract more customers. Growers are now able to identify and control key pests such as spider mites and worms. They frequently use UCCE as a resource for production questions.

Key Theme: 3.03 Human Nutrition
Title: Nutrition Education Programs for Professionals
Scope of Impact: state
Source of Funding: Smith Lever and State
Healthy dietary intake is especially critical for infants and young children because the effects of nutritional deficiency on physical development during stages of infancy and early childhood cannot always be reversed with improved dietary intake. Research shows that by age six children acquire most of their eating attitudes and behaviors. The early years area prime time for intervention. Training in nutrition for child care and health care professionals working with young children were a primary target for nutrition programs in this California county.
Impacts:

- 40 child care professional registered for an on-line nutrition education course. As a result of taking the on-line course participants report they are more likely to serve a variety of foods from each food group, try new foods and preparation techniques, read food labels, engage in physical activity, and use a thermometer during food preparation.
- 49 health care professionals attended a Child and Weight: How Professionals Can Help Workshop. Based on training evaluations over 60% of the participants planned to use the

BMI charts for height and weight, 9)% would modify their charting assessments of children, 95% felt an improved competence at assessing and caring for overweight children.

- 33 child care professional attended a training on Turn Off the TV..Tune into Family Fun. A retrospective survey found that participants gained a better understanding of the importance of good nutrition and physical activity. 76% reported they would make changes in their current behavior in these areas.
- Over 10,000 child nutrition placements were developed and distributed. The posters contained three distinct messages about family meal time, physical activity, and healthy eating habits. The child care providers indicated that the parents were very interested in the placements and that the children were trying new foods as a result of using the placements and discussing their messages. Most child care providers were able to list at least one behavior they would change as a result of their participation in the program.

Key Theme: 3.02 Human Nutrition
Title: Tast-D Cooking for Your Health
Scope of Impact: State
Source of Funding: Smith-Lever and State

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 diabetes, and osteoporosis. Many of the subpopulations within San Joaquin County are considered to be at higher risk of nutrient deficiencies and/or nutrition-related problems such as children, women of childbearing years, families/individuals living in poverty, substance abusers, elderly, migrant workers, and certain ethnic subgroups such as African Americans, Latinos, and Southeast Asians. Goals of the project were to conduct research, develop materials, and pilot test nutrition education projects/materials and to improve dietary habits of population groups with higher incidences of diabetes, obesity, and heart disease than the general population. Three series of 6 workshops each were conducted from Fall 2002 through Fall 2003--two series in English and one series in Spanish. Approximately 100 county residents received diabetes awareness and prevention education--both those at risk of diabetes and those already diagnosed with diabetes. See above results.

Impact: Clients in both the Spanish-speaking and the English-speaking series enthusiastically responded to evaluation questions during their final workshop. They appeared to feel free to express both what they liked about the classes as well as what they felt could be improved. Four participants shared special achievements during the four months of the project that deserve special attention:

1) One female participant lost 26 pounds
2) One female participant lost 21 pounds
3) One female participant lost 15 pounds
4) One male participant lowered his very high blood pressure significantly by switching from canned vegetables to fresh vegetables.

The participants reported these achievements were due to the knowledge they had acquired in class on portion control and sodium content of canned foods. More than one participant articulated the following in response to the questions:

- Clients discussed in detail how they now felt empowered to ask their doctor questions and to take control of their health because of the knowledge gained in the Tast-D workshops.
- Clients learned that substitute foods (i.e. light mayonnaise, Splenda) tasted as good as regular food.
- Clients were cooking many of the recipes at home and sharing recipes with friends.
- Clients learned that daily exercise is important. Clients especially liked that they could exercise sitting down--chair dancing.
- Clients discussed using the food label more often to make healthier choices. Several clients talked about learning to pay attention to the "per serving" concept of the Nutrition Facts Label.
- Clients started using fresh vegetables instead of canned vegetables after finding out how much sodium was in canned vegetables.
- Clients talked about cutting red meat consumption to 1-2 times per week.
- Clients talked about understanding how to identify carbohydrates in their diet
- Clients talked about using the Plate Method to control portions and balance their diets

Key Theme: 3.02 Human Health
Title: 1% Milk Promotion Increases Sales 43.8%
Scope of Impact: State
Sources of Funding: Smith Lever and State.
Milk is an important food for children and adults, providing calcium, Vitamin D and protein as well as helping to prevent osteoporosis. Compared to whole milk, low fat (1%) milk provides all these benefits and also significantly reduces the amount of saturated fat in the diet (8 grams of fat in a cup of whole milk, 2.5 grams in a cup of 1% milk). In children and adults alike, reducing fat in the diet can help prevent overweight and obesity, heart disease, cancer, stroke and type 2 diabetes. This is particularly true in Hispanic population groups, since data indicate Hispanics consume more high-fat milk than non-Hispanics. A recent community-based social marketing campaign targeting low income Hispanic women with a "1% Milk ...Healthy & Delicious" message was developed by UCCE and other members of the Central Valley LEAN Coalition. Implementation of the campaign involved an array of community partnerships: schools in the targeted zip codes allowed parent education classes with taste tests, a Loteria Bingo game, posters and brochure distribution to all parents; posters and brochures were distributed at local health clinics and doctors' offices; WIC, the Fresno County Health Department and Head Start distributed brochures and posters and strengthened their own 1% milk message; local supermarkets displayed posters and shelf-talkers and sponsored taste tests; 30- and 60-second Spanish and English TV and radio commercials were developed and run on local stations, and both English and Spanish local newspapers printed articles supporting 1% milk.
Impact: Pre- and post-campaign milk sales data collected from local supermarkets in the targeted zip codes demonstrated a 43.8% increase in 1% milk sales during the first four-month campaign. Pre- and post-campaign exit surveys done at the supermarkets with Hispanic women confirmed that behavior had changed...barriers of knowledge about the nutritional advantage of 1% milk had been overcome by the information provided in classes and in the brochures; barriers of taste had been overcome by taste tests allowing people to discover that they liked 1% milk; barriers of habit had been overcome by point-of-sale reminders to purchase 1% milk. Over a life-time, this single behavior change will have a significant impact on the health and well-being of children and adults in California.

Key Theme: 5.11 Family Resource Management
Title: Increasing Use of the Earned Income Tax Credit for Low Income Families
Scope of Impact: State
Source of Funding: Smith Lever and State
The Earned Income Tax Credit has been described as the largest and most successful federal assistance program for low-income working families. Last year, the EITC was responsible for elevating the families of 5 million children above the federal poverty line. However, many eligible families do not take advantage of this valuable income supplement for various reasons, as indicated by the findings of Rural Families Speak. Recognizing the need to reach out to rural families about the EITC, Rural Families Speak distributed English and Spanish IRS materials explaining eligibility and the filing process to research participants between their first- and second-year interviews. County advisors were informed about the lack of rural families' use of the EITC and the need for education about the credit. EITC information is being included as part of EFNEP (Expanded Food Nutrition Education Program) and FSNEP (Food Stamp Nutrition Education Program) efforts. The University of California Cooperative Extension Spanish Broadcast and Media Services is disseminating written materials and radio announcements.
Impact: As a result of distributing educational materials about the credit to low-income Latino families living in rural communities, more than twice as many families received the credit the following tax year. The additional information provided by EFNEP and FSNEP and in public service announcements will further increase the number of families taking advantage of this valuable income supplement, contributing to their financial security and well-being.

Key Theme: 5.26 Workforce Preparation
Title: Gateway to a Better Life
Scope of Impact: County
Source of Funding: Smith Lever and State
The stagnant Imperial county economy has negatively impacted the economic and social welfare of a large portion of Imperial County residents. Unemployment and poverty are notably higher in Imperial County than in other California counties. According to the US Census 2000, 22% of Imperial County residents were living below the poverty level, compared to the California average of 14% and unemployment has ranged from 23% to 35% during the past ten years. Through collaboration with the Imperial County Housing Authority and the Regional Occupation Program, over 500 low-income individuals have been reached in the past two years with segments of the Gateway to a Better Life curriculum. The Gateway curriculum helps prepare welfare recipients to enter the workforce with greater success, providing them with the information they need to get a job and balance the demands of work and home. The easy-to-understand lessons were developed in English and Spanish, and were used in small group settings. The field-tested lessons help welfare-to-work recipients find jobs and stay employed through the development of life skills.
Impact: In the last two years the Imperial County Housing Authority has enrolled over 98 participants in its Self-Sufficiency Program, which features segments of the Gateway to a Better Life curriculum. Lessons were presented on establishing goals, decision making, paying bills on time, stretching your dollars and banking. The Food Stamp Nutrition Education Program was also presented. Twenty-four participants completed the Self-Sufficiency Program and half of them were able to purchase their first home and leave public-assisted housing.

(3) Did the planned programs describe the expected outcomes and impacts?

The planned programs achieved many of the performance goals 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 other institutions results in efficient programs delivered to the citizens of California. Collaborative work with other institutions builds on the comparative advantage of each institution and leverages the expertise within the region/area. This results in less duplicative efforts or "reinventing the wheel" in each state. The collaborations bring about improved program efficiency, making the most effective use of the resources in each institution. This is particularly important in the current economic environment of limited or declining resources. This is illustrated, for example, in the continuing multistate activities in the Northern California/Southern Oregon intermountain efforts and the livestock collaborations among California, Oregon, Idaho, and Nevada.

The strong integration of California's AES and CE research and extension programs ensured effective and efficient programs addressing the needs of California citizens in agriculture, human and natural resources. The strong linkages between the local county CE programs and the campus research base guaranteed that there is a research base for the county programs to draw upon as the local clientele identify the problems and issues affecting them. Through the program planning processes described in Section B., AES faculty, CE specialists and CE advisors interacted through the workgroups and Program Planning Advisory Committees throughout the year, keeping communication from the field to the laboratory constant.

SECTION E. MULTISTATE EXTENSION ACTIVITIES

(1) Did the planned programs address the critical issues of strategic importance, including those identified by the stakeholders? The programs described below were initiated in response to the critical needs of stakeholders.

Key Theme: 1.03 Agricultural Profitability
Title: Intermountain Winter Seminars
Cooperating States: CA, OR
Source of Funding: Smith Lever and State
Annual winter seminars are conducted jointly by UC and Oregon State University in the Klamath Basin. In 2003, three all day seminars were conducted on Pest Management, Potato Production and Crop Marketing.

Key Theme: 1.27 Plant Health
Title: Spinach Downy Mildew
Cooperating States: CA, AK
Source of Funding: Smith Lever and State
A California advisor continued his collaboration with his counterpart at the University of Arkansas to identify new strains of the spinach downy mildew in California. The publication, *Identification and cultivar reaction to three new races of the spinach downy mildew pathogen from the United States and Europe. Plant Disease 87: 567-572*, was produced in FY 2003.

Key Theme: 1.27 Plant Health
Title: Fusarium Wilt in Lettuce
Cooperating State: AZ
Source of Funding: Smith Lever and State
A California advisor is working with a University of Arizona colleague in documenting a new problem, the presence of Fusarium wilt of lettuce in the Yuma area. Results from this project can be used to assist California lettuce producers. A publication was produced in FY 2003, *First report of Fusarium wilt of lettuce caused by Fusarium oxysporum f. sp. lactucae in Arizona. Plant Disease 87:1265*

Key Theme: 1.27 Plant Health
Title: Celery Integrated Pest Management Project
Cooperating State: CA, MI
Source of Funding: Smith Lever and State
A California advisor is working with a Michigan State colleague on development of an integrated pest management system for celery. The goal of the project is to improve control of pests and to document IPM advances.

Key Theme: 1.27 Plant Health/1.12 Bioterrorism
Title: Western Plant Diagnostic Network
Cooperating States: CA, NM, NC, FL, AK, USDA-CSREES
Source of Funding: Smith Lever and State
This collaborative project is developing a network for the detection, diagnosis and containment of biological threats to American agriculture. Congressionally mandated, at the local level county-based Farm Advisors will provide input for deploying the network of first detectors. The

goal is improved surveillance of farmland and forests against intentional or accidental introduction of pests, increased diagnostic capacity, and improved response time to critical events. All crops and area should be surveyed. A web site has been set up to share information and findings.

Key Theme: 1.28 Plant Production Efficiency
Title: National Sweetpotato Collaborators Trial
Cooperating States: CA, NC, SC, LA, MISS, AL, TX
Source of funding: Smith-Lever and State
The objective of this collaboration is to valuate new sweet potato cultivars in various locations throughout the United States for production, quality, insect and disease resistance and potential commercial release. California is the number two producing state for sweet potatoes but it does not yet have a breeding program. The Collaborators Trial allows academics in California to evaluate potential new lines from other states to determine their potential use in this environment. The release of new cultivars with greater disease and insect resistance, greater productivity, or both, directly impacts the profitability of growers in California. Many Japanese, Hispanic, and Indian 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. Publications include the Annual National Sweet potato Collaborators Group Progress Report and the Annual National Meeting Minutes.

Key Theme: 1.28 Plant Production Efficiency
Title: Potato Production and Marketing
Cooperating States: CA, OR
Source of Funding: Smith Lever and State
The short growing season in the Intermountain Region restricts crop options. Research is needed to identify new crops, and new markets for existing crops, to promote diversity and improve agricultural profitability. The most significant threats to economically sustainable agriculture in the Klamath Basin are continue to be low market prices, particularly for potatoes and the uncertainty of future water supplies for irrigation. Low market prices for potatoes the past five years have placed great economic strain on potato producers forcing some farms unto bankruptcies. The unexpected cut off of irrigation water in 2001 by the U.S. Bureau of Reclamation caused tremendous losses in farm income and placed Basin growers in even deeper financial difficulties. The following collaborative projects are helping to provide improved profitability for California and Oregon producers in the Klamath Basin.

A: Potato Seed Conditioning Trial: A California advisor and specialist and Oregon State researchers continued their field experiments at Intermountain Research and Extension Center and the OSU Klamath Experiment Station to determine whether seed conditioning (physiological aging of seed) could be used to overcome slow initial emergence after the planting of two promising new potato varieties. Reports were published in the Klamath Experiment Station Annual Report and the Annual Report to the California Potato Research Advisory Board.

B. Planting Methodology for the Production of New Potatoes: A California advisor continued his trials at the Intermountain Research and Extension Center and at the Klamath Experiment Station to establish optimum planting and harvest times for the production of “new potatoes.” The research resulted in the development of planting guidelines for “new potato” production and for the production of two new russet-skinned potato varieties.

C. "New Potato" Investigation: A California Advisor and an Oregon State researcher investigated "new potato" production and marketing methods and techniques in the European markets.

D. Value Added Marketing Group: A California advisor continued to work with the local grower operated collective marketing group whose primary function is to establish new strategies for marketing potatoes, with particular emphasis on value added marketing. The new group continued to work on a strategy for the marketing of "new potatoes." The group has been successful in striking close working relationships with the Oregon State Food Innovation Center and the UC Potato Work Group.

Key Theme: 4.12 Integrated Pest Management
Title: Western IPM Coordination
Cooperating States: Western States
Source of Funding: Smith Lever and State
The goal of this collaborative project is to foster cooperative regional research and extension programs that solve critical pest management problems by enhancing communication among stakeholders, IPM research scientists, IPM extension specialists and other professionals involved with IPM strategies in the West. The group conducts assessment of pest management research and extension activities; fosters development and delivery of IPM systems that protect human health and the quality of environmental resources, and encourages collaborative pest management strategies. The group is active in increasing stakeholder involvement in the design and implementation of IPM programs and was deeply involved in the planning of the 4th National IPM Symposium where stakeholders were encouraged to participate in IPM planning and evaluation. The regional meetings often include a tour and lecture by a local IPM practitioner. Small farms and limited resource farmers are a targeted clientele. The publication for FY 2003 is the Minutes from the 4th IPM Symposium.

Key Theme: 4.14 Natural Resources Management
Title: Development of Sage Grouse Conservation Strategy
Cooperating States: CA, OR, NV
Source of Funding: Smith Lever and State
Northern California advisors worked with colleagues in neighboring states on the development of a conservation strategy that will prevent the need for a threatened and endangered species designation for sage grouse. The goal is to develop a comprehensive plan that will meet the needs of sage grouse through their range in our three states, and be accepted by the US Fish and Wildlife Service as a habitat recovery plan. Stakeholders include state and federal agencies and private land owners and managers in Nevada, Oregon, and California. Major cooperators were Cooperative Extension colleagues and state game biologists working to develop a plan that will meet the needs of the three states. The Washoe/Modoc plan will be submitted to the Governor of Nevada by the end of March. The California plan is still in the development stages.

Key Theme: 4.14 Natural Resources Management
Title: Invasive Plant Species Management
Cooperating States: CA, NV, OR
Funding: Smith Lever and State

California advisors are working with Extension colleagues in Oregon and Nevada to evaluate various methods of management and control of invasive species on western rangelands. The objective is to reduce rangeland habitat loss, and restore a healthy ecosystem function on Great Basin Rangelands. Stakeholders are Northeastern California Resource Advisory Council, the Bureau of Land Management, the US Forest Service, and private land owners in Oregon, Nevada, and California. The group presented a Poster and gave a presentation at The Society for Range Management Annual Meeting in Salt Lake City Utah in January 2004.

Key Theme: 4.17 Pesticide Application
Title: Southwestern Insecticide Resistance Group
Cooperating States: CA, AZ
Funding: Smith Lever and State
In response to local Extension meetings in both states requesting input on critical problems related to insecticide resistance, Extension colleagues in California and Arizona are collaborating on insecticide resistance problems common to both states. The goal is to improve the use of insecticides, extend longevity of product life, reduce unnecessary or ineffectual applications, and improve the overall understanding of practical resistance management programs.

Key Theme: 4:23 Water Quality
Title: Optimization of Water and N Application Efficiency for Surface Irrigated Production Systems
Cooperating States: CA, AZ
Funding: Smith Lever and State
The low deserts soils are commonly used for the production of high value vegetable crops. Water scarcity in the arid southwestern United States is a major impetus for improving water use efficiency in agriculture. Nitrate contamination of surface and groundwater is often associated with excessive irrigation and fertigation practices. The objective of this project was to conduct field experiments to develop a database for the calibration and validation of surface hydraulics and chemical transport models. Such models can be used to develop improved management guidelines for the N-fertigation practices in the desert southwest. California and Arizona advisors developed new design and management approaches and guidelines for N-fertigation systems in surface irrigation settings through field experiments and modeling simulation studies. California and Arizona growers are under continuous pressure to save water and reduce the amount of nitrogen and fertilizers in surface and subsurface drainage. Results from our work will develop guidelines for new fertigation practices under varying soil and irrigation management practices. It is expected that the recommendations will be used by growers to improve fertilizer use efficiency and reduce the impact of non point source pollution on the Salton Sea watershed. Growers can use the educational materials to meet the expected Salton Sea Nutrient TMDL regulations. Results from this project are published online at the ANR website http://ucanr.org/index.shtml (*UC Delivers: Reduce Pollution with Proper Fertilizer Timing*)

(2) Did the planned programs address the needs of underserved and under represented population? The programs described below involved under served/under represented stakeholders with specific needs.

Key Theme: 1.17 Home Lawn and Gardening
Title: Training Master Gardeners in the Las Vegas region

Cooperating States: CA, NV
Funding: Smith Lever and State
A California advisor worked with his Nevada colleagues and trained master gardeners about growing fruit trees and grape in the home garden. He has also been training the group of volunteers that operates the Cooperative Extension experimental orchard in North Las Vegas. Many of the participants were senior citizens and area gardeners. They learned how to raise healthy fruit and nuts to supplement their diets and to extend their food budgets.

Key Theme: 1.19 Invasive Species
Title: Invasive Species on Rangeland - Hawaii and California
Cooperating States: CA, HI
Funding: Smith Lever and State
Invasive plant species are cited by the Bureau of Land Management as the greatest threat to the ecological health of their land in western U.S. California and Hawaii Extension academics are working to increase knowledge of invasive plant species common to rangelands in Hawaii and California. They seek to empower landowners and land managers to control invasive plant species by providing science based information on the biology and control strategies for these species. Invasive species were identified as a critical issue through the ANR Program Planning Advisory Committee which involved significant stakeholder input. The potential impact of the project is the eradication of a large array of invasive plant species across significant portions of rangeland in California and Hawaii. Native American and Pacific Islander landowners in both Hawaii and California are a significant part of the stakeholders being served.

Key Theme: 5.07 Communications Skills
Title: Extension en Español (EEE)
Scope of Impact: National
Source of Funding: Smith Lever and State
The Spanish-speaking audience in the United States is growing much more quickly than any state or Extension service's ability to keep up. The need for quality educational support and materials surpasses the resources available within any one state. Language and cultural expertise are also not abundant throughout Extension. A group of Extension educators collaborated on a national scale to allow Extension to better serve this important client group by providing educators high-quality materials in Spanish as well as providing a place to share expertise and experiences that will improve the quality of Extension outreach to Spanish-speaking audiences across the Cooperative Extension System. The Extension en Español (EEE), a clearinghouse for Spanish-language educational materials was opened for use in FY 2003. The clearinghouse contains hundreds of Extension-related documents in Spanish and English free of charge for users to view and download. This was a national effort undertaken by UC ANR, Texas A&M, New Mexico State University and the Universities of Illinois.
The database contains:

- Bilingual news reports, columns and feature stories
- Links to other extension Web sites with Spanish-language materials
- Resource guides, such as glossaries of Spanish-language translations for Extension and USDA agencies and institutions, and style guides for Spanish usage
- Educational materials to learn more about Hispanic communities and reaching out to Spanish-speaking audiences
- An online forum to consult with other specialists about Spanish-language materials

- Extensive contact lists to communicate individually with specialists on specific issues

In addition, specific individuals are listed to contact for specific assistance. Several California academics and staff are listed.

Key Theme: 5.11 Family Resource Management
Title: Tax Preparation and Asset Development for Rural Low Income Families
Cooperating States: CA, GA, MI, KY, MO, NH, OK
Source of Funding: Smith Lever and State

Recognizing the gap between full-time, year round work at the minimum wage and the federal poverty level, Congress has turned more and more to refundable tax credits as a mechanism for "making work pay." Refundable tax credits targeted to working poor families with children have been expanded in recent years with the goal of raising full-time, low-wage earners up to the federal poverty level and as incentives to "make work pay." Maximum credits go to families earning between approximately $10,000 and $12,000 per year, with families outside of that income range receiving progressively less. Evidence suggests that a significant portion of potentially eligible recipients (between 10% and 30%), particularly in rural areas, fail to receive the credits because they don't file taxes. The majority of rural EIC recipients utilize paid preparers for tax assistance because of the limited availability of free tax assistance programs (VITA, TCEE) in rural America. By using paid preparers, the value of these credits is eroded. Moreover, use of a paid preparer significantly increases the likelihood of high-cost refund anticipation loans and reduces the likelihood of direct deposit.

The average tax refund for EIC recipients was $1800, with many receiving refunds of as much as $4000 or more. The high dollar value of the refunds, when linked with appropriate education, provides a teachable moment to facilitate asset development for working poor families leading to improved economic well-being and financial stability.

Seven state Cooperative Extension Services, the Internal Revenue Service and the Center on Budget and Policy Priorities began a collaboration to increase the availability of free tax assistance programs in rural America. Participating states will work towards the following objectives: 1) maximize value of tax refunds for EIC eligible families with children, and 2) link EIC recipients to Cooperative Extension Service educational programs.

Impact Indicators include**:** 1) 50% of filers using CES-arranged tax preparation services will have utilized a paid preparer in the previous year; 2) The percentage of filers using refund anticipation loans will decrease (as evidenced by those reporting use of RALs in the previous year); 3) The percentage of filers using Direct Deposit will increase; 4) 25% of filers using CES-arranged tax preparation services will subsequently take advantage of Extension financial literacy programs.

Participating sites will utilize a common "tally sheet" to measure the impact of Extension-led tax preparation sites. While in some states, Extension staff will staff the VITA sites and prepare returns, other states will use a volunteer model. It is understood upfront that each state will have to develop a unique plan that fits in to the existing infrastructure. While the approach may be different in each state, each participating state will collect the same data.

(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.

Key Theme: 1.06 Animal Production Efficiency
Title: National Pork Board Swine Educators Advisory Committee
Cooperating States: CA, SC, IA, MI, MS, WA, TN, MT, VT, UT, IL, MN, GA, OK, WI, PA, OH, KS, KY, OR, NE, MO, NC, IN, ND, SD, AR, TX, AL
Source of Funding: Smith Lever, State and National Pork Board
The objective of this program is to provide opportunities for Extension Swine Specialists and adult educators to network for the benefit the nation's pork producers. Activities include the conducting the annual Swine Educators' Conference and the dissemination of a CD with information swine educators can use in their educational programs. This is one effort funded by the National Pork Board where funding has continued in the face of a reduction of funding for education overall. Educational information is made available to pork producers to improve their financial status and/or to keep them in business. The 2003 major publication is the Swine Educators 2003 Conference Proceedings - Teaching Curricula and Resource Materials for the Pork Industry. (CD)

Key Theme: 1.06 Animal Production Efficiency
Title: California, Oregon, Idaho, Nevada Livestock Programs (C.O.I.N.)
Cooperating States: CA, OR, ID, NV
Source of Funding: Smith Lever and State
With decreasing staffing in livestock extension positions in all western states, the goal of this group is to band together to provide critical mass to address the livestock industry's education and applied research needs. The project has an email list serve that Extension livestock advisors and specialists use to post questions and obtain educational and research information from the four western states. An annual tour is held in one of the states to review their research and education programs in livestock. The impact is quicker problem solving by staff for clientele through the sharing of coordinated research and education programs. The group produced the *COIN Beef Book,* used by all members with their clientele.

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.

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 Conservation Tillage (CT) Workgroup is an example of the strong integration of AES and CE academics, working together to address a critical issue for California agriculture. Maintaining or improving soil resources is important to long term agricultural productivity, to overall water quality, and to maintenance of agricultural and natural systems. The CT Workgroup was formed to respond to the needs for information on reduced tillage production alternatives in California as one way of addressing the issue of soil conservation. Since the Workgroup was formed in 1997, it has grown to over 200 members. This includes over 80 University members (CE advisors and specialists and AES faculty) and external stakeholders from USDA, ARS, and NRCS as well as private industry, farmers and environmental groups.

The Workgroup's mission is to provide up-to-date information on research and education activities related to conservation tillage production systems in California.

The purpose of the Workgroup is to develop knowledge and exchange information on conservation tillage production systems; coordinate related research and extension programs; to respond to needs for information on reduced tillage production alternatives; to plan and conduct statewide and regional conferences, workshops and training demonstrations; and to produce publications and internet materials that summarize research that the workgroup conducts

During FY 2003, the CT Workgroup held its annual conference that involved 270 participants with additional updates provided at meetings at three locations in the state. The CT Workgroup is involved in more than 40 research and demonstration sites throughout the state and includes CT production systems evaluations for cotton, wheat, tomatores, melons, corn, beans, lettuce, and cover crops. The case study below is one example of the impact of the UC CT research and extension programs

California dairies require year-round availability of inexpensive, locally-produced forage materials. Common dairy forage production systems consist of winter small grains seeded either individually or in mixes in November and December. These winter forages are then harvested as "green chop" the following March. In conventional production systems, fields may be disked a number of times following the harvest of these winter forages, relisted or bedded and then preirrigated for spring corn planting. Turnaround time between winter small grain forage harvest and spring corn planting routinely takes about two weeks. Spring silage corn is then produced for mid-summer harvest. Occasionally, corn may be double-cropped with the second crop coming off sometime in early fall. Most current production systems, intercrop tillage and seedbed preparation is done ahead of each successive crop. Such production systems, however, lend themselves quite well to a variety of conservation tillage approaches that have been developed in other production regions, and in recent years, a number of California dairy forage producers have begun experimenting with these reduced till forage production alternatives.

Mike Nutcher, the owner and general manager of Hidden Valley Dairy in western Stanislaus County, is one such farmer who began experimenting with strip-till silage corn production in 2002.

Hidden Valley is a medium sized, independent dairy with 1200 cows. Mike, his wife and his crew of ten, manage the entire operation. To provide a steady supply of forage for his cows, Mike farms about 350 acres of forage production land adjacent to his dairy. Prior to the spring of 2002, Hidden Valley Dairy used a pretty standard tillage approach to forage production as outlined above.

In the fall of 2001 though, Mike became interested in reduced till practices through his reading of work done by farmers and researchers in Oregon and by his participation in one of our CT Workgroup's seminars. He then decided to experiment in the spring of 2002 with strip-tilling corn following his winter forage harvest.

"I think that our first try at strip-tilling turned out pretty well. We averaged 29.5 tons per acre of corn silage on the strip-till field, while the ranch average was 31.5 tons per acre. I think there are 2 main things that we could have improved on and those are to have had better plant populations

(by keeping the corn planter better in line with the strip-tiller and/or having more down pressure on the planter) and to have had more fertilizer available at planting."

In summary, I think there are great advantages to this system, with the money savings and time savings it offers. It takes some forethought and planning to make sure you have enough moisture in the soil. We irrigated 12 days prior to chopping the winter forage off and had no problems with the moisture level when we were ready to plant the corn with the strip-tiller."