

FY 2006 Annual Report of Accomplishment and Results

Colorado State University
Agricultural Experiment Station

A. Program Summaries

USDA Goal 1: An Agricultural Production System that is Highly Competitive in the Global Economy

CSU Program: Plant and animal improvement and new agricultural products

Topic - Developing Improved Dry Bean Cultivars

Short Description - Dry edible bean is an important crop in the High Plains and Intermountain Western US. Production is primarily limited by pathogens and yield potential of cultivars. White mold disease reduces yield annually from 10 to 30% in Colorado and the High Plains. Research efforts have identified five quantitative trait loci (QTL) that accounted for 48% of the variation for resistance to white mold disease. Lines have been identified with high levels of resistance have been increased for additional testing and to develop white mold resistant pinto bean varieties. We completed development of a breeding population that combines genes for resistance to white mold found in scarlet runner and common bean. Cultural practice studies that influence yield determined that when plant population was increased 50 percent yield increased for varieties that had upright growth habit such as Matterhorn and Vision. A companion experiment with S.P. Singh in Idaho showed that fungicide protection improved yield by more than 50 percent for the susceptible vine type Montrose. The economic benefit to these findings should enhance the net return for production of dry beans from 2 to 5 % and reduce the impact of white mold on the quality of commercial beans. Research on the health benefits of beans continues confirm that beans in the diets of laboratory animals have a significant effect on reducing the incidence of mammary cancer. Dosage levels of dry beans in the diet of laboratory animals suggest a linear response for protection against mammary cancer. This information should enhance the consumption of dry beans and thereby reduce the incidence of chronic disease. Colorado State University coordinated the Asian soybean rust and soybean aphid monitoring network in CO, ID, OR, WA, and Canada to monitor for the occurrence of Asian soybean rust (SBR) and the soybean aphid (SBA). The project; (1) confirmed involvement of local cooperators and provided diagnostic training; (2) established linkage with the National Plant Diagnostic Network contact to share primary pest information on soybean rust and soybean aphid; and (3) established linkage with the USDA/CSREES PIPE Web Site and protocol to access resources and upload weekly survey data made available to the public at <http://sbrusa.net/>. No samples of soybean rust or soybean aphid were detected in Sentinel Plots or commercial fields of legumes in Colorado and the western region. As a result, thousands of acres of legumes were not sprayed needlessly with a preventive fungicide or insecticide which provided economic benefits to growers and reduced chemical exposure to the environment and food supply.

Impact - Research on mechanisms of resistance for major pathogens provide the breeding program with useful genes that have been used to reduce the cost of production and impact of biotic pest to the bean industry. Currently, cultivars released by this project that possess multiple pest resistance are produced on approximately 40% of the acreage in the state and have increased yield by 5 to 10% over cultivars they replaced. Research on the health benefits of dry beans indicate that dry beans in the diet provided protection against mammary cancer in animal studies. This information should increase dry bean consumption and economic return to producers. Meteorological forecasting enabled timely and efficient application of pesticides and disease surveys enable bean producers to more efficiently manage diseases to reduce costs and improve profitability. Monitoring fields in the western US and Canada for soybean rust and the soybean aphid prevented the use of unnecessary pesticides and concern to producers regarding a new pathogen.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Developing Improved Winter Wheat Cultivars

Short Description - In fall 2006, experimental line CO00016 was released as an improved cultivar named Ripper. Ripper was developed from the cross CO940606/TAM107R-2 made in 1996. Ripper is a white-chaffed, short semidwarf (similar height and heading date as Prairie Red) hard red winter wheat. Ripper has shown high dryland yields, excellent milling and bread baking quality, and excellent drought and high temperature tolerance. In four years of statewide testing in the dryland Colorado Uniform Variety Performance Trial (UVPT), Ripper was the top yielding entry in the trials, approximately 1.6 bu/a greater than Hatcher, 3.8 bu/a greater than Yuma, and 4.2 bu/a greater than Prairie Red. Ripper is resistant to biotype 1 of the Russian wheat aphid (RWA), susceptible to biotype 2 of RWA, susceptible to both leaf and stripe rust, and moderately susceptible to stem rust. Ripper will be an excellent replacement for other stress tolerant, early-maturing cultivars in Colorado, particularly TAM 107 and Prairie Red, which tend to perform better in dry years yet have a marketing penalty due to their poor milling and bread baking quality. In fall 2006, one experimental line (CO01385-A1) was advanced for Foundation seed production to enable release in fall 2007. CO01385-A1 was developed from the cross Yumar/Arlin made in 1997. CO01385-A1 is a white-chaffed, medium-height semidwarf with high yield under both dryland and irrigated conditions, high test weight, and good stripe rust resistance. CO01385-A1 is currently in its third year of statewide testing. Across 21 dryland trial locations between 2005-2006, CO01385-A1 has been the highest yielding entry in the trials, 0.8 bu/a greater than Ripper, 1.7 bu/a greater than Bond CL, 2.9 bu/a greater than Hatcher, 3.7 bu/a greater than Keota, and 4.4 bu/a greater than Avalanche (the next five highest yielding lines). Test weight of CO01385-A1 in these trials was the third-highest among all entries, about 1 lb/bu greater than the trial average. CO01385-A1 was the highest yielding entry averaged across two years (six total locations) of testing in Irrigated Variety Performance Trial, about 3.1 bu/a greater than TAM 111, 4.9 bu greater than Bond CL, and 9.2 bu greater than Hatcher (the next three highest yielding lines). CO01385-A1 has shown lower grain protein and average bread baking quality characteristics based on testing in the CSU Wheat Quality Lab and the USDA-ARS Hard Winter Wheat Quality Lab (Manhattan, KS). Resistance to new RWA biotypes continues to be used extensively in the crossing program, both for forward (three-way crosses) as well as backcrossing into elite backgrounds.

Impact - CSU-bred wheat cultivars account for over 50% of Colorado's 2.4 million acres (2006 crop) with the remaining acreage planted mostly with cultivars from university breeding programs in adjacent states. During this time, average wheat grain yields in Colorado have more than doubled with at least 50% of this increase attributed to improved cultivars. Estimates from Colorado wheat industry leaders indicate that end-use quality enhancements from cultivars developed at CSU provide an average of \$20 million per year increased income for Colorado wheat producers (83 million bushels x \$0.25 per bushel price increase; 2003 dollars). Production risks have been reduced significantly and the breeding program continues to address new production risks, such as those arising from the appearance of new Russian wheat aphid biotypes or races of stripe rust.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Developing Improved Potato Cultivars

Short Description - The major objectives of the Colorado Potato Breeding and Selection Program are: (1) to develop new potato cultivars (russets, reds, chippers, and specialty) with increased yield, improved quality, improved nutritional characteristics, resistance to diseases and pests, and tolerance to environmental stresses; (2) to collaborate with growers, shippers,

processors, and research personnel to assess the production, adaptability, marketability, and other characteristics of advanced selections from the Colorado program; (3) to provide a basic seed source of selections to growers for seed increase and commercial testing; (4) to evaluate promising selections for potential seed export (interstate and international). Cultivars with these characteristics will help assure that the potato industry in Colorado will remain productive and in a competitive position. Ninety-three parental clones were planted in 2006 in two separate crossing blocks. The emphasis of the first crossing block was russet cultivar development, PVY immunity, and nematode resistance. The second block emphasized russets, reds, specialty, and late blight resistance. Seed from 272 combinations was obtained. Approximately 55,215 seedling tubers representing 282 families were produced from 2004 and 2005 crosses, for initial field selection in 2007. These seedlings represent crosses segregating primarily for russet, reds, specialty types, and disease resistance/immunity (late blight, PLRV, and PVY). Second through fourth size seedling tubers will be distributed to Idaho (USDA-ARS), Minnesota, North Dakota, Texas, Wisconsin, and Alberta, Canada. Colorado grew 80,019 first-year seedlings in 2006, with 653 selected for subsequent planting, evaluation, and increase in future years. A portion of these seedlings were obtained from the USDA-ARS, Agriculture Canada, North Dakota State University, and Texas A&M University. Another 1,080 clones were in 12-hill, preliminary, and intermediate stages of selection. At harvest, 263 were saved for further observation. Forty-eight advanced selections were saved at harvest and will be increased in 2007 pending final evaluations. Advanced selections evaluated in the Southwest Regional Trials, Western Regional Trials, or by producers in 2006, included 9 russets, 1 red, 7 chippers, 16 specialty selections and one long white. Two other selections, AC92009-4RU (Canela Russet) and NDC5281-2R (Rio Colorado), will be named and released as new cultivars in 2007.

Impact - Colorado State University releases accounted for 46% of the 59,900 acres planted to fall potatoes in Colorado in 2006. Of the Russet Norkotah fall potato acreage in Colorado, 46% was planted to Colorado Russet Norkotah Selections 3 and 8. Colorado cultivars and clonal selections accounted for 52% of the 13,249 acres of Colorado certified seed accepted for certification in 2006. Advanced Colorado selections accounted for another 5% of the seed acreage. Three of the top six russet potato cultivars (Russet Norkotah-S3, Russet Norkotah-S8, and Rio Grande Russet) produced for seed in the U. S. were developed by the Colorado program. Additionally Canela Russet (AC92009-4RU), Centennial Russet, Silverton Russet, and Russet Nugget are in the top 20 russet cultivars. Of the cultivars released since 1990 by the 12 potato breeding programs in the U.S., those developed by the Colorado program ranked first nationally in total acreage approved for seed certification in 2006.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Improving Cryopreservation of Bovine and Equine Embryos

Short Description - Vitrification is an effective approach to cryopreserving preimplantation bovine and equine embryos. Dozens of protocols have been published that differ in types and concentrations of cryoprotectants, timing of procedures, and the nature of the vitrification container. However, only a few studies have involved transferring the hundreds of embryos per treatment needed for thorough evaluation of pregnancy rates. A vitrification procedure was designed that is practical under field conditions. Cryoprotectant is added to embryos in two steps, and embryos are vitrified in 0.25-ml straws. Diluent containing 1 M galactose is aspirated into 0.25-ml straws, then air, and then vitrification solution and embryos followed by air and more diluent. These columns are mixed post-warming so that embryos can be directly transferred nonsurgically into recipients. Both vitrification solutions and diluent have been added to a medium that contains no animal products. Promising pregnancy rates have been obtained with both *Bos taurus* and *Bos indicus* embryos.

Impact - The simplified method of cryopreserving embryos already has been commercialized for equine embryos, and is expected to result in a commercial product for bovine embryos next

year. While vitrification does not fit all commercial situations for technical reasons, we expect this technology to become widely applied in the bovine embryo transfer industry.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Identifying Economically Relevant Traits in Beef Cattle

Short Description - Continuing our approach for identifying the economically relevant traits (ERT), the traits that are directly related to a cost or an income from the production of beef, we have completed preliminary studies on developing EPD for days on feed in the feedlot. This ERT has a direct impact on profitability of beef production through a potential reduction in costs of production. Animals that more quickly reach appropriate harvest endpoints spend less time in the feedlot thereby reducing yardage and feed costs. Breed association field data including pedigree and performance data was used to estimate heritability for days on feed when the animals were fed to a constant back fat. A two-trait model was used that included weaning weight to account for any selective reporting and/or sequential culling and days to a constant back fat. Analysis indicated considerable genetic variation for this trait and yielded a heritability of .45, suggesting that development of EPD for this trait is feasible. In turn, selection on that EPD should yield a reduction in the number days animals are fed in the feedlot when those animals are fed to a target back fat endpoint. EPD for number of days to a constant backfat were then calculated using this heritability value. The range in these EPD were -33.5 to 69.9 days. Using this tool, producers should improve profitability in the feedlot through a reduction in costs while maintaining animal performance. Realizing that animals are often fed for target endpoints other than back fat, we are also evaluating days to a marbling score, or quality grade endpoint, and days to a weight endpoint. This approach is also being developed using additional sources of large quantities of field data.

Impact - A reduction in time spent in the feedlot or in development could reduce production costs and in turn, improve profitability for the 33 million animals harvested in the U.S. in 2006. For instance, assume 80% of the animals harvested were steers and heifers raised specifically for harvest who reached the same target endpoint and that yardage costs are \$.20/head/day. A reduction of 5 days in the feedlot would result in approximately a \$27 million dollar reduction in costs of production. Realizing that the spread in EPD for this data set encompassed over 100 days between the lowest and highest EPD, there is a large potential benefit to continued development and application of this technology.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

CSU Program: Plant and animal production systems

Topic - Improving Cryopreservation of Equine Semen

Short Description - In order to maximize the efficiency (or fertility) of cooled and/or frozen semen, two parameters can and were investigated. The first involves the sperm cells themselves. During the past few years studies were conducted to investigate the effects of cryopreservation on the sperm cells. Both freeze rate and type of cryoprotectant were evaluated. These studies suggest that stallion semen is rather tolerant of osmotic changes prior to cryopreservation and that glycerol remains the better cryoprotectant. As a follow up we investigated the possibility of protecting the cells following the freeze-thaw cycle by enhancing membrane fluidity with cholesterol (as has been demonstrated in the bull). We found that semen motility parameters were increased. These data suggest that a fertility trial is in order. The second factor effecting fertility of the semen is the mare. We investigated the possibility of enhancing fertility by both increasing the chances of fertilization by increasing the number of

oocytes available each cycle and by minimizing the sperm used through a more synchronous ovulation. We discovered that by "coasting" treatment of FSH mares were more responsive and produced more follicles. We were less successful in manipulating ovulation through the suppression of LH.

Impact - We developed a procedure by which cholesterol can be added to the sperm membrane and aid in maintenance of post thaw motility (and presumably fertility). Additionally, we have enhanced fertility by increasing the chance of fertilization by stimulating the mare to produce more oocytes each cycle. Together these procedures should make the use of processed semen more effective.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Developing a Modified Calving System

Short Description - The impact of calving season was evaluated using the cow herd at the San Juan Basin Research Center. The cows were randomly divided by age and breed-type into two treatment groups. Cows in Group I (n=181) were bred for a traditional March and April calving season with cows in Group II (n=188) bred for a non-traditional May and June calving season. Replacement heifers are included in these numbers and were assigned to the treatment groups in the same manner. Subsequently, replacement heifers from the respective calving groups remain in those groups. The first group of calves born in the respective calving seasons were born in the spring and summer of 2002. Conception rates for Group I and Group II were 92.0% and 97.0%, respectively, in 2001; 93.6% and 85.6%, respectively in 2002; 90.0% and 84.5%, respectively in 2003; 96.0% and 95.3 % respectively in 2004 and 90.6% and 81.5%, respectively in 2005; 91.0% and 75.0% in 2006. A severe drought in 2002 forced a reduction in numbers of calving females in both groups to approximately 100 head. Additional replacement females were kept in 2003 and 2004 to begin increasing the number of calving females in each calving group. Average birth weights for all calves in both groups were similar in 2002 (38.3 kg) and 2003 (37.5 vs. 36.6 kg). Birth weights in 2004 were slightly higher for Group I (41.4 kg) compared to Group II (37.3 kg). Similarly, birth weights in 2005 and 2006 were slightly higher for Group I (40.0 and 38.2 kg, respectively) compared to Group II (31.8 and 35.0 kg, respectively). Calving difficulty and calf health following calving has been similar for both calving groups. Death loss for the two calving groups has also been similar (2.0%). Due to the severe drought in 2002, calves from both calving groups were weaned at an average age of 150 days. Average weaning weights in the fall of 2002 were 157.7 kg for calves in Group I and 161.8 kg for calves in Group II. All steer calves from both groups were sent to the research feed yard at the Colorado State University ARDEC facility for finishing. All calves were weaned at an average age of 205 days in the fall of 2003, 2004, 2005 and 2006. Average weaning weights for Group I calves was 238.2 kg, 247.4 kg, 246.4 kg and 243.0 kg respectively for those years. Group II calves had average weaning weights of 231.4 kg, 211.8 kg, 223.6 kg and 219.2 kg, respectively for those same years. All heifer calves in both groups and for the years 2002, 2003, 2004, 2005 and 2006 were retained as potential replacements. Results indicate that a potentially significant reduction in harvested forages fed may be realized. A fairly consistent trend in reduced weaning weights for Group II calves has been present, but may be offset by higher prices when sold at weaning. There also appears to be a trend for reduced conception rates for Group II females, although the conception rates in 2004 were similar. While the reductions in conceptions and weaning rates for Group II were most likely impacted by the drought in 2002 and 2003, these averages have not returned to levels similar to Group I. It will be important to continue evaluation of these traits during the final year of the project.

Impact - This project evaluates the economic viability of two different calving seasons. Forage requirements can be reduced by calving in late spring rather than the traditional early spring timeframe. A reduction in weaning weight by late spring calving may be offset by reduced forage costs.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Evaluating Oilseeds for Biodiesel

Short Description - Biodiesel has recently attracted interest because of the high cost of petroleum diesel that has occurred in the recent past. Tri-glyceride seed oils, found in crop plants such as canola, mustards, sunflower, cotton, safflower, soybean, corn, and also in used cooking oils, fats, and tallows can be converted into biodiesel. The objective of this research was to evaluate thirty-two sunflower varieties for seed and oil yield and related agronomic characteristics to assess the potential for commercial production of sunflower under irrigation in western Colorado. Data were collected for plant population, flowering date, plant height, plant lodging, seed moisture at harvest, test weight, and seed yield. Seed yield for the sunflower varieties averaged 2420 lbs/acre. There were significant and a wide range of differences among entries for seed yield. Seed yields ranged from a high of 3500 lbs/acre for HySun 454 to a low of 701 lbs/acre for Croplan Genetics 3080 DMR. Three of the thirty-two sunflower varieties (HySun 454, Producers Hybrids 7203, Garst 454) were high yielding and two varieties (Croplan Genetics 308 NS and Croplan Genetics 3080 DMR) had particularly low yields. Seed oil content averaged 44.3%, which is typical for many sunflower varieties. Oil contents ranged from a high of 47.0% for Mycogen 8N453DM to a low of 42.0% for Dyna-Gro 93N05 #2. Oil yield averaged 1072 lbs/acre. Oil yields among the sunflower varieties varied widely and ranged from a high of 1530 lbs/acre for Mycogen 8N462DM to a low of 310 lbs/acre of Croplan Genetics 3080 DMR. The variety with the highest seed yield did not have the highest oil yield. In summary, most sunflower varieties established well and exhibited very good growth during the growing season. Many sunflower varieties produced good seed yields, had low seed moisture contents at harvest, and had good seed oil contents and thus oil yields. The seed yields would likely have been somewhat higher if the plots could have been harvested sooner with a reduced seed loss due to bird damage. Oilseed sunflower production in western Colorado appears promising based on the one year of agronomic data obtained at Fruita in 2006. Weed control in the sunflower field was excellent. Additional years of field research are needed to determine the long-term potential for producing sunflower under irrigation in western Colorado.

Impact - A biodiesel production facility in southwest Colorado is planned for construction by the San Juan Biodiesel Cooperative in the near future. The main crops targeted for use in this facility are sunflower and canola. Construction of this biodiesel manufacturing facility will open the possibility of growing alternative crops such as sunflower in western Colorado to supply vegetable oil for the biodiesel facility. Variety yield performance data is of value to various people- farmers when selecting varieties to plant on their farms, seedsmen in knowing which varieties to grow for seed production, companies to determine which varieties to market and the locations where varieties are best adapted, and research personnel in developing new varieties and in educating people about them. Many sunflower varieties produced good seed yields, had low seed moisture contents at harvest, and had good seed oil contents and thus have potential as a economically viable crop in the region.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Improving Nitrogen Use Efficiency by Irrigated Corn

Short Description - The Western Great Plains region is among the leaders in the nation's irrigated crop production with average corn grain yields exceeding the national average. An environmentally sensitive crop input, nitrogen (N) is an essential nutrient that is a key component of intensive irrigated agricultural systems. Excess N is prone to offsite degradation of the environment through runoff and leaching - a serious environmental issue in this region and

additional N is purchased at a cost that may be unnecessary. Our previous research work has demonstrated that variable N management under site-specific management zones differ significantly and consistently in grain yield production and overall N response between the low and high management zones. However, there has been no evidence that variable rate N management across site specific management zones would minimize N losses from the fields. The objective of this study was to evaluate the potential of N fertilization prescriptions based on site-specific management zones to reduce nitrate-N leaching losses. The study was conducted over two site years. Sites were located in northeastern Colorado, under a continuous maize cropping system, with furrow irrigation systems. Site-specific management zones were delineated based on soil color from aerial photographs, topography, and the producer's past management experiences that reflect spatial soil variability. The Nitrate Leaching and Economical Analysis Package computer simulation model was used to assess the benefits of N management based on site-specific management zones. Our results indicate that across site-specific management zones, nitrate-N leaching was variable. The highest level of nitrate-N leaching occurred in the low productivity zone while lowest level of nitrate-N leaching occurred in high productivity zone. This is a significant finding because it provides a strategy for N management that would decrease the environmental concerns associated with N losses. Furthermore, this study demonstrates that applying N fertilizer in accordance with the productivity potential of the management zone can reduce nitrate-N leaching.

Impact - Research clearly demonstrated that variable rate nitrogen management based on the productivity potential of the land zones, i.e., low levels of N application on low productivity zones and relatively high levels on N application on high productivity zones, has the potential to reduce N losses below the crop root zone. This will have a significant positive impact on the environment and increases net return to the farmer.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Dryland Cropping Systems

Short Description - This project's hypothesis is: No till practices permit cropping system intensification beyond wheat fallow (WF) because no till improves capture and retention of precipitation. Results from 1986 to 1997 showed that cropping systems with fallow every 3 or 4 years were superior to WF systems with 70% increases in grain production and 25 to 40% increases in economic return. In 1998, the WF treatment was dropped and wheat-corn-fallow (WCF) became the standard, with three and four year continuous crop rotations being added. Results from 1998-2001 confirmed a 70% increase in grain yield for the WCF rotation. During the drought period from 2002-2006, grain yields were still greater for the WCF system compared to the WF system, but the increase was only 50%. Grain yield for the three and four year continuous cropping rotations have been similar to the WCF rotation. During periods of drought, reducing fallow frequency to every third year is beneficial, but more intensification and continuous cropping do not improve yields. There was no crop failure observed for average or above precipitation from 1998-2001 in the WCF system, while crops failed 18% of the time for the continuous cropping during the same period. During drought, frequency of crop failure increased with less frequent fallow. Crop failure occurred 14% and 16% percent of the time for the WF and WCF systems and 21% and 42% of the time for the WCMF and continuous cropping, respectively. During drought, rotating summer fallow is important for reducing risk of crop failure. A runoff and erosion study was conducted during the 2005 and 2006 seasons on side slopes of the WCF, wheat-corn-millet (WCM), and perennial grass (G) systems at Sterling and Stratton. There was runoff from 10 events at Stratton averaging 2.9 cm, 3.1 cm, and 0.9 cm for the WCM, WCF, and G systems, respectively. There was runoff from only 2 storm events at Sterling with less than 0.4 cm average runoff. An analysis of long term weather records suggest that there are an average of 3.1 rain events expected to cause runoff per year. Frequency of high intensity rain events is as great or greater during drought compared to average precipitation

years. As a result, risk of runoff and erosion is greatest during drought periods when soil cover from canopy and residue is lowest. Erosion rates were generally low, showing that the no-till systems protect the soil from erosion caused by water. Total erosion for all 10 events at Stratton totaled less than 5 Mg/ha for all systems. Farmer interest in the dryland research continues to be strong as demonstrated by demand for dryland cropping systems information and by practice adoption rates. Adoption of crop rotations with summer crops illustrates the impact of this project. Overall summer crop acreage has increased by about 500,000 acres in Colorado since 1986. Assuming that summer crops are grown in a 3 year rotation, there are about 1,500,000 acres under more intensive cropping systems compared to 75,000 in 1986. Producers have publicly testified that they use our research findings as they shift from wheat fallow to more continuous cropping.

Impact - Intensive cropping systems build soil organic carbon, improve soil quality, and improve both air and surface water quality because they provide high amounts of year around cover. These benefits have been realized for about 1,500,000 acres in CO that have been converted from wheat-fallow to wheat-summer crop-fallow. This conversion increased net return by \$22,275,000 per year under normal precipitation conditions. Net returns are less under drought, but are still superior to the wheat fallow system.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - New Landscape Plants for Colorado

Short Description - Woody and herbaceous plants continue to be evaluated for adaptability to the High Plains on a 30 ha site. Woody (53 taxa) and herbaceous plants (22 taxa) were acquired in 2006 for evaluation. Performance records for 2950 taxa of woody and herbaceous plants were entered into a computer system, which are available on three websites. Over 1,300 varieties of annual flowers were grown and evaluated in 2006 and a performance report was published and sent to all cooperators and industry personnel in the state and region. Many vegetatively propagated annual varieties, including argyranthemum, calibrachoa, coleus, New Guinea impatiens, osteospermum, petunia and verbena have become important bedding plant crops in the state, due to this research. In 2006, eight plant species were recommended or introduced by Plant Select. In 2006, over 1.7 million Plant Select plant labels were sold which is our best estimate of the number of Plant Select plants sold. Over seventy-five demonstration gardens are displaying Plant Select plants throughout Colorado. The multi-site woody plant trial continued at five locations throughout the state with the additional planting of seven taxa in spring of 2006. Plants tested for five years are being extensively evaluated and *Cupressus arizonica* from the 2002 planting will be a future Plant Select recommendation. In 2007, seven additional plants are being recommended or introduced. The 2006 season was a very dry season in Fort Collins which yielded exceptional data on the water use study of landscape shrubs and turfgrass. In the lysimeter study, plant water use at full saturation by plant area shows that Kentucky bluegrass uses about 65% of reference ETo. Bluemist spirea used about 60% of reference ETo. Both common lilac and three-leaf sumac used less water than Kentucky bluegrass. In the drought tolerance study, visual ratings showed tall fescue and Kentucky bluegrass were the only plant species to show physiological stress due to water. Depth of rooting is a common drought avoidance mechanism. This is one major difference between shrub and grass species. More extensive rooting systems result in more water available to plants. Irrigation in the landscape should focus less on individual plant's water use and more on maintaining adequate soil moisture in plant rooting zone.

Impact - Specific performance results from annual flower trials will help determine which new and superior annual flower varieties growers throughout state and region will grow and market. These superior annuals will become available to consumers who ultimately will be more successful in gardening. Plant Select plants which are introduced or recommended throughout the state and region mean marketing more profitable plants for growers in the state and region.

Weed control research helps growers control weeds in container production, which ultimately lowers overall cost of production, which is often passed on to consumers. Water requirements of shrub and turf species will help all property managers and homeowners ultimately conserve water use in landscapes.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Improving Management of Turf

Short Description - Compost can improve soil properties when incorporated into soil; however, little information is available regarding impacts of compost topdressing on turfgrass. A study, completed in 2006, evaluated the effects of topdressing composted dairy manure onto Kentucky bluegrass (*Poa pratensis*). Plots topdressed with compost at 0, 33, 66, and 99 cubic meters per hectare were monitored for: saturated hydraulic conductivity, bulk density, water retention, and soil nutrient levels. A rainfall simulator was used to apply known amounts and intensity of precipitation; runoff was collected and analyzed for total nitrogen (TN), nitrate nitrogen (NN), ammonium nitrogen (AN), total phosphorus (TP), total dissolved P (TDP), and ortho-phosphate (OP). Compost application of 99 cubic meters per hectare reduced bulk density, and increased water retention and P, K, Fe and Mn concentrations in the surface soil. Compost applications of 66 cubic meters per hectare or greater increased soil EC; however, increased EC did not negatively impact turf quality. Rates of runoff and erosion and concentrations of TN, NN, TP, TDP and OP in runoff were not different among treatments. However, all compost treatments did increase AN concentrations in runoff. There were no differences in soil NN or available P levels below the active rooting depth. As progress in the development of turf-type saltgrass (*Distichlis spicata*) continues, a need for research on enhancement of saltgrass seed germination (*Distichlis* has a low germination rate due to seed dormancy) was identified. We conducted three experiments to evaluate different seed treatments for germination and establishment enhancement. In Experiment I, seven different seed treatments were tested for their ability to enhance germination percentage in the growth chamber and compared to a control of no treatment. These included treatments with hot water, hydrogen peroxide, sulfuric acid, potassium nitrate, bleach, machine scarification, stratification, and hand nicking. Results indicated that germination percentage was increased only by stratification, hand nicking, and machine scarification treatments as compared to the control. In Experiment II, machine scarification, stratification, hand nicking, and a control were tested in the growth chamber. Hand nicking, scarification, and stratification increased percent germination from 13.0% to 61.7%. Stratification resulted in the quickest germination, followed by hand nicking and scarification. Experiment III was conducted in the field; seed treatments included machine scarification, stratification, and the control. Two months after seeding, plots seeded with both stratified and scarified saltgrass seeds produced acceptable turf coverage, whereas the control coverage was considered unacceptable and exhibited inferior turf quality. Both stratification and machine scarification can significantly improve both germination and establishment rate of seeded saltgrass. An experiment was begun to examine the quality and relative drought resistance of newer bluegrass cultivars marketed as hybrid bluegrasses (*Poa pratensis* X *Poa arachnifera* crosses).

Impact - Although readily available, relatively few turf managers use compost as a topdressing material. Concerns about compost quality, consistency, application ease, potential for salt injury, environmental concerns and cost all are given as reasons for non-use of compost as a topdressing material by professional turf managers (golf, sports turf). This research shows that environmental concerns (nutrient runoff and/or leaching) are likely minimal when compost is applied to turf at reasonable, recommended rates. And previous research has demonstrated positive effects on turf quality and drought resistance. Turf applications (as both a soil amendment and for topdressing) present viable and environmentally safe uses for compost, including compost derived from animal manures. Continued progress towards the development

of turf-type saltgrass cultivars was highlighted this year by success in treating saltgrass seed for enhanced germination and establishment. The ability to establish saltgrass from seed will make it more accessible and cost-effective for those interested in using this grass for turf in saline and droughty environments.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

CSU Program: Pest management

Topic - Managing Vegetable Diseases

Short Description - The Colorado State University Vegetable Pathology Project coordinated the Asian soybean rust and soybean aphid monitoring network of sentinel plots located in the western U.S. (Colorado, Idaho, Oregon, Washington) and Canada (Alberta, Manitoba, Saskatchewan) to monitor for the occurrence of Asian soybean rust and the soybean aphid. During 2006, the western network of more than 25 Sentinel Plot specialists and observers monitored more than 40 legume (primarily common bean or *Phaseolus vulgaris*) plots in 4 states and 3 provinces from May to September for both pests. There were no suspicious samples of soybean rust or soybean aphid detected in any Sentinel Plot or commercial field of legume in Colorado and the western region during 2006. Bacterial wilt was confirmed in dry bean samples submitted to our laboratory by collaborating scientists and growers in western Nebraska and Wyoming during 2004 to 2006 and we also collected samples from infected plants in some Colorado fields during 2005 and 2006. Future collaborative work will focus on gaining a better understanding of this resurgent pathogen and disease in the high plains region in recent years; as well as evaluate cultivars and germplasm for effective sources of genetic resistance. A white mold experiment evaluated the role of cultural practices such as plant density upon disease development. There was a noticeable increase in plot yield when plant population was increased 50 percent from 1 line to 2 lines per bed. The percent increase in yield when comparing 1 to 2 lines was 26, 55 and 74 for Matterhorn (upright growth habit), Vision (upright growth habit) and Montrose (vine growth habit), respectively. A companion experiment with a collaborator in Idaho with moderate disease pressure showed that fungicide protection improved yield by more than 50 percent for the susceptible vine type Montrose. Development of ecologically-based onion production systems that account for interactions of multiple pests, horticultural practices, and environmental concerns continue to be a long-term research priority to address threats to the onion industry from Iris yellow spot virus and the vector of this virus, Thrips tabaci, which is also a pest of onion. Integrated pest management research and recommendations include: crop rotation schemes that minimize overwintering of the pathogen and vector; the role of planting material (bulbs, seed, and transplants) in disease development; effects of planting patterns and populations on the disease; economic injury level for thrips alone and in the presence of iris yellow spot; cultivar resistance or tolerance to IYSV and/or thrips; the role of insecticides, herbicides, and fungicides used in onion production on the disease, and the compatibility of these pesticides with biologically-based pest management systems; and cultural and biological management tactics that may reduce or replace conventional insecticides for thrips management and reduce the impacts of IYSV.

Impact - Timely reporting on Asian soybean rust monitoring in the west allowed pest management specialists to advise crop consultants and growers regarding disease status and threat. As a result, thousands of acres of legumes (e.g., 50,000 irrigated acres in eastern Colorado) were not sprayed needlessly with a preventive fungicide which provided economic benefits (1 to 1.5 million dollars based on an applied fungicide cost of 20 to 25 dollars per acre) to growers and reduced chemical exposure (25,000 pounds at 8 oz per acre) to the environment and food supply. A reduction in white mold infection and yield loss of 50 percent as a result of improved germplasm with genetic resistance and/or upright growth habits or the timely use of a fungicide on irrigated bean fields with a history of the disease (e.g., 25,000 acres in eastern Colorado) could improve total yield by 250,000 hundredweight (assuming average of 20

hundredweight per acre) worth 5 million dollars (assuming 20 dollars per hundredweight to the grower). During 2006 it was estimated that the onion virus and thrips contributed to a four-fold increase (from 15 to 60 dollars a hundredweight from 2005 to 2006) in the price of white onions marketed from the western states, including Colorado.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - New Methods for Control of Termites

Short Description - Termite bait stations with or without a CO₂-generating bait (Focus Termite Attractant, produced by Brotica, Inc., Fort Collins, Colorado, and distributed by Ensystex Australasia) were tested at tree and house locations in Australia. The termite species *Coptotermes acinaciformis* (Froggatt) (Isoptera: Rhinotermitidae), *Schedorhinotermes intermedius* (Brauer) (Isoptera: Rhinotermitidae), *Microcerotermes turneri* (Froggatt) (Isoptera: Termitidae), and *Nasutitermes exitiosus* (Hill) (Isoptera: Termitidae) discovered more monitoring stations when the CO₂-generating bait was present, and also discovered the monitoring stations more quickly when the CO₂-generating bait was present. *Reticulitermes tibialis* Banks, *R. flavipes* (Kollar) and *R. virginicus* (Banks) termites contain the phototoxic alkaloid norharmane, and ultraviolet light exposure experiments (60 and/or 30 W/m²) caused high autophototoxic mortality in all three species. This may be the first known instance of autophototoxicity in nature. Norharmane has been previously reported as a phototoxin when fed to other insects, and this termite endosymbiont-produced beta-carboline may be the causal agent in *Reticulitermes* spp. autophototoxic mortality. Regardless of mechanism, the observed UV-induced termite mortality suggests novel pest control possibilities. UV exposure bioassays with half-covered arenas showed that *Reticulitermes* termites are negatively phototactic to ultraviolet light. Additionally, mortality was significantly reduced in half-covered arenas compared to uncovered controls and this may be a mechanism by which the termites avoid autophototoxicity. Norharmane transfer between trophic levels was observed in saprophagous *Tyrophagus* sp. mites, associated with laboratory colonies of *Reticulitermes*, which become fluorescent after ingesting norharmane from termite cadavers. In contrast to termites, these mites showed no mortality when exposed to UV light. No UV-mediated mortality was observed in pavement ants, *Tetramorium caespitum* L., fed on sucrose and norharmane, discounting the hypothesis that norharmane may play a role in predation protection.

Impact - The discovery that 6 species of termites in Australia are attracted to CO₂ can be used in the global development of improved monitoring and pest management techniques for termites. In addition, discovery that ultraviolet light causes high mortality in termites, due to the high concentration of the phototoxin norharmane that termites naturally contain, means that a new method of termite pest control is now possible.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Integrated Weed Management in Riparian Areas

Short Description - Recreation and irrigation are important uses of Colorado's limited aquatic resources. These uses are threatened by the spread and rapid growth of both native and exotic submersed aquatic plants. The invasive, Eurasian watermilfoil (*Myriophyllum specatum*), currently infests 33 states including Colorado and negatively impacts recreation and the efficiency of water delivery systems i.e., irrigation and drainage canals. In Colorado, Eurasian watermilfoil has spread from a single location in Boulder County to at least 10 other locations mainly along the Front Range. The native, sago pondweed (*Potamogeton pectinatus* L.), is a problem weed of rivers, irrigation and drainage canals throughout temperate and subtropical parts of the world. Sago pondweed is a recurring problem in irrigation canals along the Front

Range and the eastern plains of Colorado. Once water temperatures reach 60F sago pondweed growth increases rapidly forcing irrigation districts to dredge canals with backhoes in order to maintain water flow. Field and greenhouse research projects were established to evaluate the efficacy of imazamox for Eurasian watermilfoil and sago pondweed control. Imazamox is an imidazolinone herbicide registered for a number of terrestrial uses and currently under investigation as a potential new herbicide for aquatic weed management. Working under an Experimental Use Permit from EPA, imazamox was used to treat three small lakes heavily infested with Eurasian watermilfoil and monitored weed control and imazamox dissipation from mid May to August. The imazamox treatments significantly reduced Eurasian watermilfoil growth, keeping these lakes completely open for the summer. The imazamox concentration in these lakes decreased rapidly after application due to photodegradation. The half-life of imazamox in these aquatic ecosystems was approximate 4 days. Emerged sago pondweed was not susceptible to imazamox; however, imazamox did reduce sago pondweed biomass by 95% when shoots emerged through treated soil. This indicates that imazamox could be used to treat dry irrigation ditches in the fall or spring and provide sago pondweed control the following irrigation season.

Impact - A safe and cost effective method to control Eurasian watermilfoil will increase the recreational use of affected lakes and ponds, while the ability to control sago pondweed in irrigation canals will increase the efficiency of water delivery for irrigation and augmentation. Imazamox appears to be effective at much lower use rates than products currently labeled for Eurasian watermilfoil control and controlling sago pondweed with pre-emergence fall or spring application could reduce or eliminate the need to use acrolein. Acrolein is a highly toxic compound that was used for chemical warfare in World War I. Very few people are qualified to apply acrolein in the west and acrolein applications are dangerous and costly.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Characterizing Weed Population Dynamics

Short Description - The ninth year of research of a 10 year weed shift study evaluating the utility of Roundup Ready crop technology for weed management has shown that over a multiple-year timeframe, excessive reliance on a single weed management strategy tends to slowly enrich the weed population with those species that may be inherently more difficult to control with that strategy. When only glyphosate is used for weed control in Roundup Ready crops, there is a slow increase in weeds such as common lambsquarter, wild buckwheat, and toothed spurge. Grasses and broadleaf weeds (including kochia) in this study continue to be well controlled. By incorporating a reduced rate of soil applied herbicides into the system, weed populations were reduced even further. There was a positive corn yield response where a soil applied herbicide program was put down prior to post-emergence applications of glyphosate. Conventional herbicide treatments failed to provide adequate weed control in 2006, and as a result, such treatments resulted in reduced corn yields. Studies on herbicide resistant weeds were conducted with kochia and with Palmer amaranth to evaluate the genetics and molecular biology of dicamba and glyphosate resistance in these weeds respectively.

Impact - As America moves to the production of more biofuels, it will become increasingly important to devise cost-effective weed management practices that maximize corn yields with minimal environmental impacts. This research helps address potential threats to sustainable corn production in Colorado, and should help maximize corn yields when limited irrigation is used to produce corn. This research will help maintain the sustainability of reduced till crop production in Colorado.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Controlling Potato Diseases

Short Description - Plant diseases and disorders caused by viruses, fungi, and nematodes are ranked by growers as key components related to yield decline and quality issues in storage. These problems limit the potential of a grower's potato crop and often add unnecessary expenses to their operational budgets. To manage early blight and late blight, disease forecasting is utilized to predict onset and maximize fungicide effectiveness. These last two years growers have been informed of several different fungicide programs with cost analysis of the different regimes available. Efforts have been made to utilize rotations of different classes of chemicals with appropriate rates. Also, late season applications of fungicides have been made to help control early blight tuber decay. In 2005 and 2006, twenty fungicide regimes were evaluated for timing of application and disease incidence. Also, during this time frame treatment of the crop using Omega, a fungicide for control of powdery scab, was elucidated under SLV conditions. This fungicide was found to be very effective in reducing levels of powdery scab on susceptible cultivars and will be instrumental in helping to control this problem as part of an inclusive management program. This disease is beginning to limit the quality of many susceptible specialty cultivars being produced in Colorado.

Impact - Over 90% of the potato acreage in the San Luis Valley is now treated with new classes of fungicides based upon efficacy data and application recommendations developed by this project. Additionally, several new chemistries have been screened for effectiveness to control foliar early blight and powdery scab. Growers have been able to reduce their fungicide applications because of use of an accurate forecasting model. Omega fungicide is in the process of having a label change to allow for its use as an in-furrow treatment to control powdery scab. 24,301 ha (60,000 a) of potatoes were grown in the San Luis Valley in 2006. The precision use of fungicides has translated into a savings of \$120 to \$180/ha for potato producers helping them remain profitable during very tight economic times.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

USDA Goal 2 and Goal 3: A Safe and Secure Food and Fiber System and a Healthy, Well Nourished Population

CSU Program: Food safety and nutrition

Topic - Characterizing Nutritional Value of Vegetables

Short Description - With the goal of promoting the production and consumption of value-added Colorado agricultural crops, this project sought to examine the antioxidant properties of Colorado-grown varieties of several vegetable crops, to further investigate the antioxidant and sensory properties of promising lettuce cultivars at harvest and post-harvest and to translate our results for use by producers and consumers. In 2002, 37 vegetable samples (kale, rhubarb, spinach, broccoli, green bean, carrot, tomato, and potato) collected from farmers markets were analyzed for antioxidant capacity using total phenolic content (TPC), DPPH, ABTS, ORAC, peroxy radical, and Fe chelating assays. All vegetables showed significant antioxidant activity which varied by vegetable and within the same vegetable across harvest. The highest TPC, cation radical scavenging activity and ORAC values were detected in kale samples. Tomato exhibited the greatest DPPH quenching activity, rhubarb the highest peroxy radical scavenging activity, and broccoli the greatest Fe chelating capacity. In 2003, 25 lettuce cultivars, grown at CSU Horticulture Field Research Center (HFRC), were examined for TPC and DPPH activity. Leaf lettuce exhibited the highest TPC and DPPH activity, 39.3 mg/gdw and 76.4 percent, respectfully, followed closely by romaine. Red lettuce possessed 2.4 times more TPC than green ($p < 0.05$). To determine effects of cultivar and seasonality, TPC and radical scavenging capacity were quantified in 8 selected lettuce cultivars grown at the HFRC early, mid and late season in 2003 and 2004. TPC varied considerably ($p < 0.001$) from 13.1 mg gallic acid equivalents/gdw in

Crispino to 48.2 mg GAE/gdw in Vulcan. ABTS radical scavenging capacity ranged ($p < 0.001$) from 160.3 $\mu\text{mole TE}/100 \text{ gm fresh wt}$ for Crispino to 653.8 $\mu\text{mole TE}/100\text{gfw}$ for Cimmaron. Leaf lettuce exhibited the highest ($p < .0001$) levels of TPC and TE among types. The red leaf and red romaine cultivars showed higher TE levels than similar green cultivars. With 4 of the cultivars, increases in TPC were observed during higher summer temperatures but trends attributable to seasonality were not consistent. A sensory panel ($n=30$) evaluated bitterness, appearance, flavor, texture and overall acceptability of 5 cultivars harvested in June, July, and August of 2004. Considerable variation in sensory ratings were observed across cultivars ($p < 0.005$); Crispino rated highest ($p < .01$) in flavor and overall acceptability and lowest in bitterness. Few differences in taste panel scores were detected across growing season, with scores for all 3 harvest dates within the acceptable range. The effects of immersion and spray post-harvest treatments (water and 1 percent ascorbic acid) on physical, antioxidant, and sensory properties of green leaf lettuce were also evaluated at 1, 7 and 14 d post harvest in 2004. The ascorbic acid spray application was rated highest for flavor and overall acceptability (day 1, post-harvest) and the water spraying treatment scored lowest ($p < 0.05$) in appearance and overall acceptability (day 14). The results are being shared with producers and consumers through fact sheets and presentations.

Impact - As part of a crop-based approach to improving nutrition, it is helpful to identify the antioxidant potential of vegetables that may provide protection against age-associated health problems such as cancer and heart disease. It is also beneficial to determine antioxidant capacity and sensory acceptability of specific crop cultivars and to test possible storage-extension treatments. This project examined the antioxidant properties of nine different crops and investigated effects of cultivar, seasonality, and post-harvest hydrocooling treatments on antioxidant and sensory characteristics of Colorado-grown lettuce. These results demonstrate the diversity of antioxidant levels among vegetable crops and lettuce cultivars. Total phenolic content and antioxidant capacity were generally found to be higher in green leafy crops and the red and darker green cultivars of lettuce. The quantification of total phenolics and antioxidant capacity verifies the potential of these Colorado-grown vegetables to serve as good dietary sources of phytonutrients. The assessment of particular health-promoting properties of specific crops and cultivars may benefit producers and improve the market competitiveness of locally grown produce. Health and nutrition information regarding specific vegetables, provided through outreach mechanisms, may promote the consumption of Colorado-grown crops.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Evaluating Food Insecurity

Short Description - The Healthy People 2010 statement includes an objective to increase food security among U.S. households. Data have shown that the United States is not progressing towards meeting this objective. Alamosa County, a region of rural Southern Colorado, is believed to have a high percentage of low-income, Hispanic and migrant residents, making this region at an increased risk for food insecurity. Although the level of food insecurity in Alamosa County is not known, it is expected to exceed the state and national averages of 11.3% and 11.5%, respectively. The objectives of this study were to evaluate the seasonality and prevalence of food insecurity among low income families with young children in Alamosa County and to evaluate the relationship between food security status and child diet and growth. In order to determine seasonal variations in food security and dietary intake, families were asked to participate in two assessment visits, 6 months apart. The youngest child 2 to 6 years of age in participating families was identified as the index child and therefore the subject of this study. Interviews were conducted to assess household food security status, dietary intake and child growth. Demographic, acculturation and household food inventory data were also collected. Food Frequency Questionnaires were analyzed using the Food Intake Analysis System Millennium Edition (FIASME). Means, standard errors, paired and individual t-tests were

conducted using the Statistical Products and Service Solutions (SPSS) 14.0 program. The food security status of each family was determined using the USDA Household Food Security questionnaire and criteria. A total of 99 families completed Visit 1, with 71 returning for Visit 2. Data showed that 32.3% (n=32) of participants were food secure at Visit 1. Security status did not change significantly across seasons or visits. Vitamin A intake from winter to summer decreased significantly in participants that completed Visit 1 in the winter and Visit 2 in the summer (p=0.03). There were no other significant differences in dietary intake based on food security status or season. Analysis of household inventory of fruits, vegetables and soda showed that on average food secure families had significantly higher inventories of fruits, vegetables and soda (p<0.05). Both food secure and food insecure children tended to have high sodium intakes (>1500-1900 mg/d) and low intakes of dietary fiber (<14-19 g/d), whole grains (<3 servings/d) and vegetables (<3 servings/d). Body Mass Indices (BMIs) did not vary significantly between food secure and food insecure children, however food insecure children tended to have consistently lower BMIs than food secure children. Educational tools were developed in order to increase the San Luis Valley health care professionals' awareness of food insecurity and nutritional concerns of this population. Additional educational pamphlets were developed for dissemination to WIC clients on an as needed basis. Due to the limited number of participants, results cannot be generalized to larger populations outside of the San Luis Valley.

Impact - In a high risk Colorado population, continued work is needed to identify risk factors for food insecurity and its relationship to eating patterns and growth. Results from this study will be used to better understand dietary patterns of children in the San Luis Valley and assist in focusing nutrition education on these needs, as appropriate. Findings will also be used as support for grant proposals and funding requests.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Interaction of Diet and Exercise

Short Description - We have shown in previous work that young, nonobese, Mexican Americans (MA) have higher risk for diabetes than their nonHispanic white (NHW) counterparts, even when the groups are matched for physical fitness, and central and total body fatness. Based on this finding we are now seeking to determine if a combination of endurance exercise and prudent diet (low saturated fat, low sugar) can enable Mexican Americans to "catch up" to the NHW. In other words, given that MA start a lower level of insulin sensitivity with greater room for improvement, will the diet-exercise intervention improve insulin sensitivity in this group to a greater extent than seen in the NHW? This project is ongoing, with a total of 32 subjects studied to date, including 12 MA and 20 NHW participants. Preliminary analyses using only a portion of the enrolled subjects suggest that the MA show similar, but not greater, improvements in insulin sensitivity in response to the diet and exercise changes. The MAs also appear to exhibit greater variability in response. That is, some individuals showed marked improvements and others very little. This research indicates that despite the high risk for diabetes in this minority population, nutrition and exercise can significantly lower their aggregate risk. However, it also points to the importance of future research to identify characteristics of those who are most sensitive to diet and exercise changes, as well as the characteristics of those who will need more aggressive approaches to lowering diabetes risk. A second investigation is designed to examine the interaction of acute exercise and macronutrient intake on substrate oxidation and insulin sensitivity. Ingestion of a mixed meal rapidly shifts fuel oxidation toward carbohydrates and away from fat, while exercise recovery is characterized by a shift toward fat oxidation, both of which have implications for fat balance and risk for body fat accumulation. In a study of young men and women (n=8), we found that following cessation of exercise prior to meal ingestion, plasma insulin was low, non-esterified fatty acids (NEFAs) were increased two-fold, and fat oxidation was high. Upon ingestion of a mixed meal (50 g carbohydrate, 7 g fat, 19 g protein), the increase in insulin produced a rapid decrease in NEFA concentrations, which were only modestly higher

than during the postprandial period without prior exercise. The rate of fat oxidation during the postexercise, postprandial period decreased to the same level as when subjects ate the same meal without prior exercise. These results suggest that ingesting a mixed meal immediately following exercise can significantly attenuate the high rate of fat oxidation that occurs during recovery from exercise, even in the face of modestly higher concentrations of circulating fatty acids. To improve fat oxidation, a delay in meal consumption following exercise may be of benefit.

Impact - Data to date, although limited by small numbers, suggest that despite lower levels of insulin sensitivity in Mexican Americans compared to nonHispanic whites, the former experience significant improvements in insulin action in response to a specific diet/exercise intervention. These data suggest that regular exercise and a low saturated fat diet may be especially important in reducing risk for type 2 diabetes in the Mexican American population. Also the research suggests that given the large variability in response to diet and exercise, future research will need to identify characteristics of those Mexican Americans who are most sensitive to diet and exercise changes, as well as the characteristics of those who will need more aggressive approaches to lowering diabetes risk.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Enhancing Safety of Meat Products

Short Description - A major concern for the cattle and meat industries is *Escherichia coli* O157:H7 which may be transmitted through consumption of undercooked ground beef or other beef products and other foods, and affect children and immunocompromised individuals. It should be noted that this and other pathogenic bacteria, such as *Salmonella*, have been associated even with foodborne illness through consumption of contaminated jerky. Thus, there is a need for control of enteric pathogens pre-harvest as well as in meat plant environments and products. In addition, *E. coli* O157:H7 is a pathogen of increased resistance to acidic environments, and this characteristic may affect its sensitivity to antimicrobial interventions and food processing stresses, and increase its virulence by increasing the survival of lower contamination levels through the gastrointestinal system. A study was conducted to determine the effectiveness of preharvest interventions on prevalence of *E. coli* O157 on cattle before transport to harvest. Cattle (24 pens) were randomly allocated (3 pens/treatment) to one of eight treatments. Fecal and hide samples were randomly collected and analyzed no more than 48 h before harvest. Results showed that control cattle had the highest prevalence of *E. coli* O157 (45.8 and 40.3 percent for fecal and hide samples, respectively) compared to treated animals. Neomix (Neo; neomycin sulfate) was the most effective single intervention, since treated animals had *E. coli* O157 prevalence of 0.0 and 8.5 percent, in feces and on hides, respectively. Bovamine (Bov; a *Lactobacillus acidophilus* NPC-747 dietary product) and a bacterin vaccine (Vac) treated animals had prevalence levels of 13.3 and 14.7 percent, respectively, in fecal samples and 22.7 and 20.0 percent, respectively, on hides. The combination of Bov, Vac and Neo resulted in a prevalence of 2.7 and 6.7 percent in fecal and hide samples, respectively. The results indicated that preharvest mitigation strategies may be effective in reducing prevalence of *E. coli* O157 in market-ready feedlot cattle. Another study evaluated *E. coli* O157:H7 changes during aerobic storage, following storage in vacuum packages, on beef. Inoculated fresh beef pieces were left untreated or immersed (30s) in hot water (75C) followed by 2 percent lactic acid (55C; HW/LA), stored for various lengths of time in vacuum packages at 0, 4, or 12C, and subsequently stored aerobically in retail packages at 7C for 5 d. Populations of *E. coli* O157:H7 remained unchanged (*P* greater than 0.05) during storage of untreated or HW/LA-treated beef under aerobic conditions following storage in vacuum packages at 0 or 4C; however, increases in lactic acid bacteria, *Pseudomonas*, and yeast and mold populations were observed. In general, reductions in *E. coli* O157:H7 and natural contamination were obtained when untreated beef samples were exposed to aerobic conditions following storage in vacuum packages at 12C.

For HW/LA-treated beef previously stored at 12C in vacuum packages, populations of E. coli O157:H7 and natural microbial flora remained largely unchanged after aerobic storage in retail packages. Thus, results indicated that aerobic storage of beef (7C, 5 d) after storage in vacuum packages at 0 or 4C did not lead to E. coli O157:H7 population changes, while transition from vacuum packages under abusive temperature (12C) to aerobic storage may have caused injury and death to the pathogen and natural microbial flora. The results suggested that the practice of storing fresh beef in vacuum packages for subsequent storage in aerobic retail packs does not promote growth of E. coli O157:H7. The residual antimicrobial effect of hot water followed by lactic acid on both E. coli O157:H7 and natural flora was confirmed in this study under both anaerobic and aerobic conditions. The combined use of temperature control and decontamination with hot water and lactic acid may increase the shelf-life of fresh beef.

Impact - Application of antimicrobial interventions to live animals pre-harvest, carcasses during slaughter, and to processed meat products should be useful for reduction and inactivation of pathogens. Such interventions are also useful because they can assist meat plants to comply with regulatory criteria. However, antimicrobial interventions should be selected and applied based on results of research indicating achievement of objectives without development of unpredictable risks. The results of these studies will provide guidance in the selection of pre-harvest feedlot cattle pathogen reduction interventions as well as potential decontamination of fresh beef and handling of raw products during storage, distribution and retail display.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Fatty Acids and Human Health

Short Description - The multistate project goal is to identify and evaluate agricultural and marine sources of n-3 polyunsaturated fatty acids (n-3 PUFA) to meet the new dietary guidelines for optimal health and reduction in the risk of disease throughout the life cycle. This projects objectives are: 1) to evaluate the effects of different n-3 fatty acids, both form (source) and amount, on biomarkers of gestational duration and premature delivery and 2) to develop effective means for translating research knowledge about n-3 PUFA into consumer food choices. Using immortalized late-pregnancy human myometrial cells in culture we have shown that incubating these cells with 10 to 100 micromolar docosahexaenoic acid (DHA) decreases oxytocin (OT) induced Ca entry, decreases plasma membrane OT receptor density and number and decreases inositol trisphosphate (IP-3) signaling concentrations. However, very similar results are obtained with equimolar arachidonic acid (AA), a n-6 polyunsaturated fatty acid. In an intact dog model with knee arthritis, where dogs lived at home with their owners, we have shown that 2.0 energy percent dietary DHA plus eicosapentaenoic acid (EPA) significantly suppressed mediators of joint (synovia) arthritis damage such as matrix metalloproteinase (MMP) 2 and 9, tissue inhibitors of MMP, and urokinase type plasminogen activator. Researchers from Colorado, Kansas, New Jersey and Nebraska working as a team have developed a questionnaire for assessing omega-3 knowledge and practices of dietitians. For the formative phase of development, 10 dietitians from each state were called and ask to respond to open-ended questions. Responses to each open-ended question were grouped and from this a detailed questionnaire was developed. The detailed questionnaire was then adapted for completion using both telephone and web survey methodologies. Kansas and New Jersey developed and conducted the surveys and the data analysis. Results indicated that > 80% of the dietitians survey in the four states indicated a need for more education and knowledge about omega-3 fatty acids.

Impact - Our data have clearly shown that modest amounts of long-chain n-3 polyunsaturated fatty acids (LC n-3 PUFA) such as docosahexaenoic acid (DHA) significantly increases gestation duration by 4 days. Also, DHA suppresses reproductive tissue (uterus, placenta) prostaglandins and matrix metalloproteinases that are involved in parturition. DHA also may decrease oxytocin mediated processes leading to early delivery. Thus we have demonstrated the efficacy, and

some of the mechanisms, by which LC n-3 PUFA increase gestation and perinatal health. Shortened gestation and preterm delivery is associated with 70% of neonatal deaths. Lengthening gestation and decreasing preterm birth by modest dietary LC n-3 PUFA intakes will improve neonatal outcomes and reduce health care costs. We also have demonstrated that dietary LC-n-3 PUFA can decrease the progression of joint arthritis. Arthritis is increasing due to an increase in life expectancy and increased diet LC n-3 PUFA will reduce the impact of this disease.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

USDA Goal 4: Greater Harmony between Agriculture and the Environment

CSU Program: Agriculture and environmental quality

Topic - Mitigation of Greenhouse Gases by Soils

Short Description - New estimates of national soil carbon changes were completed during the past year and submitted for inclusion in the US National Greenhouse Gas Emissions and Sinks report (EPA 2006). A more advanced approach using the Century biogeochemistry model and Monte-Carlo based uncertainty estimates was implemented. We estimate that US agricultural soils are sequestering around 33 million metric tons of carbon dioxide per year. Work was completed on the 2006 IPCC National GHG Inventory Guidelines, as a Coordinating Lead Author on Volume 4, Agriculture, Forestry and Other Land Use, which was adopted at the IPCC Plenary in April, 2006. The document will be used for preparing national inventory reports by all signatory countries to the UN Framework Convention on Climate Change. In 2003, we initiated a project in collaboration with USDA/NRCS to develop estimation techniques for voluntary reporting of greenhouse gas mitigation from soil management, under the US Department of Energy's 1605B program. An online, web-based simulation tool (COMET-VR) was developed for estimating soil C changes and changes in agricultural fuel usage by individual farmers. The tool has been implemented for use in the voluntary reporting system and is being used in a pilot program as part of USDA's Conservation Security Program. Work is ongoing to expand the management options available in the tool and to include estimates of nitrous oxide emissions for each of the management systems. As part of a USDA/NASA project, work with NRCS is developing a national-level soil monitoring network in conjunction with the National Resource Inventory. Approximately 40 benchmark soil monitoring locations were established in IA, MN and IL during 2006. Data from the network will provide independent validation data for the US national GHG inventory and for the COMET-VR system.

Impact - Accurate inventory and assessment methods are needed to: 1) assess current and future emission and sequestration levels, 2) meet international treaty obligations, 3) evaluate impact of USDA farm programs and 4) help design cost-effective future mitigation policies. The information obtained from this work has been included in the US national communication to the UN Framework Convention on Climate Change (UNFCCC). Improvements in inventory methodologies developed for the IPCC will be used by most countries in the world for their reporting to the UNFCCC. USDA is using the COMET-VR tool in guiding decisions on conservation components of national farm policy, including how to allocate Conservation Security Program participation funds to agricultural producers, in Colorado and the rest of the US

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic - Characterizing Colorado's Climate

Short Description - Colorado's 2006 statewide climate patterns were actively monitored by the Colorado Climate Center. The year was characterized by extreme variations and contrasts. The

midwinter months (2005-06) brought generous snowfall to the high elevations of the northern and central mountains while leaving southern Colorado and the Front Range very dry. For some of the state, this was the 13th consecutive warmer than average winter continuing to fuel 'climate change' concerns. But some mountain valleys, like Gunnison, had a colder than average winter. The spring and early summer was abnormally dry and warm statewide bringing a quick return of drought conditions and concerns to many parts of the state. Beginning in early July, moisture began streaming into Colorado from the south, and beneficial and locally heavy rains fell throughout the summer over portions of the southern 2/3 of the state. Rains were sufficient to reduce irrigation demands and in some cases increased reservoir levels. At the same time, northern counties of Colorado continued very dry, as part of a large drought-stricken area of the northern plains states. The fall and early winter were characterized by normal to cooler than average temperatures and several large storms. Two major snowstorms in the last 2 weeks of December paralyzed large areas across the eastern half of Colorado and resulted in federal disaster declarations for many counties. Snow was actually deeper at the end of the year in cities such as Denver, Greeley, Longmont and Trinidad than in many of the state's mountain communities, a rare midwinter event. Noteworthy climate monitoring and research activities included: 1) The completion of the 118th year of continuous climate monitoring at the official Fort Collins weather station on the CSU campus. 2006 was 20% drier than average and one of the warmest years in history at this premier long-term station. 2) Coordination and leadership of the Colorado Agricultural Meteorological Network (CoAgMet)--a 60-station statewide network of automated weather stations serving Colorado's agricultural and water management decision-making needs. Current and historic data as well as data analysis tools are provided via www.coagmet.com. Efforts to improve data quality from this network highlighted 2006 activities. 3) The Community Collaborative Rain, Hail and Snow network (CoCoRaHS) has now grown from a local precipitation resource to a national effort expanding into many other states. This network provides data updated daily from close to 1000 backyard weather stations across Colorado and has become a platform for cooperation among many of Colorado's weather, agric. and natural resources organizations. Data are available for research and monitoring at www.cocorahs.org. 4) We are leading a national effort to use new technologies to improve the quality and availability of snow fall and snow depth data (snowstudy.cocorahs.org). Outreach: All of the above efforts involve a strong outreach component to the state of Colorado with publications, websites, classroom instruction, year-round community seminars, invited presentations and close relations with the state's print and broadcast media.

Impact - The Colorado Climate Center is a climate information resource to the state of Colorado and beyond. Weather and climate affects agriculture but also recreation, transportation, and resource management. Based on website activity, thousands are accessing climate information each week. By knowing current climate conditions, local and regional climate variability and how current conditions compare to the past, we provide critical support to help sustain a viable agricultural economy in an environment where water supplies are limited, and competition for these natural resources is high. Through diverse means of climate monitoring and many channels of information delivery, this project is helping the citizens of Colorado see and understand how climate affects their lives and livelihoods. Helping state officials document recent winter weather extremes helped bring critical disaster relief to the State.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - The goal of this project is to develop improved approaches for high time resolution measurement of ammonia concentrations emitted by confined animal feeding operations. Measurements of this type are critical to improving understanding of how CAFO emissions of ammonia interact with other atmospheric pollutants and impact downwind concentrations of airborne fine particles. Although ammonia itself is not a regulated ambient air

pollutant, the fine particles that form from reaction of ammonia with nitric acid and sulfates are regulated due to their adverse effects on human health and visibility. Efforts during the initial months of the project focused on development and testing of a system for high time resolution measurement of both airborne particle composition and concentrations of gaseous ammonia. An existing, state-of-the-art, Particle-Into-Liquid Sampler (PILS) was modified to permit simultaneous measurement of gaseous ammonia, fine particle ammonium, and other key aerosol species at a time resolution of 15 minutes. Testing of the PILS measurement system was conducted at a local dairy field site in conjunction with a separate USDA NRI funded ammonia emissions project. Gaseous ammonia concentrations determined using the PILS sampling system were considerably lower (by ~50%) than those measured using a conventional, denuder sampler due to apparent loss of a fraction of the sampled ammonia to wet walls inside the PILS instrument. This is a consequence of the instrument's original design for particle-only sampling. The loss of ammonia in the modified PILS system led us to select a new sampling approach for the high time resolution measurements. This new approach makes use of a steam jet sampler, in which particles and gases are simultaneously collected into aqueous solution by mixing them with high temperature steam. The condensed water is collected and analyzed by ion chromatography. As with the PILS, the steam sampler is capable of measuring not only ammonia, but also other key air pollutants including sulfates and nitrates. The steam sampler approach is not new, but to our knowledge has not previously been used in a high ammonia environment such as a dairy farm. pH increases from water capture of large ammonia quantities could raise solution pH high enough to decrease the efficiency of ammonia scavenging from the gas phase (a pH dependent process). If this becomes problematic, the steam pH might need to be lowered by acid injection. A steam sampler was constructed and tested in our lab. The sampler was then deployed to the dairy site for a number of intercomparison measurement periods in Fall 2006. Samples collected with the steam sampler have been analyzed in our laboratory and are currently being compared with conventional denuder measurements to evaluate the system's field performance.

Impact - Development of semi-continuous measurement systems for key particle and trace gas species concentrations will greatly enhance the ability of air quality researchers to document impacts of CAFO and other ammonia emission sources on downwind air quality. By deploying these systems on mobile measurement platforms, they can be positioned downwind of different emissions sources, even within a given operation, to look at both ammonia emissions fluxes and how emitted ammonia impacts formation of new particles downwind. Information gained from measurements of this type will aid emissions' researchers and CAFO operators evaluate dominant ammonia emissions sources and test approaches to emissions reduction. Findings from applying this new measurement approach will also help air quality researchers and regulators to better understand the impact of agricultural ammonia emissions sources on regional concentrations of fine particles.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - Analytical methods for quantifying three ionophore antibiotics, monensin (MNS), salinomycin (SAL), and narasin (NAR), were developed for water and sediment matrices. Samples were prepared with solid phase extraction (SPE) and HPLC tandem mass spectrometry was used to measure extracts. Since they are not used for human purposes, these compounds can act as markers for the transport of animal pharmaceuticals to the watershed. The occurrence of three ionophore compounds was determined at five sampling sites in the Poudre River watershed. MNS and SAL were only detected at the sample points in the agriculture-influenced section with a range of 0.002 to 0.011g/L and 1.8 to 14.6 g/kg for water and sediment respectively. NAR was detected at sites 2 and 3 (urban landscape) but showed the highest concentration in agriculture areas. All three ionophores were found in the sediments

at significantly higher concentrations than in water. The occurrence and fate of veterinary antibiotics in lagoon water and animal manure are a critical and emerging environmental issue. One of the objectives of this study was to understand the disappearance of oxytetracycline (OTC), sulfamethoxazole (SMX), tylosin (TYL), and monensin (MON) through biodegradation in waste lagoons. Analytical methods using SPE and LC-MS-MS with ESI(+) and SRM were used to quantify the compounds in this matrix. Four lagoon conditions were compared: aerobic-20 °C, aerobic-4 °C, anaerobic-20 °C and anaerobic-4 °C. OTC, SMX, TYL and MON were spiked at a concentration of 20 mg/L in each experiment and 50 g/L of sodium azide was added in abiotic control experiments to eliminate biological activity. Sodium azide (50 g/L) and mercuric chloride (0.1 g/L) were added for the abiotic anaerobic control experiments. OTC, SMX, TYL, and MON showed measurable biodegradation in all experiments. OTC, SMX, TYL, and MON at 20 °C followed first-order degradation kinetics with half-lives of 12, 6.5, 16, and 9.2 days, respectively, under aerobic treatment and 17, 59, 19, and 71 days, respectively, under anaerobic treatment. The half-lives of OTC, SMX, TYL, and MON at 4 °C were found to be 80, 204, 46, and 128 days, respectively, under aerobic treatment and 110, >242, 103, and 193 days, respectively, under anaerobic treatment. Biodegradation half-lives in the antibiotic spiked at 20 °C followed the order of TYL<OTC<MON<SMX under aerobic treatment, and MON<SMX<TYL<OTC under anaerobic treatment. At 4 °C, the degradation half-lives were slightly different with SMX<MON<OTC<TYL under both aerobic and anaerobic conditions. The biodegradation rate of antibiotics at the reduced temperature (4 °C) was slower than that of 20 °C for all four antibiotics and in general aerobic conditions were more effective than anaerobic. Currently we are running additional experiments to verify these results. In addition, we are working to translate the lab results to management practices in the field. Aerobic conditions seem to be most effective for biodegrading these compounds so we are trying to determine the best way to accomplish this in large waste lagoons

Impact - The project has identified ionophores in the environment and since these antibiotics are only used for animals, the source appears to be animal feed operations. We have developed and published methods for measuring antibiotics in lagoon water. By simulating the operation of animal waste lagoons in the lab and defining Best Management Practices, the project will allow producers to minimize the release of these compounds to the environment helping support sustainable operations.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - Recent court rulings require the implementation of a new augmentation accounting methodology in Colorado's South Platte region. Water users must now provide monthly reports giving their augmentation requirements and showing how they have met these requirements. These reports need to be done in a timely fashion and must utilize a methodology that is valid, transparent and consistent. This methodology must take into account lag times and must allow for by-pass flows and exchanges. **Narrative:** The South Platte Mapping and Analysis Program (SPMAP) includes a GIS tool, a tool for calculating consumptive use (IDSCU), and a tool for calculating stream depletions (IDS Alluvial Water Accounting System). SPMAP has become the program of choice in the South Platte region for water users, but new needs continue to be expressed. This year there was significant increase in the use of the Consumptive Use model (IDSCU). As a result of this increased use, we interacted with many users and provided technical support to them. We fixed bugs in the program and made enhancements to the model. Some of the major enhancements to IDSCU included adding Arizona Meteorological Network (AZMET), California Irrigation Management Information System (CIMIS), and the Middle Rio Grande's ET Toolbox weather data formats. We now have users of the model in California and New Mexico. In addition to using the traditional consumptive use models we are working on developing a remote sensing algorithm known as RESET (Remote Sensing of

Evapotranspiration) which uses Landsat 7 and 5 imagery to calculate actual evapotranspiration (ET). ET is computed for each pixel for the instantaneous time of the satellite image. The process is based on a complete energy balance for each pixel, where ET is predicted from the residual amount of energy remaining from the classical energy balance, where $ET = \text{net radiation} - \text{heat to the soil} - \text{heat to the air}$. We plan to generate actual ET from the satellite energy balance approach and compare it with the results from computing ET using the traditional method (crop coefficient * reference crop ET). This comparison will be invaluable to farmers and water users because it will aid them in determining areas that are water short and help in the development of crop coefficients for the South Platte. We are working on developing ET estimates based on remote sensing for 2004 and 2005.

Impact - Accurate estimates of water availability, demand, use, and augmentation requirements play an essential role in keeping Colorado agriculture competitive, in developing rural communities, and in promoting harmony between agriculture and the environment. CSU, being a credible impartial party in water issues, is able to develop methodologies and software, that build consensus on water issues and prevent costly legal battles. The SPMAP tools, including the Augmentation Accountant and IDSCU, have a proven track record with water managers dealing with the complex issues pertaining to water scarcity and high demand. SPMAP models are used in the South Platte to determine augmentation requirements for over 75% of the basin (approximately 4,000 wells). Other western states are also adopting some of the tools.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - This project uses various methods to attempt to diagnose and solve irrigation-induced salinity, waterlogging, and pollutant loading problems in the lower Arkansas River Valley in Colorado. High water tables are a factor in the region's salinity problems. Thousands of measurements of water table depth have been taken at wells around the study area. Water table depth has been found to vary greatly with the amount of precipitation and irrigation water available in the area. Irrigation has also been investigated as a factor in the salinity problem. Hundreds of irrigation events have been monitored to determine the amount of water applied to a given field, the amount of runoff, and the amount of deep percolation. Soil salinity has been examined. Soil samples from the area were collected and analyzed, and a correlation between soil salinity measurements from Electro Magnetic (EM) readings and laboratory ECe measurements was developed, allowing for a significant reduction in the amount of time it takes to determine soil salinity in a field. Soil properties, including texture and density have been analyzed, and the local soil survey maps were digitized in preparation for updating. Several models of different scales, including the basin scale, have been developed to investigate the effects of salinity and to examine the expected impact of various improvement strategies including: increased irrigation efficiency, altered pumping rates, canal lining to reduce seepage, subsurface drainage, and combinations of these alternatives. The models predict the impacts on water table depth, water table salinity, soil salinity, crop yields, return flow and salt loads to the river, and upflux from the shallow water table to nonbeneficial consumptive use. The basin scale model integrates artificial neural networks for estimating return flows to the river, based upon regional-scale model results, into the MODSIM-Q network model for routing flows and salt loads along the river. Finally, an economic model of crop production for existing acreage allocations in the Arkansas River Valley is in development. The model shows how changes in salt levels that are external to the farm influence on-farm profits, production levels, and water applications. Mathematical simulations of agricultural production indicate that saline conditions cost producers significantly. More dynamic responses by growers may help or hurt the farmer's bottom line. Changes in irrigation technology due to saline conditions are of particular concern, since parallel econometric results indicate a positive and significant effect on the adoption of more advanced sprinkler irrigation systems when irrigators perceive soil salinity as an on-farm problem.

Impact - Solution alternatives considered show promise both for boosting agricultural productivity on the land and enhancing the environmental health of the river. Results from the study suggest that strategies to reduce recharge to the water table by improving irrigation efficiency and reducing canal seepage would (a) lower the saline high water table leading to lower soil salinity and increased crop yields, (b) significantly reduce loading of salts and other pollutants to the river, and (c) markedly reduce nonbeneficial consumptive use under fallow land. As the results of this study are conveyed to farmers and land managers at public meetings and through demonstrations and publications, the stakeholders can make well-informed decisions about the adoption of techniques and technology while keeping in mind their economic bottom line.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - As communities throughout US are becoming interested in innovative approaches to water resource sustainability, recycled wastewater (RWW) reuse and household graywater reuse for turf and landscape irrigation is gaining in popularity. In collaboration with three CSU faculty members and Water Environment Research Foundation, a project was completed in 2006. This project comprised an extensive literature review and synthesis of information to define current knowledge and information gaps regarding household graywater irrigation impacts on residential landscaping. The literature review examined overall graywater issues, especially 1) quantity, quality, treatment methods, and legality, and 2) potential effects of graywater on residential landscape plants and soil chemical and microbial functions. Knowledge gaps were found in five areas, particularly as it relates to human health, landscape plants and the environment. At the same time, work towards the understanding of long-term recycled wastewater irrigation on landscape plants and soil continues. Water samples were collected to assess variability of chemical properties of recycled wastewater in the Front Range of Colorado. Results indicated that there were variations in water quality between wastewater treatment facilities. The chemical constituents of recycled wastewater were dominated by sulfate, bicarbonate, chloride, and sodium. The average sodium and chloride concentrations of 50 water samples collected from all the sites were 99 mg/L and 95 mg/L, respectively. Adjusted sodium absorption ratio (SAR) of RWW samples ranged from 1.6 to 8.3. We have collected and analyzed soil, turfgrass clippings, and different landscape plant samples from 14 landscape facilities (7 were irrigated with recycled wastewater while the other 7 were irrigated with surface water). Our results indicated potential problems associated with recycled wastewater irrigation exist. Salts (especially the relatively high Na⁺ and high EC) in the treated wastewater were associated with needle burn symptoms observed in several conifer species subjected to RWW irrigation. Likely, problems associated with saline soils may increase in the future as more recycled wastewater is applied to turf sites. Selection and development of salt tolerant turfgrasses and landscape plants is important for the long-term sustainability of water reuse. Work towards the development of turf-type saltgrass continues. In 2006, we investigated different seed treatments in enhancing germination and establishment of inland saltgrass. We found that cold moist stratification and dry scarification significantly improved germination and enhanced establishment of seeded saltgrass.

Impact - The graywater literature review and synthesis describes the status of knowledge that currently exists about graywater and its reuse at the household level. The knowledge gaps identified will help the water foundation to identify the research needs and priorities. Our recycled water irrigation project helps to determine what proactive steps should be taken to minimize any negative effects during planning and managing landscapes receiving recycled wastewater. Understanding the responses of urban landscape plants and soils to recycled wastewater irrigation and identifying proper management practices are critical to the long-term success of water reuse.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - Our work spans two areas key to understanding forests of the Rockies: the interaction of fire, aspen, wildlife, and livestock, and human impacts on forests via invasive species and urbanization. During the 20th Century, the lower and mid-elevation forests in the Rocky Mountains changed fundamentally in structure and composition. Aspen forests responded in a variety of ways to changes in fire regimes and browsing by wildlife and livestock. Changes in fire regimes altered the structure and composition of many ponderosa pine and mixed-conifer landscapes. These fundamental changes have led to unprecedented increases in risks to forest health. Our project has been examining several aspects of these changes, with a key focus on spatial and temporal patterns. A key focus of this year's work has been on determining the age structure of aspen trees in Rocky Mountain National Park. Our previous work determined that most of the aspen stands in the Front Range had at least some successfully regenerated trees in the past 40 years, despite very high populations of elk. Exceptions to this general trend occurred only in areas of the heaviest, year-round use (such as Horseshoe and Moraine Parks). Based on the second year of intensive sampling, it appears that regeneration of aspen has remained relatively strong across the Park as whole despite high elk populations over the past 4 decades. The intensively used winter range is an exception to this overall trend, however, and aspen recruitment was dramatically lower in the past 4 decades than in earlier periods. Humans are having strong impacts on the structure of forests in the West, not only through logging, grazing, and fire suppression, but also through the expansion of suburban and urban settlements. We expanded our studies this year to include the assessment of the carbon storage capacity of urban forests in the Front Range. The Colorado Front Range is interesting as a set of semi-arid ecosystems that represent one of the most rapidly growing regions in the US. We modeled potential carbon storage in aboveground woody biomass for urban trees in the city of Fort Collins, Colorado. In our model potential carbon storage depends on species composition, tree density, and age distribution. These factors vary through time based upon the spatial and temporal distribution of human decisions. Our results suggest that the aboveground carbon pool in urban areas can reach values that compete with native forests in Colorado, and approach values within 30% of the most productive forests in Colorado.

Impact - Forest managers in the Rocky Mountain West need to have a solid understanding of what controls forest structure and recruitment, to make decisions that will provide for future sustainability of timber, grazing, and wildlife resources. Our results indicate that elk grazing does not generally limit aspen recruitment, except in the very most heavily grazed systems associated with winter range. Among the most important management priorities in the Rockies today are minimizing fire risk, minimizing invasive species, and maximizing carbon storage potential of Front Range Forests. Our recent results indicate that fuels treatment protocols that minimize nutrient availability during initial phases will decrease invasive species, particularly cheatgrass. Finally, many municipalities in the U.S. are beginning to develop carbon credit trading, and our results show that investments in urban forests along the Front Range have a strong potential for capturing significant carbon over several decades.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

USDA Goal 5: Enhanced Economic Opportunity and Quality of Life for Americans

CSU Program: Community and rural development

Topic -

Short Description - The study has provided numerous educational opportunities to landowners and ditch company representatives over the past two years. These efforts have been designed to improve the working trust between the researchers and local landowners. The subject of water is a sensitive one, and researchers coming in from outside the community are often at a disadvantage, and can be viewed somewhat suspiciously when doing sensitive research such as this. In order to facilitate this research process, the Sociology Water lab conducted the following activities in support of the study: 1. Organized a three day study tour for the board members of the Fort Lyon Canal Company, which is the largest mutual irrigation company enterprise in Colorado. This tour included a visit to a large mutual irrigation company in the Northern Colorado Water Conservancy District service area that is undergoing canal modernization, and for the purpose of developing a well augmentation program for its shareholders. The New Cache la Poudre Irrigating Company, located in Weld County, has an active water exchange program on the Cache La Poudre River, and participates in traditional water banking with other ditch companies in the basin. This banking includes numerous exchanges and transfers through water storage facilities that allow a great deal of flexibility in the allocation of water to landowners. 2. Organized a two day study tour for the superintendent of the Fort Lyon Canal Company to the Irrigation Training and Research Center at the California Polytechnic State University, San Luis Obispo, California. The purpose of this study tour was to familiarize the Fort Lyon Canal Company with some of the important technology innovations being adopted by irrigation district in California, including SCADA, GIS, and automation of headgates and canal check structures. These new technologies play an important role in assisting agricultural water supply organizations in participating in water banking and other forms of water marketing. 3. Organized a one day workshop for sixty landowners and mutual water company representatives in the lower Arkansas Valley. Guest speakers for this workshop included two representatives from the Idaho water banking tradition, a representative from the Palo Verde Irrigation District, California who spoke on successful fallow leasing programs, a representative from the City of Fort Collins, Colorado who explained the innovative and long-standing water rental market in northeastern Colorado, and additional speakers from California and Utah who addressed canal consolidation and joint operation of canal companies on the Kern River (California) and Sevier River (Utah). 4. Organized a two day forum on groundwater management, water banking and canal and pipeline corridor easement protection in Tulare, California, scheduled for January 30-31, 2007, and hosted by the Tulare Irrigation District. This activity will provide the research project with important information on current approaches to water banking and water marketing in California.

Impact - The Sociology Water Lab's perspective on water banking is that it is simply one of a family of water marketing and transfer institutional mechanisms used to move water around the landscape. As water marketing experiments occur throughout the West, water users and organizations must sort through locally unique traditions, circumstances, and constraints to find suitable mechanisms to conduct this marketing. The limited success of the recent HB-1354 initiative suggests that future state efforts to form these institutions should be approached with care. This may mean allowing for even more participation and inclusiveness in the outreach program associated with building innovative institutional arrangements, and ensuring that such initiatives are welfare-enhancing and in keeping with local values and norms. Given the way the West's water supplies are generally organized, if water banking and water marketing are to have any success, then it would appear that some effort should be made to understand how mutual irrigation companies (and irrigation districts for that matter) respond to these incentives. This is a key idea running through this study. In the context of increased competition over water and its effect on traditional social values and behavior in agriculture, it may be of use to view mutual irrigation companies as having both a productivity-oriented (growth-oriented) dimension as well as a maintenance sustainability dimension to their day-to-day management. These organizations may be crucial to efforts in promoting water banking and water marketing in the West.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - Several time series applications were completed during last year. First, a study using weekly USDA-AMS fed cattle price data from 1992 to 2006 for five U.S. regional fed cattle markets, including Colorado, investigated effects of mandatory price reporting on spatial market integration. Results indicated that these markets have been, and remain, highly cointegrated after implementation of mandatory price reporting. Following introduction of mandatory price reporting, the five regional fed cattle markets have become more fully integrated. Secondly, the economic impact of food safety scares, specifically, bovine spongiform encephalopathy (BSE) in domestic cattle, was examined using time series techniques. Retail meat purchase data was used to test if consumer purchases were altered by the BSE event. Results suggested that hamburger purchases were adversely affected while pork purchases increased. The second research thrust compared a simple dummy variable representing the BSE event to a media index variable simulating the weight of negative media coverage. The simple dummy variable captured the effect of the BSE outbreak on consumer purchases better than the media data. Several research activities in this project provided perspectives on key Colorado products. Colorado cooperatives are important to producers of potatoes, wheat, corn, sugar beets, and millet. CSU researchers obtained consolidated financial statements for 505 cooperatives from 1995 - 2005 and calculated DuPont profitability ratios. Findings suggest that cooperatives compete against one another to capture equity and business from producer-members, to garner inputs and services from regional cooperatives, and to secure financing. The first quintile firms had, on average, a rate of return to local equity that was 7% higher than the next quintile and much higher than the remaining quintiles. Three other research activities examined consumer behavior related to beef products. First, choice experiments analyzed US consumers' preferences and willingness-to-pay for meat attributes in labeled ribeye beef steaks. Consumers value USDA food safety certification more than any of the other choice set attributes, including country-of-origin labeling, traceability and tenderness. As a result, indication of origin may only become a signal of enhanced quality if the source-of-origin is associated with higher food safety or quality. Secondly, survey data from Colorado consumers determined market segments for various natural beef products. Almost two-thirds of the differences among responses regarding the importance of meat attributes were related to production practices (e.g. use of antibiotics, hormones and environmentally friendly grazing). A third analysis was done to determine sensory preference and value of fresh beef steak differing in aging technique. No significant differences for sensory traits of flavor, juiciness, tenderness, or overall acceptability were detected between wet-aged Choice samples and dry-aged Choice samples. Although more consumers preferred wet-aged samples, markets exist for dry-aged beef and consumers are willing to pay a premium for this product.

Impact - The research provides stakeholders with insight into the consumer response to animal disease events. Quantifying consumer effects aids stakeholders in weighing the benefits of animal identification systems against its costs. Colorado cooperatives provide valuable input purchasing and marketing services to Colorado farmers. Moreover, these cooperatives are an integral part of the rural Colorado economic landscape. The research results from this area of the project have been directly applied to the training of board members for Colorado cooperatives through yearly Director Certification Programs. The educational emphasis is on financial decision making and improving the financial performance of Colorado cooperatives. The work on mandatory price reporting should help in the evaluation of this relatively new legislation, and provide useful results for other production-distribution systems that are becoming more vertically integrated. The various analyses of consumer responses to beef attributes will provide marketing information for processing and retailing forms as they try to design new products and understand their markets. As the researchers also have Cooperative Extension appointments, they will produce non-technical summaries of the research in a variety of fact

sheets and presentations.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - There are several consumer segments that show great potential with respect to their willingness to pay for organic, locally sourced or nutritionally superior produce. Complementary work on natural meat markets are important to show whether consumer behavior is consistent across food products. The Colorado wine study was finished in the summer of 2006 and results were presented to funding groups in December 2006. The report found that the economic contribution related to the small but growing Colorado wine industry totaled \$41.7 million, of which \$11.2 million came from direct sales of wine products by Colorado producers, and another \$11.8 million in indirect effects was related to the purchases of inputs and labor by wine producers. Nearly half of the total impact came from tourist revenues from wine festivals through the state, which amounted to \$20.8 million. It appears that there is a small, albeit, growing number of Colorado consumers who have interest in Colorado wines, and if the industry continues to develop, there is potential to double sales between 2005 and 2010. Plans for future work with wineries in their business planning is under discussion

Impact - Research for the wine industry will be used to guide business planning by wineries and help with strategic market planning for the whole industry. However, there continues to be significant distribution issues that may motivate the need for future research as the industry grows out of the size of a niche market. This type of analysis should allow them to better manage the 100% growth in market share the industry has experienced in past years. Work with various businesses to assess the market opportunities, and to a lesser degree, explore the financial feasibility of differentiated meats, produce and wine continues to gain positive feedback from constituents. In addition to guiding specific businesses, this research is becoming cited at the National level for its implications for the national marketplace.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - County, State and Federal agencies often need economic valuation information about providing recreation access, valuation of ecosystem services, protecting forest homeowners, as well as information about general public support regarding resource management policies. However, public policy decisions frequently must be made quickly using available estimates of the economic value of natural resources. Thus, one important research issue is to provide estimates of the economic value of visitors and residents to managers on policy relevant issues. Another issue that arises is developing valid economic methods to value non-market recreation and ecosystem services for agency staff to adopt in their everyday benefit cost analyses. Research undertaken and published this year provides recreation value estimates to public agency staff and decision makers for their use in making natural resource management trade-off analyses involving forest fire prevention, protection of ecosystem services, and recreation benefits from providing public access to Colorado's 14,000 foot peaks. We also developed a new technique for valuing wildlife recreation (Allen and Loomis, 2006) as well as tested the validity of survey based valuation methods (Loomis and Richardson, 2006). Results: Two approaches were used to estimate the economic value of reducing wildfire. Research with graduate students involved comparing house prices before and after multiple fires to trace out the effect of repeated wildfires. We found that house prices dropped 10% after the first fire and 23% after the second fire. This paper is under second review at a journal. Published research (Loomis, et al. 2006) indicated support for wildfire prevention among three distinct populations:

Whites, African Americans and Hispanics. Values of fishing and rafting on rivers were estimated using the travel cost and contingent valuation methods, as well as regional economic methods. The regional economic effect of fishing and rafting on just a portion of the Snake River was estimated at over 1000 jobs supported that generate \$46 million in county income (Loomis, 2006a). One publication reported on methodological improvements for regional economic analysis of recreation on public lands (Loomis and Caughlan, 2006) while another (Loomis and Richardson, 2006) reported our test results regarding the accuracy of using survey responses to predict changes in visitation at Rocky Mountain National Park. Our economic analysis of the State of Colorado and Park County's decision to reduce liability to private landowners in exchange for access to three 14,000 peaks suggests this opening of access provided 74 tourism-related jobs in the county and 85 tourism-related jobs in the state.

Impact - This research is being used by federal agencies such as the National Park Service, U.S. Geological Society and U.S. Bureau of Reclamation. Our previous research on protecting forests for wildlife is being used by Washington State Department of Natural Resources to formulate forest management regulations. The USDA Forest Service utilized our joint analysis with University of Georgia on the economic values of ecosystem services in their report on this topic to the Deputy Chief of the USDA Forest Service. Non-profit organizations such as Trout Unlimited and the Henry's Fork Foundation helped fund and are using the research on the Snake River for water management negotiations with the U.S. Bureau of Reclamation and in preparing their response to a hydropower dam modification proposal. Our economic valuation research conducted under this project last year that appeared in the American Agricultural Economic Association's publication called Choices was awarded an Honorable Mention for the Outstanding Choices article in 2005. These examples suggest significant cost savings are being realized by agencies and non-governmental organizations being able to apply our new and existing studies to emerging natural resource policy issues without having to conduct their own expensive studies and without having to delay management decisions while new economic studies are conducted.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Topic -

Short Description - Research this year focused on three areas: a. institutional and non-price water management policies (Schuck, et al. 2006) to encourage adoption of alternative irrigation systems as a means of reducing irrigation induced waterlogging, soil salinity and selenium pollution, with particular emphasis in Arkansas Basin and San Luis Valley. Since selenium does not directly affect crop yield, the study focuses on the type and level of incentives that could be given to farmers to increase irrigation efficiency on farms in the Uncompahgre Valley, as a primary method of selenium and salinity remediation. Research found that institutional structures in Colorado limits the incentives for farmers to adopt less water intensive irrigation systems. Thus, adoption of such systems in Colorado may require significant use of cost sharing programs. The type and amount of cost share was estimated in Clements (2006). Regional economic analyses show relatively large regional benefits associated with the government purchase of more efficient irrigation technology for farms within the San Luis Valley (Clements, 2006). b. Statistical estimation was performed to provide an aggregate river basin water demand model across competing water users in the Gunnison River Basin. c. A meta analysis was published on the price responsiveness of irrigation water diversion demand in the western U.S. A statistical synthesis of 24 studies yielded a price elasticity of .48, and the long run elasticity for water planning purposes is likely even more responsive. This suggests that in the western U.S. there is some degree of price responsiveness in both the short run and the long run in irrigation water diversion, and hence price can be used in conjunction with other policy tools to reduce irrigation water diversions.

Impact - The results of the research on salinity and selenium have been disseminated to water

managers through the Colorado State University Water Center. The information on water demand in the Gunnison River Basin was requested by the USDA Forest Service Rocky Mountain Research Station and provided to that agency for its use in water modeling and watershed analyses. The results of the meta analysis on price responsiveness has been published in a journal read by water resource management agencies such as the U.S. Bureau of Reclamation and may aid in their use of water pricing through annual contracts as a tool to reduce short run water diversions in response to drought, and long run water diversions associated with planning new water projects.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

C. Stakeholder Input

The Colorado Agricultural Experiment Station (CAES) annually utilizes multiple means of obtaining stakeholder input on programs conducted and solicits input on changes in program direction. The CAES supports research in 16 departments on the Colorado State University campus as well as at 8 off-campus research centers. Programs at the research centers are administratively responsible to the Director of the CAES who coordinates these programs with one or more academic departments. During the past several years, numerous meetings have been held with general purpose organizations and specific commodity oriented associations to discuss budget cuts at the state level. The CAES continues to hold organized meetings around the state to help identify priority programs and discuss with the stakeholders the impacts that the budget reductions would have.

D. Program Review Process

All projects conducted by the CAES are subjected to a peer review process. Each College at Colorado State University has adopted a process for conducting a peer review on all CAES projects submitted for support by state and federal funds. Documentation is available upon request for the specific process adopted by each College and approved by the CAES Director.

E. Evaluation of the Success of Multi and Joint Activities

The following are selected examples of the interactions occurring within the multi-state program conducted at Colorado State University. CSU faculty are actively engaged in a range of multi-state research and integrated extension efforts.

Potato cultivar development - A formalized agreement between the potato breeding and development programs in California, Colorado, and Texas was established in 1997 to address the needs of the industry in the Southwestern US. The overall objective of the Southwest Potato Breeding and Cultivar Development project is to develop and evaluate improved potato cultivars that meet the unique production, marketing, environmental, and consumer needs of the Southwest. From 2001-2004, 721,219 first-year seedlings representing 3,026 parental combinations were planted for initial field selection. In 2004, the Southwestern Regional Trials were grown in 5 locations and included 11 selections (7 russets, 1 chipper, and 3 specialties) and appropriate check cultivars. Colorado and Texas entered 7 russet, 3 red, 1 chipper, and 7 specialty selections in the Western Regional Trials. Currently the states in the Southwest Region Cultivar Development Program have several advanced selections released for grower evaluation. These include 5 from Texas and 15 from Colorado. Many of these selections are undergoing final stages of grower evaluation prior to naming.

Wheat cultivar development - In spring 2004, additional virulent RWA biotypes were identified in Colorado and wheat production areas in adjacent states. Working in collaboration with scientists in Oklahoma, we have confirmed that some of the most promising biotype 2 resistance sources (except the Dn7 gene) also confer resistance to one or more of the new biotypes. Field research confirmed that the Dn7 gene provided as much protection from RWA as the Dn4 gene under artificial RWA biotype 1 infestation.

Dry edible bean cultivar development - Bacterial wilt was confirmed in dry bean samples submitted to our laboratory by collaborating scientists in western Nebraska, and future collaborative work will focus on gaining a better understanding of this resurgent pathogen and disease in western Nebraska and elsewhere in North America in recent years. Outreach efforts culminated in the release of the updated version of a regional extension publication, Dry Bean Production and Pest Management, written by Colorado State University, University of Nebraska and University of Wyoming specialists.

New Fabrics - To develop value added products from renewable and recyclable resources -It is hoped that with additional systematic research, natural colorants can be tailored to approach the stringent functional parameters of synthetic dyes and can be a viable commercial alternative for the coloration industry. Success in this area of research has potential in generating additional sources of income for U.S. agriculture. - An optimal enzymatic treatment was developed for scouring of flax fabrics. It is expected that further research will minimize the need for using harmful chemicals in flax processing. 2.To develop bioprocessing and related new technologies for textiles - Use of empirical models is important in order to obtain mechanistic information regarding the usefulness of enzymes in bioprocessing. Such information includes the structural nature of the cellulose-cellulase system, the rate of the reaction, the sterical and diffusional features of the system and probable inhibitory effects of excess substrate and products of reaction on enzymatic hydrolysis. - A novel technology for reducing chemical consumption in textile processing is by the use of high molecular weight polymers as demonstrated in this research. Further work is being conducted on the potential and feasibility of using higher molecular weight polymers in enzymatic treatment baths with the objective of making wet processing more environmentally friendly.

Bark beetle infestation - Problem: Is there a relationship between mountain pine beetle attacks and dwarf mistletoe on Front Range ponderosa pine trees? Study methods: A random ground survey was conducted to determine the frequency and severity of Southwestern dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum*), mountain pine beetle (*Dendroctonus ponderosae*), and *Ips* spp. within Colorado's northern Front Range ponderosa pine (*Pinus ponderosa* var. *scopulorum*). The study area was bisected by the northern range limit of southwestern dwarf mistletoe (DM). A total of 833 (0.04 ha) plots, with 308 plots in the non-DM region and 525 plots (144 infested with dwarf mistletoe) in the DM region, were established in the Canyon Lakes Ranger District, Roosevelt National Forest, Colorado. Results: Significantly more mortality due to mountain pine beetle occurred in the DM region (18.1 stems/ha + 2.6 se) than the non-DM region (3.3 + 1.0 se). The same was true with mortality due to *Ips* spp. in the DM region (8.7 + 2.5 se) than the non-DM region (0.2 + 0.14 se). Significantly higher incidence of mountain pine beetle occurred in plots with the highest dwarf mistletoe ratings (80.81 + 14.19 se) than those plots with light (10.6 + 2.7 se) or no dwarf mistletoe infestation (7.3 + 1.5 se). These results strengthen the idea of bark beetles utilizing pockets of stressed trees in endemic populations.

W6 - The National Plant Germplasm System provides germplasm to plant breeders and users worldwide. This project documents germplasm distributed by the NPGS to Colorado. The germplasm is primarily used to enhance private and public breeding programs that provide crop, vegetable, and fruit growers with improved and pest resistant plant material. The germplasm is provided free to all users and increases productivity and reduces the cost of production by reducing the dependence on pesticides. Orders for germplasm from the NPGS constituted delivery of accessions from both clonal repositories and Plant Introduction Stations. Eighty six requests were filled for 44 individuals which constitute approximately the same level as the previous year. Orders were made from the following locations: COR, NSGC, NC7, W6, S9, NSGC, GEN, MIA, NE9, and NR6, RIV, NR6, PARL, GSHO, and the NCGRP. Germplasm accessions were used for numerous reasons including, genomic research on rice, barley breeding research, soft white wheat breeding, and Triticum species for Russian wheat aphid resistance.

Waste Management - The nutrient-assessment research shows that biosolids application at agronomic rates supplies sustainable levels of plant nutrients while posing very small environmental threats. For dryland wheat in eastern Colorado, biosolids are an excellent source of plant-available N, P, and Zn. The co-application research shows that commingling of WTR with high P-bearing materials (e.g. biosolids) can sorb excess P, reducing the likelihood of offsite movement and helping prevent waterway eutrophication. WTR appear to act as a sink for Mo as well, reducing the amount of plant available Mo and helping to increase plant Cu:Mo ratios above critical values considered a risk for molybdenosis.

Projected Resources for AES Programs at Colorado State University
 Updated for Actual FY06 Expenditures

		AES Research Program			
		Projected		Actual FY06	
USDA Goal	CSU Program	FY 06 Funds ¹	FY 06 FTE	FY 06 Funds	FY 06 FTE
1	1		10		8.6
1	2		14		13.8
1	3		10		9.8
2 & 3	4		3		3.6
4	5		13		8.5
5	6		3		3.4
	State+USDA		54		47.7
USDA Goal	Integrated Research and Extension Program CSU Program				
1	1	740,096		135,398	2.0
1	2	1,200,506		299,815	1.4
1	3	657,456		174,023	1.8
2 & 3	4	221,479		176,262	0
4	5	610,436		89,661	.4
5	6	52,541		57,855	.1
	USDA			933,014	
USDA Goal	Multistate Research Program CSU Program				
1	1	203,283		344,993	1.7
1	2	98,154		212,085	0.3
1	3	149,672		39,234	.4
2 & 3	4	54,309		116,033	1.0
4	5	358,732		128,670	2.0
5	6	88,077		162,318	1.0
	USDA	979,401		1,003,333	
		USDA Funding in FY04			
	Hatch	1,495,011	Multistate	1,003,333	
	McIntire-Stennis	352,051	Total	2,850,395	

¹ State plus federal funds were presented in the POW proposal. Data reported for FY06 for Integrated and Multi-state are Federal funds only.