FY 2005 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

Key Theme - Develop improved potato cultivares

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 provide a basic seed source of selections to growers for seed increase and commercial testing; (3) to evaluate promising selections for potential seed export (interstate and international). One hundred parental clones were intercrossed in 2005 in two separate crossing blocks. The emphasis of the first crossing block was specialty cultivar development and PVY and late blight resistance. The second emphasized russets, reds, specialty, and PVY immunity. Seed from 279 combinations was obtained. Approximately 56,302 seedling tubers representing 219 families were produced from 2003 and 2004 crosses, for initial field selection in 2006. These seedlings represent crosses segregating primarily for russet, reds, chippers, specialty types, and disease resistance/immunity (late blight, PLRV, and PVY). Colorado grew 85,007 first-year seedlings in 2005, with 848 selected for subsequent planting, evaluation, and increase in future years. A portion of these seedlings were obtained from the other breeding programs. Another 789 clones were in 12-hill, preliminary, and intermediate stages of selection. At harvest, 254 were saved for further observation. Fifty-three advanced selections were saved at harvest and will be increased in 2006 pending final evaluations. Advanced selections evaluated in the Southwest Regional Trials, Western Regional Trials, or by producers, included 7 russets, 4 reds, 5 chippers, and 11 specialty selections and one long white. Recent releases undergoing commercialization include Rio Grande Russet (AC89536-5RU), Colorado Rose (CO89097-2R), Mountain Rose (CO94183-1R/R), and Purple Majesty (CO94165-3P/P). Two selections, AC92009-4RU and NDC5281-2R, will likely be named in the near future, one is a fresh market selection with excellent tuber type and a long dormancy and the second has a bright red skin with a high percentage of B sized tubers.

Impact - Since 1975, there have been 16 potato cultivars and 5 clonal selections released by Colorado State University or in cooperation with other agencies. These materials accounted for 51% of the 12,813 acres of Colorado certified seed accepted for certification in 2005. Advanced Colorado selections accounted for another 4% of the seed acreage. Colorado State University releases accounted for 49% of the 58,200 acres of 2005 fall potatoes planted in Colorado. Of the Russet Norkotah fall potato acreage in Colorado, 52% was planted to Colorado Russet Norkotah Selections 3 and 8. Three of the top ten potato cultivars produced for seed in the U.S. were from the Colorado program. 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 2005. Many of these cultivars and clonal selections have significantly reduced nitrogen and fungicide input requirements.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Increasing health benefits of potatoes

Short Description - Previous research on biodiversity of antioxidant properties with Colorado

potatoes identified a number of advanced selections developed by the breeding program that are substantially higher in antioxidant content and free radical scavenging capacity. In order to sharpen the focus on putative active antioxidant phytochemicals, six cultivars that had previously been identified with diverse antioxidant properties were selected for analyses by LC/MS and HPLC. Two of these cultivars were also discovered to inhibit growth of two human mammary cancer cell cultures. Major glycoalkaloids and phenolic components in extracts from oven baked tubers, identical to those used in the cancer cell culture experiments, were identified and concentrations estimated from known standards. Concentrations of several specific compounds varied greatly among cultivars, as did our previous analytical estimates of antioxidant properties. Two major (alpha-chaconine, alpha-solanine) and two minor glycoalkaloids (solasonine and solandine dehydrodimer) were identified. Alpha-chaconine was slightly more abundant in all but Russet Nugget. One cultivar, Rio Grande Russet had double the content of all others, but this was well below federal and industry standards for newly introduced cultivars. The purple and red flesh pigmented cultivars Purple Majesty and Mountain Rose contained 3 to 4 times the content of three chlorogenic acid isomers, compared to Russet Burbank, Russet Nugget and Yukon Gold. Eight different anthocyanin pigments were identified in the purple flesh of Purple Majesty and six different anthocyanin pigments were identified in the red flesh of Mountain Rose. Yukon Gold had the lowest phytochemical content of all cultivars

Impact - Germplasm diversity for antioxidant traits provides opportunity for developing new specialty potato cultivars with potentially improved health attributes. These data provide the first comprehensive phytochemical composition of purple and red flesh potatoes, and suggest key components that may be candidates for additional studies. This study also provides data to support marketing of new cultivars with potential health benefits.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Improved cultivars of winter wheat for the Central Great Plains

Short Description - The objectives of the wheat breeding project are to a) develop wheat cultivars and germplasm having desirable agronomic and end-use quality characteristics and b) conduct basic research to improve understanding of genetic and environmental factors that affect wheat yield and end-use quality in Colorado. In fall 2005, one experimental line (CO00016) was advanced for Foundation seed production to enable release in fall 2006. CO00016 was developed from the cross CO940606/TAM107R-2 made in 1996. CO00016 is a white-chaffed, short semidwarf (similar height and heading date as Prairie Red) with excellent high temperature and drought stress tolerance. CO00016 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. In Colorado dryland variety trials, CO00016 has shown high yields, excellent yield stability, and average test weights (similar to Jagger and Yuma). CO00016 is currently in its fourth year of statewide testing. Across 21 dryland trial locations between 2003 and 2005, CO00016 has been the highest yielding entry in the trials, about 0.5 bu/a higher than Bond CL, 1.7 bu/a higher than Hatcher, 3.1 bu/a higher than Above, 4.1 bu/a higher than Avalanche, and 5.3 bu/a higher than Jagalene (the next five highest yielding entries following CO00016). CO00016 has also shown very good milling and bread baking quality characteristics based on testing in the CSU Wheat Quality Lab and the USDA-ARS Hard Winter Wheat Quality Lab (Manhattan, KS). In the breeding program, we continue to focus on several different research areas. Resistance to new Russian wheat aphid (RWA) biotypes continues to be used in the crossing program, both for forward (three-way crosses) as well as backcrossing into elite backgrounds. We completed the screening of 7,300 Iranian landrace selections for resistance to RWA biotype 2 with approximately 330 biotype 2 resistant accessions also showing resistance to RWA biotype 1. Approximately 155 accessions carry resistance to both biotypes; DNA molecular marker mapping populations are under development with at least 5 of these accessions. Three advanced experimental lines with resistance to RWA biotype 2 derived from Triticale performed well enough to justify advance to state variety trials in fall 2005.

Impact - Development of improved wheat cultivars serves the wheat industry in Colorado by reducing wheat production costs, reducing pesticide use, and providing improved marketing options. CSU-bred wheat cultivars account for nearly 60% of Colorado's 2.4 million acres (2005 crop) with the remaining acreage planted almost exclusively 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

Key Theme - Developing improved dry bean cultivars

Short Description - There is a need to provide dry bean producers and processors with updated information on cultivars and pest control to maximize economic return and reduce pesticide use. Research efforts focused on the introgression of genes for resistance to white mold into adapted pinto germplasm. We determined that a QTL for resistance from Andean common bean G-122 confers partial resistance to white mold. Mapping studies have detected four additional loci that are responsible for resistance to white mold. We have combined resistance from G 122 with genes from the related species Phaseolus coccineus. One pinto line is being increased for Foundation seed and release in 2006. Previously released pinto cultivars contribute to increased production (~5% statewide) and reduced use of pesticides (to control rust) in the High Plains region. Plant disease evaluations continued to focus on identifying sources of resistance to priority pathogens and their diseases, including rust, common bacterial blight, Fusarium wilt and white mold under greenhouse and/or field conditions. Experiments demonstrated that the conventional fungicide, thiophanate methl, applied in 46 to 2337 liters of water per hectare, provided very good control (84 to 96 %) of white mold, even after 5 days of incubation. A newer fungicide, boscalid, provided less control (39 to 93 %). Both fungicides were more efficacious when applied in 234 liters of water per hectare. Experiments demonstrated that Topsin and Endura provided very good control of white mold. Both fungicides provided 90 to 98% control when there was no simulated rain event post treatment regardless of the application gallonage. Analysis of weather data during the last 20 years has revealed associations between rust outbreaks and temperature and rainfall patterns. Late-season outbreaks of common bean rust in southwestern Nebraska during 2005 facilitated our forecast model validation. Epiphytic bacteria responsible for common bacterial blight were recovered from symptomless onion plants in fields cropped to dry bean the prior year, but not from fields cropped to a host other than dry bean. Crop rotation schemes may need to be altered to reduce survival of these pathogens in onion and dry bean cropping systems. Bacterial wilt was confirmed in dry bean samples submitted to our laboratory by collaborating scientists in western Nebraska during 2004 to 2005 and collected from infected plants in some Colorado fields during 2005. Efforts are underway to confirm identification, conduct pathogenicity trials in the greenhouse, and to evaluate cultivars and germplasm for effective sources of genetic resistance. Outreach efforts culminated in the release of the updated version of an international publication, Compendium of Bean Diseases, Second Edition

Impact - The dry edible bean crop contributes between $40 and $60 million in farm gate value to the agricultural economy of Colorado. 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 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 indicated that dry beans in the diet provided protection against mammary cancer in animal

studies.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Enhanced beef marketing

Short Description - On December 23, 2003, Bovine Spongiform Encephalopathy (BSE) was detected in an imported dairy cow in Mabton, Washington. A second domestic case of BSE was detected in Texas (June 2005). The Program in Meat Science thus allocated substantial effort to address marketing and food safety issues associated with discovery of BSE in the U.S., including a collaborative focus with the Federal government and trade organizations to restore U.S. beef exports. Food safety issues associated with Specified Risk Material (SRM) cross-contamination of beef was addressed by conducting three field studies; efforts in this area will continue in 2006. Pre- and post-harvest microbiological food safety continued to be emphasized, and several separate studies were conducted in 2005 in these regards. Red meat quality issues were addressed by extending efforts to characterize postmortem tenderness improvement for 18 beef carcass muscles, by researching the impact of Optiflex on beef quality, and by assisting the private sector and government with implementation of beef carcass instrument grading technology. Economic analysis of data from national consumer surveys evaluated consumer value of beef attributes. A 2003 survey was used to assess value of country-of-origin labeling (COOL) for meat products; consumers appear very concerned about food safety issues. Consumer WTP for Certified U.S. products was relatively low, but above expected implementation costs. Data from a 2004 survey were used to determine market segments for natural beef products; multiple segments of consumers exist that are likely to purchase natural beef, and different segments are motivated by different factors. One segment of consumers ranked importance of all production attributes lower than the sample average, while another segment appeared to be altruistic, ranking all production attributes such as no antibiotics significantly higher. The probability that a consumer would pay a premium for natural and regionally produced beef products was estimated and depends on purchase behavior/shopping location, stated importance of production attributes, and awareness/interest in private and civic agricultural issues. These studies illustrate the types of market research that are useful for beef producers seeking value-added marketing opportunities, and portray the types of consumers who are fueling the growth in natural meats in the U.S. Such market analysis can facilitate producers ability to effectively develop product concepts, labeling and promotional strategies targeted at the most receptive consumer segments.

Impact - Over time, food safety efforts have continued to generate reduced prevalence of food-borne pathogens on meat as documented by USDA-FSIS and CDC, and human prevalence of vCJD due to ingestion of contaminated beef remains extremely low globally. These results indicate the potential strength of production methods (and marketing of such quality differences) as product differentiation criteria. This research illustrates the type of market research that may be useful for beef producers seeking value-added marketing opportunities, and portrays the types of consumers who are fueling the growth in natural meats in the United States. Such market analysis can facilitate producers ability to effectively develop product concepts, labeling and promotional strategies targeted at the most receptive consumer segments, and illustrates that there is more than one type of consumer interested in purchasing products differentiated by sustainable production methods.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Improved genetic evaluation of beef cattle

Short Description - In the past, genetic evaluation of beef cattle often focused on traits for which data was easily collected. These traits were often indicator traits that were only indirectly related

to profitability of beef production such as birth weight. Using a developed approach for identifying the economically relevant traits (ERT), or more precisely, the traits directly related to a cost or an income from the production of beef, EPD have begun to be calculated for ERT. Efforts have also begun to evaluate methodologies for increasing the accuracy of those EPD related to the economically relevant traits. Some of these ERT include stayability, heifer pregnancy, and docility. These EPD and all others currently produced are based on data from individual animals. Unfortunately, EPD for the ERT related to costs of production in the feedlot phase are lacking. Therefore it is difficult for producers to accurately select sires that will produce offspring with lower costs of production in this phase where the primary expense is the amount of feed consumed by the animals. The lack of EPD for this sector of the beef industry stems from the difficulty associated with measuring individual feed consumption when labor costs dictate that animals be fed in a group, or pen, setting. This restriction results in data on pen average performance but not on individual performance. A simulation was employed to develop methods to better utilize this pen average performance data to generate EPD for selection of sires whose progeny will have lower overall feed consumption and in turn lower feed costs in the feedlot. Results showed that better predictions of genetic merit were obtained when progeny were grouped in pens by sire. Reductions in the number of animals per pen also resulted in more accurate EPD. Regardless, the information currently generated in a pen setting can be used to calculate EPD when individual animal information is not available and that even though accuracy of the EPD is reduced, selection can be almost as effective as when individual observations are available.

Impact - In 2004, over 32 million animals were harvested in the U.S. and on January 1, 2005 over 13 million cattle were on feed. The production and use of EPD for feed consumption could result in reduced costs of production for these cattle on feed and in turn improved profitability for the producers owning those cattle. If the average animal gains a total of 500 pounds in the feedlot and that gain costs 45 cents per pound, a 10 percent decrease in feed costs would result in a savings of over 20 dollars per head on feed resulting in a more efficient and profitable feedlot industry. For just those animals on feed January 1, this would potentially result in a total savings of 260 million dollars. Given the nature of genetic change, this progress could be maintained in perpetuity.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Improved methods for cryopreservation of bovine embryos

Short Description - Research has focused on two aspects of cryopreservation of bovine embryos via vitrification: simplifying procedures to make them practical and developing procedures that do not include animal products, such as proteins from blood. The latter circumvents possible problems with virus contamination. We have made considerable progress on both fronts. We have developed a simple procedure to vitrify embryos so that the containers (thin plastic straws) can be thawed on the farm and the thawed embryos transferred to the uterus directly without even seeing the embryos at this step. Preliminary results are very promising in terms of embryo survival and pregnancy rates. Dispensing with animal products in media also has been successful with no apparent decrease in efficacy. The vitrification procedure was successful in a single step of adding embryos to cryoprotectant followed by plunging the container into liquid nitrogen. While most embryos survived this process, nearly half did not, so a 2-step procedure of adding cryoprotectant was required, which still is fairly simple.

Impact - The simplified method of cryopreserving embryos has already 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

Key Theme - Textiles to mediate environmental hazards

Short Description - Objective 1: To improve protection and human factor performance of PPE through product development. Enzymatic treatment has gained considerable attention in recent years as a useful wet-processing tool to impart value-added properties to fabrics. Of the many enzymes that are used, cellulase is one of the most important because of its wide use in treatments such as bio-polishing to improve fabric smoothness and in bio-finishing to produce the worn look. The enzymatic action of cellulase on cellulose is a surface phenomenon that results in significant morphological changes in the treated fabrics. In the current study, cotton knit fabric was treated with cellulase and the effect of structural changes on Percent Cover and Ultraviolet Protection Factor (UPF) was examined. The fabric used was a bleached cotton T-shirt fabric (Weight 124 g/m2; Testfabrics, Inc.). The enzyme used was Cellulase (Cellusoft L; Novozymes NA, Inc.). Prior to enzymatic treatment fabric samples were subjected to boiling water treatment for 10 minutes. Enzymatic treatment was carried out under the following conditions: pH 4.8 (acetate buffer); liquor ratio 40:1; temperature 50C; enzyme concentration: 2 g/L; Agitation: 50 rpm and 80 rpm (VWR Scientific reciprocating water bath model # 1217); treatment time: 1h and 4h. Enzyme activity was terminated by boiling in distilled water for 10 minutes. Percent Cover was determined by image analysis using a stereo zoom microscope attached to a Windows XP-based PC and equipped with a CCD camera and below stage illumination (Model DM 143 Motic Instruments, Inc., Vancouver, BC). Software applications used for analysis included Photoshop (v7.0, Adobe Systems, Inc. San Jose, CA), ImageJ (v1.3, National Institutes of Health, Bethesda, MD) and a Photoshop plug-in to control the camera supplied by Motics standard software. UPF was measured using a labsphere UV Transmittance Analyzer. Results showed that enzymatic treatment increased the ultraviolet protective ability of the cotton knit fabric. Rate of agitation and duration of treatment were important parameters influencing the UPF values. Increasing the rate of agitation during enzymatic treatment results in higher increase in UPF values with correspondingly higher percent cover. After a 1h treatment, the UPF increased by 70% at 80 rpm compared to an increase of 54% at 50 rpm. Also, longer the enzymatic reaction, higher is the UPF value and percent cover. At 50 rpm, the UPF increased by 65% after a 4h treatment compared to an increase of 54% after an hour of treatment. The increase in UPF after enzymatic treatment is probably due to a decrease in porosity. Porosity is a measure of the degree of closed versus open space in a fabric and reflected in the values of percent cover. It may also be that enzymatic treatment by degrading and removing the protruding microfibrils leads to a more compact knit structure thereby making the fabric more opaque to UV radiation.

Impact - Enzymatic treatment has been shown to increase the ultraviolet protective abilities of a knit fabric. This is a hitherto unknown and unintended but welcome benefit of bio-finishing cotton fabrics. On-going studies are directed towards investigating the effect of post-enzymatic dyeing on UPF and percent cover. Other fabric constructions are also being studied to verify whether the results obtained for the knit fabric holds for other fabrics as well.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

CSU Program: Plant and animal production systems

Key Theme - Understanding aspen forest ecology

Short Description - Quaking aspen (Populus tremuloides Michx.) is an important component of forests of the west, but there has been concern that it is declining during the 20th century. Aspen is the primary deciduous canopy species amid expansive conifer forests and is highly valued as a critical component of ecosystem diversity. For over a century, fire suppression, increased

herbivory from wildlife and livestock, and the conversion of aspen stands to conifer stands for increased timber production have altered the distribution and abundance of aspen. Aspen regeneration dynamics including sprout production, growth, and clone size were measured to determine the effects of fire on small aspen clone persistence following a mixed-severity wildfire in the Black Hills, South Dakota. Four years post fire, 10 small, isolated aspen clones per low and high fire severity classes were compared with 10 unburned clones. Regardless of severity, fire did not cause an increase in the area occupied by individual aspen clones. Clones affected by high severity fire had the greatest suckering response producing an average of 31 930 sprouts per ha more than double the sprout density in unburned clones and 67% greater than the sprout density in clones affected by low severity fire. Sprout growth in high severity clones was 135% and 60% greater than sprout growth in unburned and low severity clones. The succession of these clones to more shade-tolerant ponderosa pine was delayed in clones affected by high severity fire as high severity fire caused significant pine mortality within and surrounding the clone, whereas, without further disturbance, pine encroachment and dominance will likely continue in clones affected by low severity fire.

Impact - Aspen provides pockets of diversity in an otherwise homogenous landscape. Therefore, maintaining and expanding the presence of aspen is often a management objective, and fire is increasingly becoming the preferred tool to carry out this objective. Logistical problems arise when prescribing a high severity fire in aspen, however. It is difficult under acceptable weather conditions to get fire of any intensity to burn though an entire clone. Combinations of mechanical pretreatment followed by moderate to high intensity prescribed fire can then be used to remove the aspen overstory and stimulate suckering . Results from this study indicate that successful regeneration of small aspen clones will require high severity fire, removal of invading pine within and surrounding the clone, and steps to control herbivory at the time of treatment. These steps will create conditions favorable to the long-term development and maintenance of small aspen clones.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Improved Decision Support System for beef production

Short Description - A prototype decision support system (DSS) accessible via the web (ert.agsci.colostate.edu) has been significantly enhanced. The system quantifies the productive and economic implications of using various sires within the context of a cow-calf system. It has been modified for routine use by seedstock producers and commercial ranchers. Sire information from the Brangus, Limousin, Red Angus, Salers, Simmental, Shorthorn and South Devon breed associations have been used to populate the database. Although producers can readily identify the economically relevant traits (ERTs) that impact their production systems, real-life selection decisions involve choosing among candidates that may be above-average for some attributes and below-average for others. Superiority or inferiority of a particular trait in this context is measured by expected progeny differences (EPDs). Such EPDs cannot be observed and are predicted from statistical analysis of pedigree and performance records. The resulting EPDs vary in their accuracy, reflecting the level of confidence that these values will not change when further information is collected. A method to account for possible change in EPDs has been developed using Monte-Carlo simulation procedures. The results will be used within the web system to quantify risk by generating the distribution of relative profit of alternative bulls. These distributions can be used to quantify the probability that one sire will be more profitable than another, and to report the associated increase (or decrease) in profitability. This allows users to discriminate, using their own attitude to risk, between sires that have identical EPDs but different levels of confidence associated with the EPDs. A further model to predict post-weaning (ie feedlot) performance from relevant EPDs in terms of time to finish, feed to finish and value at finish has been designed, and will in future be incorporated as a web-based tool along with the existing cow-calf production model.

Impact - Improved productivity by selection, equivalent to a 1 lb increase in weaning wt per

breeding cow is worth at least $20 million per year in perpetuity, given the national cow-herd comprising some 30 million cows. Such improvement does not necessarily imply an increase in industry output, as the progress may allow rangeland resources to be redirected to other uses, such as enhancing wildlife values or conserving riparian zones. The DSS will allow the value of annual genetic changes to be reliably quantified, providing decision makers with the tool to ensure that valuable selection opportunities are directed at improvement rather than simply change.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Recycling of compost on turfgrass

Short Description - Long-term over-application of manure to agricultural fields has increased nitrate and phosphorus contamination of groundwater and surface water along the South Platte River basin. Concerns about water quality issues and desire to maintain ecosystem sustainability have contributed to the increasing interest in composting manure and topdressing it on turfgrass. Following core cultivations, compost treatments (0, 33, 66, and 99 cubic meters per hectare) were topdressed onto established Kentucky bluegrass (Poa pratensis; cultivars Nuglade, Livingston, and Kenblue) in the field. In addition, a non-cultivated and no compost treatment was included. Topdressing compost at 66 and 99 cubic meter rates increased the overall quality of all three turfgrass cultivars by 10% for at least 12 weeks during the growing season, allowed the turfgrass to retain color in the fall and early winter, and increased the rate of spring green-up. During July and August, the 66 and 99 cubic meter rates increased clipping yields by 48 and 56 % higher clipping yields, respectively, over the control. No differences in rooting mass among treatments were detected in the 0-50 cm depth. Three 10-day dry down periods were imposed during the summers. During the dry down periods, compost treatment increased soil water content in the 15-30 cm soil depth 1-4 days into dry down and in the 0-15 cm depth 7-10 days into dry down. Compared to the control, compost applied at 66 and 99 cubic meters per hectare reduced turf canopy temperature by 1.2-3.3C 4-10 days into dry down, indicating a reduction in drought stress. Compost topdressing following core cultivation allowed Kentucky bluegrass to maintain acceptable turf quality 2-3 days longer during dry down periods. Our results suggest that compost topdressing may improve turf quality and shoot growth via its action as a slow release fertilizer and that topdressing after core cultivation is a management practice that could reduce turfgrass irrigation requirements.

Impact - The use of compost for topdressing of high-cut (2-3 inch mowing height) turf can improve quality (color, color retention, spring green-up), and may enhance drought tolerance and allow a reduction in irrigation requirement.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Developing a nuna popping bean

Short Description - The nuna bean, also referred to as a popping bean is an Andean subspecies, Phaseolus vulgaris subsp. nunas. When dropped into hot oil, boiled, or toasted the bean expands similar to puffed grains, but does not invert like popcorn. Nuna seeds are multi-colored and seed coat patterns vary, often resembling variations of miniature bird eggs. Popping beans are endemic to Bolivia, Ecuador, and Peru and may be the oldest of all the common beans. The first commercial nuna cultivar was released in Peru in 1996. Nunas have traditionally been produced at equatorial latitudes at high elevations (2,500 m). In the U.S, nunas would have an attractive market potential as a high protein snack food. A nuna variety, adapted to Colorado environments and produced in Colorado, would have tremendous potential as a new crop for farmers and as a new snack food for industry in Colorado. Because of their daylength requirements, Andean nunas grown in northern latitudes remain vegetative, do not flower, and,

thus, do not produce seed. A small research and development program was initiated in 1992, 14 years ago, at Colorado State University to develop nunas that were adapted for production in at least some if not many Colorado environments. Ten nuna lines (F10 generation) have been recently developed at Colorado State University in the Dry Bean Breeding Project and were increased during 2005 at the Western Colorado Research Center at Fruita. Average first flowering of the ten nuna lines occurred 49 days from planting and ranged from 47 to 52 days from planting. Average days from planting to harvest maturity for the ten nuna lines were 130 days and ranged from 124 to 137 days from planting. In 2005, the growing season at Fruita, Colorado was 199 days, while the average growing season is 181 days. Total seed production from these ten lines exceeded more than 20 kg. This quantity of seed will be sufficient to allow us to conduct limited yield performance trials in 2006. Popping characteristics of the ten popping lines have yet to be evaluated fully, however, recent popping evaluation shows excellent popping quality of these breeding materials.

Impact - Ten nuna (popping) bean lines have been developed by Colorado State University. These breeding materials show promise in yield and popping characteristics, but further development will be needed to improve disease resistance and shorten the number of days required from planting to reach maturity.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Improving dryland cropping systems

Short Description - This project's working hypothesis is: No till practices permit cropping system intensification beyond the standard wheat fallow (WF) system because no till improves capture and retention of precipitation. Results from this project from 1986 to 1997 showed that cropping systems with fallow every 3 or 4 years were superior to WF systems with 70% increases in annualized grain production and 25 to 40% increases in economic return. In 1998, the WF treatment was dropped and the 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 2002-2005, annualized grain yields were still greater for the WCF system compared to the WF system, but the increase was reduced to 30%. Annualized grain yield for the three and four year continuous cropping rotations have been similar to the WCF rotation, but the annual probability of a crop failure is greater for continuous cropping. There was no crop failure observed from 1998-2001 in the WCF system, while crops failed 18% of the time for the continuous cropping systems. During the drought period of 2002-2005, crops failed 20% and 42% of the time for the WCF and continuous cropping, respectively. In 2005, a hydrology study was initiated to evaluate runoff from the WCF, wheat-corn-millet (WCM), and perennial grass (G) systems on side-slopes at the Sterling and Stratton locations. In 2005, runoff at the Stratton location averaged 4.3 cm, 3.9 cm, and 1.8 cm for the WCM, WCF, and G systems respectively. This runoff occurred for high intensity rainfall events occurring from May through October. There was very little runoff at the Sterling location, where rainfall was below average and there were few rain events with high rainfall intensity. We have been evaluating alternative summer annual crops that would be profitable, break weed and pest cycles in the grass dominated systems, and have a short enough growing season to allow for timely wheat planting in the fall. We evaluated triticale and Austrian winter pea as potential winter annual forage crops. Triticale produced an average of 3,900 kg ha-1 of dry matter, while triticale pea mixture produced 3,200 kg ha-1 dry matter. Farmer interest in the dryland research continues to be strong as demonstrated by demand for dryland cropping systems information and by practice adoption rates. Farmers who attended a June field day at the Stratton site collectively manage 31,200 hectares and in the evaluation they valued the information presented at $25 ha-1 for an overall impact of $770,000 for this field day alone. 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 (wheat summer crop fallow), it means 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

Key Theme - Improving vegetable production systems

Short Description - Onion is a high cash value crop that is commonly fertilized with high N rates to maximize yield. In addition, the shallow-rooted onion requires frequent irrigations. In 2005, six N rates were applied (0, 45, 90, 135, 180, and 225 kg N/ha) to existing N plots previously cropped to corn (2000-2003) and chile pepper (2004). The N source was a polycoated urea with a 90 to 120 day release period which was applied prior to planting. The N main plots were split to allow irrigation by furrow (normal method) and by a drip system. At the end of the season, a total of 68 cm of irrigation water had been applied with the drip system and 244 cm with the furrow system. In the furrow-irrigated treatment, 127 cm ran off the end of the field for a net application of 117 cm. Total marketable fresh onion yield increased with increasing N rate in both systems, with less response of onion to N with the drip system compared to the furrow irrigation system. Significantly higher onion yields were obtained with the drip system. The percentage of the onion crop that was of colossal size (> 10 cm diameter) increased from 5% to 14% with increasing N rate, jumbo size (7.5-10 cm diameter) which made up 80% of the yield was not affected by N rate, and medium size (5-7.5 cm diameter) decreased from 14% to 5% with increasing N rate. Adjusted gross economic returns were greater with drip irrigation than with furrow irrigation. This work demonstrates that economic returns can be maintained by using the more efficient drip irrigation system for onion production rather than the inefficient furrow irrigation system. With the drip system, onion yields were maximized with a lower rate of N fertilizer and 72% less irrigation water than with the furrow irrigation system.

Impact - Onions are one of the most profitable and intensively managed crops for Colorado growers. In Colorado and other western states, water shortages have caused growers to examine more efficient methods of irrigation. Onion yields were maximized with drip irrigation using 72% less water and less nitrogen fertilizer than furrow irrigation. Overall, adjusted gross economic returns were greater with drip irrigation than with furrow irrigation.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

CSU Program: Pest management

Key Theme - Managing turf and ornamental diseases

Short Description - Snow mold diseases of turfgrasses are caused by a number of psychrophilic fungi but their frequency and distribution in Colorado has not been fully documented. Snow mold samples were systematically collected from courses located above 2,000 m altitude in north central, central, south central and southwest regions of the state. The most frequently isolated species on all courses (greater than 90 percent) was Typhula ishikariensis var. ishikariensis. Typhula incarnata, T. ishikariensis var. canadensis, and Myriosclerotinia borealis were also recovered at low frequencies (les than 5 percent). Pythium paddicum was isolated from a sample collected at Steamboat Springs and represents the first report of this oomycete in the Rocky Mountain region. Snow mold caused primarily by T. ishikariensis var ishikariensis was

controlled by applications of PCNB, or by combinations of chlorothalonil and QoI or triazole fungicides. Split applications in the fall did not enhance fungicide efficacy.

Impact - Pythium paddicum was first described on wheat in Japan and was subsequently reported in the Pacific Northwest on turfgrasses exhibiting snow mold symptoms. This is the first report of this oomycete in the Rocky Mountain region. Fungicide applications for snow mold control are an expensive but necessary management tool for golf course superintendents on golf courses with extensive winter snow cover. These studies show that several other fungicide combinations are as efficacious in controlling snow mold as PCNB, but may be more expensive.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Understanding cheatgrass ecology

Short Description - Bromus tectorum (cheatgrass, downy brome) is a problematic invasive annual grass species that has large impacts on plant communities and ecosystems. It has been implicated in increasing fire frequencies and intensities, which has resulted in its replacement of shrubs and perennial grasses, becoming the most ubiquitous weed in steppe vegetation in Western North America. The invasion of cheatgrass into high elevation sites throughout the west is a key problem that directly affects our ability to sustain ranching, forestry, and rural communities. Managers are concerned about losing valuable winter habitat for wildlife and grazing land for livestock in montane regions due to the invasion of cheatgrass. The purpose of this research is to develop effective control and mitigation techniques to restore montane habitats invaded by cheatgrass through increasing our understanding of the interactions between cheatgrass, native plant species, and the soil microbial community, especially arbuscular mycorrhizal fungi (AMF). In low nutrient environments, late-successional species with more dependence on AMF can take advantage of mycorrhizal associations to extract scarce resources and gain a competitive edge over early-successional species such as cheatgrass. Mycorrhizae are ubiquitous and easily colonize sites, thus the addition of mycorrhizal inoculum is generally not required. However, mycorrhizal inoculation may increase the competitive ability of highly mycorrizal dependent, late-successional plants in low nutrient environments. Two factorial greenhouse experiments were conducted to compare biomass of plant species with and without field soil and commercial inoculum treatments along a phosphorus (P) gradient, which ranged from ambient field levels to 12% of field levels, using dilutions of native soils. The two field soil inoculum treatments resulted in significant biomass differences for all species studied. Late-successional species responded positively to field inoculum, whereas, early-successional species responded negatively. The two commercial inocula had a low colonization rate (14 out of 166 inoculated plants). The commercial inocula substrates had significant treatment effects on five of the seven species included in the study in the apparent absence of mycorrhizal symbiosis. Soil P levels influenced mycorrhizal responsiveness in only one species, Aster laevis. Our results show that, at least for the species studied here, locally collected field inoculum is the best choice for re-establishment of late successional, native plant species. The implications of these results for management include: (1) Locally collected field inoculum is more effective than commercial inoculum for establishing late successional plant species, (2) Native species tend to respond better to commercial inocula that contain higher AM fungal species diversity compared with commercial single species inoculum, (3) AM fungal inoculation should not increase the spread of cheatgrass, (4) For many perennial native species, AM fungi may improve establishment and growth of native plant species regardless of the soil P levels.

Impact - Montane regions in the West are being invaded by cheatgrass, an invasive annual grass that has large negative effects on plant communities and ecosystems. Cheatgrass increases the frequency and intensity of fire, competes with native vegetation and alters soil microbial communities. It can compromise valuable grazing land for livestock and winter habitat for wildlife in montane areas. This research will help land managers effectively restore native plant communities and reduce the abundance of cheatgrass in invaded montane habitats.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Use of biological control for pest management

Short Description - Dalmatian toadflax (Linaria dalmatica, Scrophulariaceae) is an introduced weed, declared noxious by 11 states. This weed has become a significant problem species in a number of western states. This plant is common in mesic to xeric locations, but larger plants in higher densities are associated with a greater abundance of early spring water deposition. At a study area in southern Wyoming, Dalmatian toadflax is found in greatest abundance in portions of the landscape that experience higher winter snow deposition or higher water accumulation from snow melt (i.e. lower areas adjacent to snow deposition that accumulate spring run off). The stem-boring weevil Mecinus janthinus was introduced into the United States as a biological control agent for this weed in 1997, and has since become established in Washington, Montana, Idaho, Wyoming, Colorado and Oregon. Adults of this species feed on the leaves of the plant, but the majority of plant damage is attributed to larval feeding within plant stems. Dramatic impacts of the weevil on Dalmatian toadflax populations have been seen in some, but not all locations. The purpose of this research was to determine: (1) The impact of water availability on Dalmatian toadflax size and fruit production, (2) The impact of well watered vs. moderately vs. severely drought stressed plants on weevil survivorship and (3) The impact of weevil attack on well watered, moderately, or severely drought stressed plants. The impact of host-plant water stress on plant performance, weevil oviposition rates, and survival was studied. Beetles were caged on potted toadflax plants and given the choice between plants in each of three water treatments. The weevil had greatest impact on toadflax fruit production in high water treatment plants, but had greatest impact on stem production and plant weight in the intermediate water treatment. None of the plant performance variables measured significantly responded to weevil feeding in the low water treatment. Weevils preferred well-watered plants, but there was no significant impact of water treatment on weevil survivorship. These results indicate that the impact of this biological control agent on its host plant is context dependent, and varies with the amount of water available to the plant.

Impact - Biological control has at times provided spectacular control of noxious weeds. Not all biological control agents are effective, and not all effective agents are effective in all locations. This research will improve our understanding of under which conditions biological controls are most effective. In the present study, Mecinus janthinus was most effective under conditions that were most favorable to its host plant. These results will aid land managers in determining which control strategies are most appropriate for their site, and will aid in the selection of the most economically sound and environmentally appropriate management strategies.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Developing methods for tamarisk control

Short Description - Riparian wetlands in the arid and semiarid west have been seriously degraded by the invasion of tamarisk. In a relatively short period of time this shrubby tree has destroyed native wetlands in Arizona, Southern California, Colorado, New Mexico, Texas and has moved north into Montana. Tamarisk control and restoration of native communities are possible, but this process can be very expensive and can fail to achieve the desired management goal. Research to evaluate integrated control strategies and their impacts on restoration success has been initiated at three locations in Southern Colorado. It was found that the interception of aerial applied herbicide, imazapyr, was only about 60% resulting in significant amounts of herbicide reaching the soil. This can seriously impact the cost of control and the success of subsequent native community establishment. In addition, the mechanical removal of tamarisk without herbicide treatments resulted in significant tamarisk regrowth and the proliferation of another invasive species, downy brome (Bromus tectorum). The ease with which

one invasive plant species replaces another in these disturbed areas is a serious issue that will need to be address in any management plan. Analysis of soil samples for herbicide residue suggests that since the initial application in fall of 2004, the amount of herbicide present in the soil has decreased by almost an order of magnitude. Greenhouse bioassays studies indicate that a number of important native species will still be affected by herbicide residues of this concentration. Of the species tested, alkali sacaton (Sporobolus airoides) appears to be one of the most sensitive, while western wheatgrass (Pascopyrum smithii) is much more tolerant.

Impact - Land owners and land managers across the west now realize the enormous negative impact that tamarisk is having on riparian ecosystems. This research seeks to develop a database that provides land managers and landowners with information about probable outcomes of integrated pest management (IPM) strategies applied to various infestation types (high, medium and low density tamarisk) with varying levels of remnant native vegetation.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Improved methods for weed control

Short Description - In 2002, a 6 hectare project area to demonstrate the use of herbicidal, cultural and biological control methods was established across a variety of ecosystems including oak brush, irrigation ditch, riparian and a dead oak brush stand. Within each ecosystem, intensive grazing, beneficial insects and herbicide treatment plots were established with replication. Yellow toadflax (TF), musk thistle (MT), and canadian thistle (CT) are the primary populations being monitored in these plots using GPS/GIS technology. Data in 2002 was limited because of severe drought. In 2003 base plant population data was compiled and all treatments were applied. In 2004 and 2005, all treatments were reapplied and 15,880 data points identifying plant species were recorded. Grazing treatments were applied during early Summer in 2005 to increase the amount of stress placed on the primary weeds. We continue to observe significant ecosystem, treatment and ecosystem x treatment interactions in the control of MT, CT and TF. As often occurs with long term control methods, beneficial insect treatments are the slowest to impact all of the primary weeds. It is showing minimal overall progress (-3.0% and -.7 %) on CT and MT. None of the treatments are having an impact on TF populations. In fact, the populations in the beneficial insect areas continue to rise and are similar to the control data (17.5% toadflax). Herbicide treatments continue to have the most cumulative effect on CT and MT (-5.80 and -8.20 percent, respectively). The overall levels of these weeds in the herbicide areas are approaching eradication so we do not expect additional significant change. Cumulative results showed a 16.4% increase in Brome, Western and other native grasses since 2003. We will continue to collect plant data and apply treatments until 2007.

Impact - Applications of both low and high rates of herbicides have significantly reduced the population of Canadian and musk thistle in all of the ecosystems being studied. While Toadflax continues to be a difficult weed to control, herbicide treatments have begun to show progress. The increases in native grass populations indicate that these more desirable species can repopulate once weed infested areas.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Synthesizing invasive plant data for Colorado

Short Description - Colorado was used as a case study to develop an effective means of predicting interstate invasive species spread. Seven non-native plants were identified that are highly likely to invade Colorado, 18 with medium potential and 20 species with low potential to invade. The areas most at risk are rangelands, pasturelands and disturbed areas such as roadsides. To create this ranked list of potential invaders, information was compiled and analyzed about invasive weed species from numerous states and databases to ascertain which

species have the greatest potential to invade Colorado. A list of qualitative criteria and a quantitative risk assessment, which rates potential invaders based on distribution and abundance with respect to climate, biological characteristics, and preferred habitats of the species, were applied to a list of potential invaders. The approach provides a system to rank species based on their potential to have negative ecological and economic effects. This system can be applied to plants as well as other types of invasive organisms.

Impact - It is essential that we improve our ability to predict which non-native species will become invasive in order to prevent their introduction and spread. Early detection and eradication are our best tools to minimize the negative economic and ecological impacts of invasive species. Past attempts to predict invasions have met with limited success, but increased computing power, better availability of information about exotic species, and comprehensive evaluations of invasion potential should improve our ability to predict which species are likely to invade most successfully. Identifying where a potential species is likely to spread is critical to ensure that land managers can prioritize areas and species in their jurisdiction, saving them direct costs in their control measures.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Reducing insecticide use for termite control

Short Description - The fluorescent alkaloid norharmane has been isolated from Reticulitermes termites and characterized by H-1 NMR, UV/Vis, mass spectrometry, and gas chromatography/mass spectrometry. Norharmane was uniformly present at approximate to 1 ng/mg in Reticulitermes tibialis Banks workers, soldiers, and alates; Reticulitermes flavipes (Kollar) workers; and Reticulitermes virginicus (Banks) workers. Subterranean termites contend with substantial microbial disease pressure due to their soil habitat and social behavior, and the fluorescent alkaloid norharmane, known from several Reticulitermes spp., may be a critical defense in countering this pressure. Termite hemolymph containing norharmane and synthetic norharmanc at ecologically relevant concentrations both showed antimicrobial activity against the entomopathogenic fungus Metarhizium anisopliae (Metschnikoff). A qualitative survey of 18 termite genera showed universal norharmane presence. Norharmane was absent from five closely related taxa that were also analyzed. GC/MS analyses further showed that norharmane was biosynthesized as a metabolite from endosymbionts cultured in isolation from Reticulitermes tibialis and R. flavipes termites. Actinomycetes bacteria are likely candidates as the endosymbionts that biosynthesize norharmane, because they arc components of the termite gut and are the only microbes known to produce norharmane. Subterranean termites, Reticulitermes spp., were attracted to carbon dioxide (CO_2) in laboratory and field tests. In behavioral bioassays, Reticulitermes flavipes (Kollar), Reticulitermes tibialis Banks, and Reticulitermes virginicus Banks were attracted to CO_2 concentrations between 5 and 50 mmol/mol. In field tests, stations containing CO_2-generating baits attracted R. tibialis away from wooden fence posts at rangeland sites in Colorado. For all of the CO_2 formulations tested, termites foraged in significantly more bait stations at treatment fenceposts than in bait stations at the control fenceposts. CO_2 used as an attractant in current baiting systems could improve their effectiveness by allowing earlier exposure of termites to an insecticide. Amounts of the insecticide thiamethoxam required for 50% mortality of western corn rootworm larvae, Diabrotica virgifera virgifera LeConte, were reduced 100-fold when extracts of germinating corn, Zea mays L., were used to entice neonate larvae to feed on it. In behavioral bioassays, neonate rootworm larvae fed vigorously on filter paper disks treated with liquid pressed from corn roots. Larvae wandered away from filter paper disks treated with distilled water without feeding. For solutions containing 10 ppm thiamethoxam, 95% larval mortality occurred after 30 min of exposure when corn extract was present, but only 38% mortality occurred when the same concentration of insecticide alone (no feeding stimulants) was tested. Thiamethoxam did not deter larval feeding on corn extract, even at the highest concentration of thiamethoxam tested.

Impact - The discovery that termites are attracted to CO_2 can be used in the development of

improved monitoring and pest management techniques for termites. The finding that termites contain a high concentration of norharmane means that termites can be used as a model system to study the effects of the toxin norharmane in human health. The discovery that feeding stimulants allow a 100-fold reduction in the amount of insecticide required to control corn rootworms can be used to improve the environmental quality of agroecosystems.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Developing disease models to reduce pesticide use

Short Description - A series of laboratory and greenhouse experiments demonstrated that the conventional fungicide, thiophanate methyl, applied in 46 to 2337 liters of water per hectare, provided very good control (84 to 96 percent) of white mold of dry bean, even after 5 days of incubation. A newer fungicide, boscalid, provided less control (39 to 93 percent) in this series of experiments with different gallonages, but still offers a lot of potential for enhanced fungicide management for fugure IPM programs on dry bean and other crops that are affected by Sclerotinia sclerotiorum. Both fungicides were more efficacious when applied in 234 liters of water per hectare. These rates are typically associated with ground rig or low volume chemigation equipment; while rates less than 234 liters of water per hectare are typically associated with aerial equipment. Another series of experiments demonstrated that Topsin and Endura provided very good control of white mold, even after a simulated rain event of 0.635 mm and 5 days of incubation. Both fungicides provided 90 to 98 percent control when there was no simulated rain event post treatment regardless of the application gallonage. Collaborative research support provided by plant pathology to plant breeders has focused on the incorporation of various genetic resistant sources to white mold from common bean and seconday gene pools. Recombinant inbred lines have been developed have been mapped with molecular markers, and highly resistant selections are being advanced for future testing in the greenhouse and field.

Impact - Enhancement of disease forecasting programs, expanded knowledge of plant pathogen biology, and improved timing of pest surveys can reduce the number of pesticide applications (by 1 spray), grower costs (by 50 to 100 dollars per hectare), and environmental exposure (by 10 to 20 percent less pesticide) for producers of susceptible varieties of dry beans when threatened by white mold; approximately 20 percent of Colorado acreage. Foliar disease outbreaks from common bacterial blight can be reduced by 10 to 25 percent when onion and dry bean do not follow each other in a cropping cycle. In addition, 1 to 2 fewer applications of a bactericide can occur with a savings of 30 to 60 dollars per hectare and 10 to 20 percent reduced pesticide exposure to the environment for both dry bean (15 percent of the Colorado acreage) and onion (50 percent of the Colorado acreage).

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

Key Theme - Enhancing the competitiveness of vegetables

Short Description - Antioxidant properties of 17 samples of spinach, broccoli, green beans, kale, carrots, and rhubarb grown in Colorado were examined. The antioxidant properties of vegetable extracts were evaluated by their free radical scavenging activities against superoxide anion radical and cation radical ABTS. Chelating activity against Fe (II) and total phenolic content of each vegetable extract was also investigated. The results showed that all vegetables had significant antioxidant activities under experimental conditions and that these activities varied across different vegetables and within the same vegetable across harvest. Among vegetable

samples tested, kale exhibited the highest cation radical scavenging activity with 42-58 umoles Trolox equivalents/g and the highest total phenolic contents with 16.3-18.8 mg Gallic acid equivalents/g. Rhubarb showed the greatest anion radical scavenging activity which quenched 96.3 percent superoxide anion at 0.4 mg/mL. Broccoli had the highest chelating activity with 23.4-29.3 mg ETDA equivalents/g. Carrots possessed the lowest anion and cation radicals scavenging activity and showed the weakest chelating activity, as well as the lowest total phenolic contents. In a continuing lettuce cultivar study, eight specific cultivars, selected for promising antioxidant and production attributes, were grown at six different times over two growing seasons and analyzed for total phenolic content and vitamin C levels. Total phenolics, measured in mg gallic acid equivalents per g dry weight (mg GAE/g), varied significantly ($p<0.05$), from 13.09 mg GAE/g in iceberg to 48.2 mg GAE/g in red leaf. Mean total phenolic values of red-pigmented cultivars were more than 50 percent higher than values for green lettuce cultivars. Romaine and red leaf lettuce exhibited the highest vitamin C content, almost 2-fold higher than iceberg or red batavia. In a lettuce storage study, we evaluated the quality of green leaf lettuce untreated (control) or treated with water or 1 percent ascorbic acid solution applied by two hydrocooling methods (immersion and spraying). Waldmann's dark green leaf lettuce was grown using standard organic methods, harvested manually, rinsed 5 min in running tap water (20C), drained 10 min, then left untreated, or treated with tap water or 1 percent ascorbic acid applied by 2 min immersion or spraying (5C). Samples were drained 5 min, sealed in polyethylene bags and stored at 5C for up to 14 d. An untrained sensory panel evaluated the samples for appearance, color, flavor, bitterness, tartness, texture and overall acceptability after 1, 7 and 14 d storage using a 15 cm 5-point hedonic scale (15=acceptable). Treatment, storage time and treatment x storage were significant factors based on ANOVA. Ascorbic acid spraying was rated highest for overall acceptability (12.09 on d 1) and flavor (12.00 on d 1). The water spraying treatment scored lowest ($p<0.05$) in appearance and overall acceptability on d 14 (8.79 and 8.85, respectively). Further experimentation is needed on the application of ascorbic acid during hydrocooling to extend the shelf life of minimally processed lettuce while maintaining optimal quality.

Impact - This research verifies the occurrence of significant levels of phenolic and antioxidant compounds in Colorado grown vegetables including specific lettuce cultivars, demonstrating their potential to serve as good dietary sources of protection from oxidative stress and age-associated health problems such as cancer and heart disease. The assessment of cultivar differences and seasonal variation on antioxidant properties and nutrients contributes to the understanding of interactions between genetic and environmental factors which may influence total antioxidant activity and nutrient content. The identification of specific vegetables and cultivars that possess higher levels of dietary antioxidants may improve market competitiveness and benefit producers and consumers. The information collected from these studies will be useful in the development of outreach mechanisms to disseminate information to Colorado consumers on dietary antioxidants and their associated health benefits.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Enhancing safety of meat productes

Short Description - The meat industry is applying carcass washing and sanitizing treatments to reduce microbial contamination and achieve compliance with regulatory performance criteria and industry specifications. In addition to water, solutions of organic acids (lactic and acetic) are used as carcass decontamination interventions in the United States. However, a potential exists for survival and resistance development by Escherichia coli O157:H7 in environmental niches of meat plants applying carcass decontamination interventions. Studies were conducted to evaluate survival or growth of previously acid-adapted and nonadapted E. coli O157:H7 in acetic acid (pH 3.6) or in water (pH 7.2) beef decontamination runoff fluids (washings) stored at 4, 10, 15, or 25 degrees C. Cells recovered from the washings after 2 or 7 days of storage were also tested for resistance to a subsequent lactic acid (pH 3.5) stress. Acid-adapted cultures survived better than nonadapted cultures in acetic acid washings; survival was highest at 4 degrees C

and lowest at 25 degrees C. The pathogen survived without growth in water washings at 4 and 10 degrees C, while it grew by 0.8 to 2.7 log cycles at 15 and 25 degrees C; growth was higher in the absence of natural flora. E. coli O157:H7 cells habituated without growth in water washings at 4 or 10 degrees C were the most sensitive to pH 3.5, while cells grown in water washings at 15 or 25 degrees C were the most resistant, irrespective of previous acid adaptation. Resistance to pH 3.5 of cells habituated in acetic acid washings for 7 days increased in the order 15 degrees C less than 10 degrees C less than 4 degrees C, while at 25 degrees C cells died off. The results indicated that inhibition of growth of E. coli O157:H7 by storage at low temperatures may be more important than competition by natural flora in inducing acid sensitization in fresh meat environments. At ambient temperatures in meat plants, E. coli O157 H7 may grow to restore acid resistance, unless acid interventions are adequate to minimize survival and to inhibit its growth. Acid-habituated E. coli O157:H7 at 10 to 15 degrees C may maintain a higher acid resistance than when acid-habituated at 4 degrees C. These responses should be evaluated with fresh meat. The results may be useful for optimization of decontamination programs and conditions of meat handling. Overall, application of acidic decontamination interventions is useful in controlling E. coli O157:H7 in the meat industry but such treatments should be optimized for maximum effects and no potential contribution to acid resistance development. However, irrespective of decontamination interventions, fresh meat should be refrigerated promptly, followed by adequate cooking, to ensure safety and consumer health. Another study was designed to evaluate the influence of an acetic acid treatment before marination on inactivation of inoculated E. coli O157:H7 during drying of beef slices to produce jerky. The results demonstrated that application of the acetic acid treatment, not only enhanced E. coli O157:H7 destruction, but it may also be valuable in inactivating higher levels of contamination if present.

Impact - Escherichia coli O157:H7 remains a pathogen of concern for the meat industry as it may be transmitted through consumption of undercooked ground beef and affect children and immunocompromised individuals. Application of antimicrobial interventions to fresh and processed meat products should be based on procedures that achieve inactivation of the pathogen without leading to resistance development through selection or adaptation. The results of these studies provide guidance in the selection of carcass spray-washing and decontamination interventions as well as beef jerky marination treatments to maximize microbial reductions without causing resistance development.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Impact of seasonal patterns on food insecurity

Short Description - The seasonality and prevalence of food insecurity was evaluated among low income families with young children in rural southern Colorado, and to evaluate the relationship between food security status and child diet and growth. Families were asked to participate in two assessment visits, 6 months apart. The youngest child >/= 2 and <6 years old in participating families was identified as the index child for this study. Interviews have been conducted to assess household food security status, dietary intakes and child growth. Demographic, acculturation and food program participation data have also been collected. A total of ninety-nine families have completed an initial study assessment, and 71 (71.7%) returned approximately six months later for assessment of growth, diet and seasonal changes in food security status. The average age (+/-SD) for study children at the first visit was 3.7 y (+/-1.01) and 4.3 y (+/-0.96) at the second visit. Forty-four percent (n=44) of the children studies were male. The majority of families (n=71, 71.7%) identified themselves as being of Latino/Hispanic race/ethnicity. Others families identified themselves as being of Non-Hispanic White (n=19, 19.2%), American Indian (4, 4.0%), Asian (1, 1.0%) or Other (4, 4.0%) race/ethnicity. All dietary measurements were taken for the target child at each study visit and BMI was calculated. The average BMI (mass index, kg/M2) was 16.7 (+/-2.33) at visit one and 17.1 kg/M2 (+/-3.74) at visit 2. The average BMI percentile for age and sex was 59.3 (+/-30.88) at the first visit and 64.8 (+/-30.17) at the second visit. Most households (n=67,67.7%) were identified to be food secure at the first visit. At

the second visit, 76 households (76.8%) were food secure while 23 (23.2%) were food insecure. In relation to ethnicity, 25 (35.2%) Latino/Hispanic households were food insecure in the first visit and 17 (23.9%) were food insecure in the second visit. Among non-Hispanic White households, 4 (21.1%) were food insecure in the first visit and 3 (15.8%) were food insecure in the second visit. Of the 99 families evaluated for food security at two visits food security status did not change for 68 (68.7%); 56 remained food secure and 12 remained food insecure at both visits. Food security status changed for the remaining 31 families with 11 becoming food insecure at the second visit and 20 becoming food secure. Using data gathered for this high risk population, further analysis will be carried out to identify risk factors for food insecurity and its relationship to eating patterns and growth of children. Results will be useful in developing strategies to reduce food insecurity and adverse effects on child health and development.

Impact - In this high risk population, continued work is needed to identify risk factors for food insecurity and its relationship to eating patterns and growth. Results will be useful in developing strategies to reduce food insecurity and adverse effects on child development.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Interaction of diet and exercise on human health

Short Description - The purpose of this study is to determine whether or not Mexican Americans (MA, a group at high risk for insulin resistance and type 2 diabetes) in comparison to nonHispanic whites (NHW, a group at lower risk) experience similar improvements in insulin sensitivity in response to regular endurance exercise. In a preliminary analysis of our first 10 subjects studied in 2005 (more to be studied in future years), we have examined the effect of lowering dietary saturated fat to less than 5% of total energy intake and high intensity exercise intervention (40 minutes per day @ 70% VO2 max for 5 sessions in 7 days) on insulin sensitivity (Si) in MA and NHW adults. Pre- and post-intervention Si was measured using the frequently sampled intravenous glucose tolerance test using minimal model analysis in previously sedentary MA and NHW. We controlled for diet by providing all study volunteers with the same low saturated fat, whole food, energy balanced diet during the 7-day intervention. The diet/exercise-induced changes in Si were of similar magnitude in the MA than NHW (post-test Si, MA=11.8, NHW=12.2), with no post-test ethnic differences in Si following the short diet/exercise intervention. When examining another measure of insulin resistance, the homeostatic model for the assessment of insulin resistance (HOMA-IR), again the MA showed similar improvements to NHW in response to the diet/exercise intervention. The small sample size to date renders this study underpowered to definitively determine if the slope of improvement might actually be greater in MA than NHW.

Impact - The data to date suggests 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.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Impact of diet on obesity

Short Description - Central obesity, inflammation and insulin resistance are all risk factors for cardiovascular disease. Omega-3 fatty acids may counteract some of the effects of these risk factors in high risk individuals. The purpose of this study was to determine the effect of isocaloric changes in alpha linolenic acid (ALA 18:3n3), a plant based omega-3 fatty acid, on inflammatory factors including interleukin (IL-6), tumor necrosis factor alpha (TNF alpha), c-reactive protein (CRP), serum amyloid A (SAA) and insulin, glucose and insulin resistance measured by the

QUICKI index in abdominally obese males and females. As of December 2005, roughly 140 subjects have been screened and 84 subjects have completed the protocol (66 females and 18 males). Forty-one of these subjects served as controls and 43 were in the intervention group. All of the subjects have met with a research dietician weekly for 4 weeks to discuss their daily diet records. All subjects taking medications known to alter inflammatory factors or insulin/glucose were excluded. Fasting blood samples, DEXA scans and anthropometrics (body mass, waist circumference (WC) etc.) were taken pre and post intervention. The experimental group consumed 5% of their calories from ALA in the form of flaxseed oil capsules, otherwise they consumed their normal diet. The control group consumed their normal diet which contained about ~0.5% ALA. Based on dietary analysis the omega-6/omega-3 ratio was reduced to about 1.3:1 in the ALA group as compared to 9.5:1 in the control group. As expected neither BMI nor WC changed over the 4 week intervention. We did not find any significant changes in the inflammatory factors TNF alpha; IL-6; CRP, or SAA after the intervention nor did we see changes in fasting insulin, glucose or the QUICKI index. The red blood cell membranes were also analyzed for incorporation of these fatty acids and we found significant increases in ALA and the metabolites of ALA, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in the ALA group. This suggests compliance of the ALA group in taking the flaxseed oil capsules as well as conversion of ALA to the long chain fatty acids EPA and DHA which have both been shown to be associated with reductions in inflammatory factors.

Impact - Previous studies showing significant changes in these factors have primarily been among older, male, dyslipidemic subjects, this study suggests there are no beneficial effects of a 4-week ALA intervention on these inflammatory factors among young, healthy, overweight/obese subjects. The information we present at the conclusion of this study will help define guidelines for the consumption of plant-based omega-3 fatty acids in humans.

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

Key Theme - Understanding forest conditions in the Rockies

Short Description - 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. Exotic Species: We conducted several experiments to evaluate where invasive species are most successful in Colorado's Front Range. We found that the most important variable for predicting both exotic species richness was accessibility of the site from large population centers. Exotic richness increased with increasing human accessibility. We also found that successful invasion of cheatgrass (Bromus tectorum) increases nitrogen cycling, which may generate feedbacks leading to persistence of cheatgrass. B. 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. We cored a number of trees, which we are still aging at this point. The distribution of stem diameters indicates thus far that the number of stems younger than 40 years may be about 75% lower than the would be predicted by the pattern that developed over the previous 150 years.

Impact - The key impacts of our project include verification that the number of aspen stems established in the past 4 decades is probably much lower than would be expected based on historic trends. The paucity of new aspen trees probably relates to heavy browsing from elk, as

the weather patterns were not unusual during this period, and the incidence of fire remained low for the entire 20th Century.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Enhancing livestock grazing in riparian areas

Short Description - Livestock grazing on rangelands has the greatest impact of the various agricultural activities to water quality (suspended sediments) in rivers and streams in Colorado and Wyoming. Much of the nonpoint source (NPS) pollution from grazing originates from trampling on streambanks. However, little information exists on the ability of different species of vegetation to bind soil on streambanks and filter sediment. A mechanical hoof simulator and live steers were used to determine direct chiseling effects of hoofprints on streambanks. Surface soil cores were also taken to determine shear strength. Additionally, samples of roots of individual riparian species were collected to determine individual root strength. Data indicated that the steers did cause significant bank changes adjacent to the stream, but this effect was localized. Soil deformation was not significant a few meters away from the stream. Surface soil (0-10 cm) bulk density and shear strength increased as long-term grazing increased from livestock exclosures to 8 years grazing to long-term (40+ years) grazing. A comparison of soil shear strength for vegetated and non-vegetated areas showed that shear strength was 3 times greater in vegetated vs. bare areas in the top 10 cm of soil. Sedge (Carex spp.) dominated plant communities had greater shear strength compared with grass communities. As expected, root strength was directly related to root diameter. Greater root strengths were found for species of sedges, rushes, and willows than for grasses and forbs. Areas under continuous seasonal grazing had greater streambank stability than ungrazed areas when measured as shear force on soil samples removed from the intact soil profile.

Impact - Results from these studies suggest that grass-like (e.g. sedges, rushes) and willow plants provide greater streambank stability than grasses and forbs. Thus, grazing management that favors a diversity of life forms, including herbaceous and woody plants, is a recommended strategy to increase streambank stability and reduce NPS in montane riparian zones. For example, management systems that limit of amount time that cattle graze riparian zones in the late summer and fall can reduce impacts to willows. Our studies suggest that properly designed grazing systems can allow riparian systems to be grazed and still maintain high water quality.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Reuse of wastewater on turfgrass

Short Description - The increasing water shortage in the arid and semi-arid western US requires use of recycled wastewater when possible. Recycled wastewater has become a common water source for irrigating golf courses and urban landscapes, creating the need to study the effects of recycled wastewater irrigation on landscape plants and soils. We have collected and analyzed irrigation water, soil, turfgrass clippings, and ponderosa pine needle samples from 14 landscape facilities (7 were irrigated with recycled wastewater while the other 7 were irrigated with surface water). Soils (sampled to 11.4 cm) from sites where recycled wastewater was used for at least 4 years exhibited 0.3 units of higher pH and 200%, 40%, and 30% higher concentrations of extractable Na, B, and P, respectively. Compared to sites irrigated with surface water, sites irrigated with recycled wastewater exhibited 187% higher EC and 481% higher sodium adsorption ratio (SAR) of saturated paste extract. We found that some conifer trees suffer different degrees of decline after prolonged use of recycled wastewater, depending on species, soil texture, and the effectiveness of drainage system. The decline in Ponderosa pine is more associated with sodium accumulation than chloride accumulation. Pine needles collected from reuse sites exhibited 11 times higher Na content, 1.3 times higher chloride content, and 50%

higher B content than samples collected from the control sites. Tissue Ca level and K/Na ratio were negatively associated with needle burn symptoms, suggesting that calcium amendment and K addition may help mitigate the needle burn syndrome in ponderosa pine caused by high Na+ in the tissue. Findings of this project have prompted us to further to evaluate different management options in mitigating problems associated with water reuse in urban landscapes. In evaluating different mowing regimes on creeping bentgrass salinity tolerance, we have found that as mowing height decreased, creeping bentgrass exhibited reduced salinity tolerance. Declining salt tolerance under lower mowing heights is associated with carbohydrate depletion that reduces the plant's ability to produce osmo-protectants (such as reducing sugars), to exclude Na from shoots, and to selectively uptake and transport K. This work showed that a moderate increase in mowing height could help to improve the quality of creeping bentgrass growing under saline conditions.

Impact - This information is useful to landscape planners and managers to determine what should be monitored and 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 the water reuse practice. We have found that modification of common management practices (increasing mowing height, for example) can also be used to reduce the negative impacts of salinity on turf quality by enhancing the plant's ability to respond to elevated soil salinity.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Developing solutions to salinity problems in the Arkansas River valley

Short Description - In 2005, water table depth and salinity were routinely measured in 102 monitoring wells in the Upstream Study Region in the vicinity of La Junta, Colorado and in 110 wells in the Downstream Region near Lamar, Colorado. Water table elevations remained higher in 2005, indicating greater recharge to the water table due to increased irrigation water applications compared to the previous few years of drought. Preliminary results indicate average measured water table depths over the 2005 irrigation season of about 3.51 m and 4.01 m in the upstream and downstream regions, respectively. Average measured water table salinity over the season was about 3.1 dS/m (2740 mg/L) upstream and 4.8 dS/m (4260 mg/L) downstream. Surface-water salinity was routinely measured at about 100 locations in the Upstream Study Region, including 8 locations in the Arkansas River, and at about 100 locations downstream, including 6 locations in river. Typically, river salinity measured downstream was 2 to 4 times greater than that measured upstream. Soil water salinity was measured early and/or late in the irrigation season on 61 fields in the upstream area and on 79 fields in the downstream area in 2005. Average specific conductance in the soil water was 3.7 dS/m upstream and 5.6 dS/m downstream. Data gathered in 2005 on crop yields reveal reductions in corn and alfalfa yields for soil salinity levels exceeding 3 - 4 dS/m. About 54 monitoring wells and 21 surface water locations (including six along the river) were sampled for dissolved selenium (Se) in the downstream area. Analysis of data collected from April 2003 until July 2005 revealed a median Se concentration of 16.4 micrograms/liter in groundwater. Se concentrations measured in the river samples ranged from 4.2 to 23 micrograms/liter with median of 9.4 micrograms/liter, exceeding the Colorado standard. Seepage tests were conducted in five canals in 2005. Results from tests conducted over the entire life of this study indicate substantial seepage loss rates of about 0.5 to 7.4 cfs per mile in four canals tested upstream and about 0.2 to 6.6 cfs per mile in three canals downstream. Calibration of the enhanced regional-scale model of ground water flow for the Upstream Study Region began in June 2005. The enhanced model is first being calibrated for the period April 1999 to October 2001 and will be applied to simulate baseline and improved management strategies for the period April 1999 to October 2004. The model will also be applied downstream to simulate flow, salt transport, and Se transport. Progress was made in continued development and testing of GeoDSS, a spatial decision support model for predicting basin-scale impacts of alternatives for managing the irrigated stream-aquifer system of the lower

Valley, constrained by state water rights and interstate compact. The 'links and nodes' of the MODSIM flow and water allocation simulation model were successfully integrated in 2005 into a geographic information system format within the model. This allows storage reservoirs, river diversions, in-stream gaging stations, etc. to be displayed and accessed from a map of the lower Arkansas River.

Impact - This project strengthens the data foundation and the modeling tools needed to characterize water conservation, salinization, waterlogging, and pollutant loading problems in the lower Arkansas River Valley and to guide the search for answers. Results to date suggest that a variety of strategies are available that could (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) possibly reduce nonbeneficial consumptive use under fallow land. Advances in the development of a basin-scale spatial decision support model indicate that alternative water management options along the river will be able to be explored in terms of their impact on the timing, magnitude, quality, and spatial distribution of in-stream flows, diversions, and state-line flows.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Estimating carbon sequestration in 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 2005). A more advanced approach using the Century biogeochemistry model and Monte-Carlo based uncertainty estimates was implemented. It is estimated that US agricultural soils are sequestering around 60 million metric tons of carbon dioxide per year. Work has continued on drafting the 2006 IPCC National GHG Inventory Guidelines (Volume 4-Agriculture, Forestry and Other Land Use) which will be submitted for adoption 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. A project was developed 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 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 was released for public comment in June 2005 and is scheduled to be implemented in spring 2006. In addition, NRCS is planning to use COMET-VR in its 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. Working with NRCS to develop a national-level soil monitoring network in conjunction with the National Resource Inventory, 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

Key Theme - New tools to manage water in the South Platte watershed

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. The South Platte Mapping and Analysis Program (SPMAP) include 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. To meet the new needs voiced by water users, we have developed the Augmentation Accountant, a program which is now being prototyped, and we have enhanced the existing IDSCU program. The Augmentation Accountant is a data-driven tool that allows well water users in the South Platte to report to the State Engineer their augmentation requirements and to show how they have met these requirements. Farmers are required to replace the groundwater that is consumptively used in their fields. To assist farmers in calculation the amount of groundwater depletions, we have added the ability to use growing degree days to IDSCU. Growing degree days are a way to calculate the amount of heat that is accumulated during the season. Previously IDSCU was able to use only crop coefficients, which assume that crop growth is occurring over an ideal or typical season. Growing degree days are able to better take into account especially warm or cold seasons. Once the groundwater depletions are calculated, their impacts need to be linked to water supply information from reservoir releases, augmentation ponds, and augmentation wells. The result of these calculations is the net effect on the river for individual augmentation plans. The state of Colorado makes available the surface water flows for irrigation in a database called Hydrobase. This year the format of Hydrobase changed from Microsoft Access to SQL Server, so IDSCU was updated to read the new format. The amount of water from augmentation ponds that can be used for augmentation is a calculation that includes weather data, pond inflows, outflows, evaporation, and surface area. Currently the water commissioner distributes a spreadsheet that contains this information for each recharge site. We have created a preprocessor to help users automatically download weather data and add it to this spreadsheet as well as perform some of the other recharge calculations. To assist water users in creating their reports in a timely manner, we have created a website, (http://animas.engr.colostate.edu/aug/index.psp) for disseminating augmentation plans of various groups in the South Platte.

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. As a credible impartial party in water issues, the project is able to develop methodologies and software, that builds consensus on water issues and prevents 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

Key Theme - Minimizing antibiotics in aquatic systems

Short Description - The goal of this project is to determine the occurrence and assess the fate of several classes of antibiotics in concentrated animal feed operation(CAFO) waste lagoons. The objectives include developing a database on the occurrence of at least three classes of antibiotics (10 individual) in cattle and swine CAFO waste lagoons. We will also simulate in the lab aerobic and anaerobic lagoons and determine the fate of at least 10 individual antibiotics under each of these conditions. In addition, we will measure antibiotic resistance genes that

correspond with the antibiotics and provide guidance on the design and operation of a waste lagoon for minimizing release of antibiotics. Measurement of relatively low concentrations of complex organic compounds in manure and lagoon water matrices is challenging. Methods that combined liquid-liquid extraction (LLE), solid-phase extraction (SPE), liquid chromatography (LC) and tandem mass spectrometry were developed for quantifying three classes of antibiotics in manure and lagoon water matrices. The antibiotics that were measured included five tetracyclines (tetracycline, oxytetracycline, chlortetracycline, doxycycline, and democlocycline, six sulfonamides (sulfathiazole, sulfamerazine, sulfamethazine, sulfachloropyridazine, sulfamethoxazole, and sulfadimethoxane and three macrolides (tylosin, erythromycin and roxythromycin). The waste stream from 25 animal feed operations (swine, beef, dairy, sheep, poultry) was sampled for either manure, lagoon water or both. The results of the occurrence survey indicates that a wide range of antibiotics are present in most animal waste streams, either runoff ponds, waste lagoons or manure. The individual antibiotic results varied widely. For example, tylosin was found in all but four waste lagoons sampled (an occurrence rate of 84%) but erythromycin and roxythromycin were found in only 36% and 10% of the lagoons sampled. Tetracycline (occurrence rate of 96%) and sulfadimethoxane (occurrence rate of 44%) were the most common compounds in their classes. The concentrations of the antibiotic compounds also varied significantly (from non-detect to over 23 mg/L of a tetracycline in a swine lagoon). The wide range of concentrations seems to indicate that feed practices along with waste management procedures can significantly impact the fate of antibiotics in the waste stream.

Impact - This project will provide information on what concentrations of veterinary antibiotics are present in the CAFO lagoons found in Northeastern Colorado. We have already documented the occurrence of these compounds in rivers in the area and we are attempting to locate the ultimate source. The second part of the project will determine the optimal approaches for operating waste lagoons to maximize biodegradation of these compounds, resulting in developing guidance in the form of Best Management Practices.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Reducing phosphorus loss of soil applied manure

Short Description - Very little research exists evaluating the relationship between soil test phosphorus (STP) and runoff P in calcareous soils. The objectives of this study were to determine soil series specific relationships between STP and runoff P for three calcareous soils, to compare the use of different soil extractants for runoff P prediction from calcareous soils, and to evaluate the impact of calcium carbonate levels on the STP-runoff P relationship. Three sites were selected, one each in Colorado, Nebraska and Kansas, with calcium carbonate amounts ranging from 1-9% in the surface horizon. Eight manure rate treatments were established with two replications in a randomized complete block design. The manure was rototilled into the soil, and all residues were removed. Prior to rainfall simulation, three soil samples were taken for Olsen P, Mehlich-3, and water-soluble P analysis. Rain was applied to 1.5 x 2 m plots at a rate of 8.3 cm/hr for 90 minutes (three consecutive 30 minute periods), and runoff samples were taken every 5 min. Mehlich-3 and Olsen extractants resulted in better correlations with runoff P than water-soluble P. The Mehlich-3 extract consistently resulted in the highest R2 values across all three soil types. The available soil P responded differently to the P added as manure on the different soils. In particular, the slope of the line (change in Mehlich-3 per unit change in P added) was significantly lower for the Kim soil (9% $CaCO_3$) than for the other soils. On average, the Rosebud and Wagonbed soils experienced an increase of 0.35 mg/kg Mehlich-3 STP for every kg/ha increase in P added, while the Kim soil only increased by 0.02 mg/kg Mehlich-3 STP. There was no difference in the intercepts of the lines. The high $CaCO_3$ soil (Kim) had lower Mehlich-3 levels at the same amount of P added, apparently due to the P being bound to Ca in forms that were unavailable to plants. The relationship between total dissolved P in runoff and Mehlich-3 STP also differed significantly by soil. Again, the intercepts of the lines were not different, although the slopes were different. The slopes ranged from 0.0004 in the Kim soil (9% $CaCO_3$) to 0.0007 in the Wagonbed soil (4% $CaCO_3$) and 0.0022 in the Rosebud (1% $CaCO_3$).

As soil CaCO3 level increased, the total dissolved P in runoff decreased at the same STP level. Next, we developed a multiple regression to predict the total dissolved P in runoff as a function of Mehlich-3 STP and CaCO3. The regression has an R2 value of 0.92 and $p<0.0001$. A similar equation was developed using Olsen P, but the R2 value was only 0.81. Therefore, we recommend the use of Mehlich-3 for the prediction of runoff P from calcareous soils.

Impact - The higher the percentage of calcium carbonate in the soil surface layer, the less dissolved phosphorus ran off the field at the same soil test phosphorus level. This research indicates that soils with higher amounts of calcium carbonate are better suited to be sinks for excess P in manure. When producers are making decisions about where to apply manure, soil CaCO3 level is an important consideration. Surface water quality can be protected by choosing to apply manures to soils with higher CaCO3 contents (everything else being equal).

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

Key Theme - Community-based collaboration in natural resource management

Short Description - Community-based collaboration in natural resource management (CBNRM) is a rapidly increasing phenomenon, yet little is known about the ecological and social outcomes of collaboration. Adaptive management (AM) is also growing in popularity as an approach to natural resource planning, yet few simple guidelines exist to help agencies incorporate AM into planning and management. This project seeks to improve techniques for evaluating the outcomes of CBNRM and to develop, test, and evaluate processes to help agencies and communities implement AM. In 2005, we completed a survey of 10 CBNRM groups in Northwest Colorado to determine whether and how collaboration increases social capital within collaborative groups and local communities. Social capital (SC) refers to social networks and relationships of trust and reciprocity that help individuals, groups, and communities accomplish their goals. We also developed, pilot tested, and evaluated a collaborative adaptive management process with one CBNRM group, the Northwest Colorado Stewardship (NWCOS). Survey results show that while SC increased in most of the groups surveyed, it declined in some. Listening and respect were the foundations of strong SC, and the greatest increases in SC were between collaborative groups and natural resource agencies. We also learned that maintaining SC takes constant work, and that factors that contribute to strong SC include: participant commitment to and continuity of participation in a group; understanding, empathy, and respect; transparency in group process and communication; and dependability and predictability in relationships among participants. Group characteristics associated with the greatest levels of SC were: participant perception of group success, initial levels of SC among group members, low levels of conflict, and the group activeness. Our pilot test of a collaborative adaptive management process and implementation of an associated community-based monitoring project led to increased knowledge and understanding about adaptive management among NWCOS members. It also identified a number of key constraints to implementing adaptive management at the Resource Management Plan (RMP) level in the BLM, including institutional barriers such as the NEPA process, and the reluctance of agency staff to include learning as an explicit objective of adaptive management. This research highlighted the different definitions and perceptions of adaptive management held by agency staff, community members, and various resource interest groups.

Impact - Our survey of social capital in collaborative groups provides a self-evaluation tool for collaborative groups and a replicable survey instrument for other researchers. The survey findings have important implications for groups that want to know how to build strong relationships among their members. This survey also shows that natural resource management agencies benefit greatly from collaboration in terms of increased respect and trust from members of the public involved in these efforts. Our pilot test of collaborative adaptive

management provides other agencies and CBNRM groups with step by step guidelines for developing an adaptive management plan. Citizen participation in the community-based monitoring project has built community capacity for ecological monitoring, and will provide baseline data for future monitoring and research on off highway vehicle impacts on cool desert soils and vegetation.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Economics of mitigating salinity problems in irrigated agriculture

Short Description - Adoption of technically efficient irrigation systems can mitigate the effects of drought by allowing irrigators to maintain water consumption with reduced applications. Data from a survey of drought response conducted previously by this project was analyzed to examine how drought conditions affect the choice of irrigation system by irrigators. Results indicate that drought conditions did significantly increase the percentage of farms using more efficient sprinkler systems relative to gravity systems. The key factors affecting the decision were land tenure, farm scale and available water supply, suggesting that those enterprises with the most owned land, the highest number of acres and the most reliable water supplies are most likely to invest in more efficient irrigation systems during severe droughts. Research also continued in evaluating the adoption of higher efficiency irrigation systems as an alternative for reducing the impact of waterlogging and salinization within a region of Colorado's Lower Arkansas River Valley. A detailed hydrologic model, which has been calibrated from extensive field data for a three-year period, was linked to an economic optimization model to estimate the productivity and profitability of agriculture under current irrigation technology and a set of proposed alternative systems. Although the results of the study indicate that increasing irrigation efficiency across the study area will reduce the negative impacts of waterlogging and soil salinization, the costs associated with achieving these higher efficiency irrigation systems were estimated to exceed the benefits to crop productivity. Although the costs associated with reducing aquifer recharge through improved irrigation efficiency were greater than the benefits to productivity, these alternatives were also found to reduce salt load to the river. Future research could evaluate the downstream benefits of reducing salt loads to the river to determine whether the inclusion of these benefits might justify the expense of increasing irrigation efficiency within the study area. In addition, the ability to estimate the benefits of these alternatives beyond three years may reveal further insights. If longer-term hydrologic modeling predicted the baseline conditions to further degrade over time given no action, the benefits associated with each alternative may be expected to increase significantly.

Impact - Waterlogging and salinization have contributed to the demise of ancient civilizations and continue to threaten the sustainability of irrigated agriculture today. The study in the lower Arkansas River Valley shows that reductions in aquifer recharge from ten to fifty percent would be expected to increase annual net returns in the region from $5.81 to $17.28 per acre, respectively. For the study area alone, this can amount to more than one million dollars annually. Unfortunately, these returns cover only about two thirds of the current cost estimates of the means used to achieve the reduction.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Innovations in fruit and vegetable marketing

Short Description - Many of the marketing and consumer analysis methods used for other products are being applied to fruit and vegetable crops, with new projects in the wine industry, specialty crops and with alternative marketing channels. Projects integrate some focus on the marketing channels used by producers to sell their products. The willingness was determined of consumers in New England to pay a premium for local specialty food products as opposed to a

perfect substitute imported from out of state. A small premium of 9-20 percent of the base price was identified for the local trait in each of three states (ME, VT, and NH), which could be used by the local labeling programs to recoup program expenses. Although the premia did not differ statistically between the study regions, there is anecdotal evidence suggesting that differing marketing programs affect the magnitude and distribution of the additional willingness to pay.

Impact - Research for the wine industry will be used to assess the feasibility of cooperative crush facilities on the Western slope, guide business planning by wineries and help with strategic market planning for the whole industry. This type of analysis should allow them to continue with the 100% growth in market share the industry has experienced in past years. Targeted marketing analyses represent a high profile impact to producers and industry associations (wine) throughout the state.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Theme - Use of valuation research in natural resources

Short Description - Public agencies often need economic valuation information about recreation visitors, homeowners and general public support or opposition to natural resource management policies, such as forest fuels reductions to decrease wildfire rise. 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 how transferable are the economic values of visitors and residents from one geographic area to another. Research published this year provides databases and 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 and recreation benefits provided by public lands. Our research has demonstrated that there is an overall positive willingness to pay for forest fire prevention activities such as prescribed burning and mechanical fuel reduction. There also appears to be some limited transferability of willingness to pay estimate across the western states of California, Colorado, and Montana. Updated recreation use values for state and federal lands throughout the U.S. was summarized and a spreadsheet database posted to the USDA Forest Service website to allow individuals with all government agencies to find studies and economic values of comparable recreation use activities. 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.

Impact - Our valuation research and benefit transfer research is being used by state and federal agencies as well as non-profit organizations for their economic analyses throughout the U.S. For example, the Colorado Mountain Club and The Wilderness Society are relying upon our research in their suggestions to the USDA Forest Service and Bureau of Land Management on how these agencies should analyze economic effects of roadless areas and public land management in Colorado. The article on non-market valuation in the American Agricultural Economic Associations publication called Choices was downloaded more than 2,500 times within the first month of its appearance on the Associations website. All of 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

Key Theme - Rural communities and labor markets

Short Description - An economic impact analysis of the Colorado wine industry was initiated in

2005, including tourism and marketing aspects. This study was partly motivated by the positive response we received from the golf economic impact study, and is a nice step into the department's stronger focus on agritourism as a community resource development strategy. Work continues to work on direct marketing and local food systems, focusing on their connections to increasing value-added activities by farmers and ranchers, as well as analyzing consumer interest in Colorado food products. The primary focus during this year was on natural meat marketing strategies based on consumer segmentation, agritourism based analysis and studies of how different agricultural portfolios may affect the financial performance of Western US counties. We were part of a California project that used a partial budgeting approach to estimate the potential economic and environmental impacts of the adoption of genetically modified (GM) rice cultivars in California. Although currently not commercially available, this research suggests that a production strategy including GM rice varieties could lead to significant economic benefits for many growers in the short run, with the benefits accruing primarily to those growers experiencing substantial weed resistance and those constrained to use certain chemical agents as a result of state or national regulations. In addition, water quality degradation is not likely to increase with GM rice adoption as input substitution would lead to lower overall chemical application rates with less toxicity than many chemicals currently applied.

Impact - Research for the wine industry will be used to justify continuance of the Colorado Wine Industry Development Board, guide future tourism promotion efforts by the industry and Western slope communities and motivate discussions with the Colorado tourism development Board to secure funding for agricultural-based tourism enterprises. Targeted marketing analyses represent a high profile impact to producers and industry associations (wine) throughout the state.

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 Activitie

The following are selected examples of the interactions occuring within the multi-state program conducted at Colordo State University. CSU faculty are actively engaged in a range of multi-state reseasrch and integrated etension 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.

Calcium nutrition - Osteoporosis is the most readily identifiable health issue associated with inadequate calcium intake. Obtaining sufficient calcium during adolescence helps ensure adequate mineralization of the skeleton to ensure bone health late in life. A multi-state project involving 13 states is actively examining parental factors (knowledge, attitudes, behaviors, environment) and their influence on calcium intake fo children in early adolescence (11-14 yoa) from race/ethnic groups most at risk for osteoporosis. 206 interviews were competed with parents of preadolescents (16 in Colorado; half with Hispanic parents). Colorado coded all transcripts, using NVIVO software, and is coordinating the analysis of the interviews. Initial analyses is being used to develop a parent motivator/barrier questionnaire to assess parental influences on calcium intake of parents and their children and 2) education messages and formats. The qualitative data base will provide detailed information on understudied populations. The validated questionnaires developed for this project will benefit future research with these populations as no comparable tools exist.

Bark beetle infestation - Problem: Recent fires in the Black Hills of South Dakota have led to eruptive populations of wood borers. Large populations prompted questions ranging from which species of wood borers are present, which traps and chemical attractants capture the largest number of wood borers to be able to monitor populations, what tree conditions are preferred by wood borers and are mountain pine beetle-infested trees and fire-killed trees colonized at different rates? Study methods: To develop monitoring techniques for wood borers in ponderosa pine in the Black Hills, two trap designs and four chemical attractants were tested and species determined in burned areas. Modified panel and funnel traps were tested in combination with chemical attractants including the wood borer standard (ethanol and X-pinene), standard plus 3-carene, standard plus

U.S. Department of Agriculture
Cooperative State Research, Education, and Extension Service
Supplement to the Annual Report of Accomplishments and Results
Integrated Research and Extension Activities
Five Year Fiscal Plan Summary

Institution **Agricultural Experiment Station**
State **Colorado**

Check one: ____ **Multistate Extension Activities**
_X_ **Integrated Activities (Hatch Act funds)**
____ **Integrated Activities (Smith-Lever Act Funds)**

	Actual Expenditures				
Title of Planned Program/Activity	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**	**FY 2005**
Plant and animal improvement and new agricultural development.	$177,681	$330,514	$190,424	$204,387	$114,245
Plant and animal production systems	$100,476	$66,126	$162,713	$179,008	$153,236
Safe and effective management of pests	$95,173	$85,213	$72,190	$159,451	$ 64,720
Food Safety and Nutrition	$65,911	$109,872	$128,882	$111,040	$ 78,928
Agriculture and environmental quality	$76,823	$57,782	$131,378	$232,959	$227,774
Rural and community development	$81,699	$493	$18,605	$ 590	$ 20,778
Total	$597,763	$650,000	$704,192	$887,436	$659,681

/s/ Lee Sommers — May 13, 2006

Director — **Date**

Form CSREES-REPT (2/00)

FY 2005 Annual Summary Report

Colorado State University
Agricultural Experiment Station

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

In the area of improved potato cultivars - Colorado State University releases accounted for 49% of the 58,200 acres of 2005 fall potatoes planted in Colorado. Of the Russet Norkotah fall potato acreage in Colorado, 52% was planted to Colorado Russet Norkotah Selections 3 and 8. Three of the top ten potato cultivars produced for seed in the U.S. were from the Colorado program. Many of these cultivars and clonal selections have significantly reduced nitrogen and fungicide input requirements.

In the area of increasing health benefits of potatoes - Germplasm diversity for antioxidant traits provides opportunity for developing new specialty potato cultivars with potentially improved health attributes. These data provide the first comprehensive phytochemical composition of purple and red flesh potatoes, and suggest key components that may be candidates for additional studies. This study also provides data to support marketing of new cultivars with potential health benefits.

In the area of improved winter wheat cultivars - Development of improved wheat cultivars serves the wheat industry in Colorado by reducing wheat production costs, reducing pesticide use, and providing improved marketing options. CSU-bred wheat cultivars account for nearly 60% of Colorado's 2.4 million acres (2005 crop). Average wheat grain yields in Colorado have more than doubled with at least 50% of this increase attributed to improved cultivars.

In the area of improved dry bean cultivars - 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 are produced on approximately 40% of the acreage in the state and have increased yield by 5 to 10% over cultivars they replaced.

In the area of enhanced marketing of beef - This research illustrates the type of market research that may be useful for beef producers seeking value-added marketing opportunities, and portrays the types of consumers who are fueling the growth in natural meats in the United States. Such market analysis can facilitate producers ability to effectively develop product concepts, labeling and promotional strategies targeted at the most receptive consumer segments, and illustrates that there is more than one type of consumer interested in purchasing products differentiated by sustainable production methods.

In the area of improved genetic evaluation of beef cattle - The production and use of EPD for feed consumption could result in reduced costs of production for these cattle on feed and in turn improved profitability for the producers owning those cattle. For just those animals on feed, this would potentially result in a total savings of 260 million dollars per year. Given the nature of genetic change, this progress could be maintained in perpetuity.

In the area of methods for cryopreservation of bovine embryos - The simplified method of cryopreserving embryos has already 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.

In the area of textiles mediating environmental hazards - Enzymatic treatment has been shown to increase the ultraviolet protective abilities of a knit fabric. This is a hitherto unknown and unintended but welcome benefit of bio-finishing cotton fabrics. On-going studies are directed towards investigating the effect of post-enzymatic dyeing on UPF and percent cover. Other

fabric constructions are also being studied to verify whether the results obtained for the knit fabric holds for other fabrics as well.

CSU Program: Plant and animal production systems

In the area of understanding aspen forest ecology - Aspen provides pockets of diversity in an otherwise homogenous landscape. Therefore, maintaining and expanding the presence of aspen is often a management objective, and fire is increasingly becoming the preferred tool to carry out this objective.

In the area of improved Decision Support System for beef production - The Decision Support System will allow the value of annual genetic changes to be reliably quantified, providing decision makers with the tool to ensure that valuable selection opportunities are directed at improvement rather than simply change.

In the area of recycling of compost on turfgrass - The use of compost for topdressing of high-cut (2-3 inch mowing height) turf can improve quality (color, color retention, spring green-up), and may enhance drought tolerance and allow a reduction in irrigation requirement.

In the area of developing a nuna popping bean - Ten nuna (popping) bean lines have been developed by Colorado State University. These breeding materials show promise in yield and popping characteristics, but further development will be needed to improve disease resistance and shorten the number of days required from planting to reach maturity.

In the area of improving dryland cropping systems - 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.

In the area of improving vegetable production systems - Onions are one of the most profitable and intensively managed crops for Colorado growers. In Colorado and other western states, water shortages have caused growers to examine more efficient methods of irrigation. Onion yields were maximized with drip irrigation using 72% less water and less nitrogen fertilizer than furrow irrigation. Overall, adjusted gross economic returns were greater with drip irrigation than with furrow irrigation.

CSU Program: Pest management

In the area of managing turf and ornamental diseases - Pythium paddicum was first described on wheat in Japan and was subsequently reported in the Pacific Northwest on turfgrasses exhibiting snow mold symptoms. These studies show that several other fungicide combinations are as efficacious in controlling snow mold as PCNB, but may be more expensive.

In the area of understanding cheatgrass ecology - Montane regions in the West are being invaded by cheatgrass, an invasive annual grass that has large negative effects on plant communities and ecosystems. This research will help land managers effectively restore native plant communities and reduce the abundance of cheatgrass in invaded montane habitats.

In the area of use of biological control for pest management - This research will improve our understanding of under which conditions biological controls are most effective. Results will aid land managers in determining which control strategies are most appropriate for their site, and will aid in the selection of the most economically sound and environmentally appropriate management strategies.

In the area of developing methods for tamarisk control - Land owners and land managers across the west now realize the enormous negative impact that tamarisk is having on riparian ecosystems. This research seeks to develop a database that provides land managers and landowners with information about probable outcomes of integrated pest management (IPM) strategies applied to various infestation types (high, medium and low density tamarisk) with varying levels of remnant native vegetation.

In the area of improved methods for weed control - Applications of both low and high rates of herbicides have significantly reduced the population of Canadian and musk thistle in all of the ecosystems being studied. While Toadflax continues to be a difficult weed to control, herbicide treatments have begun to show progress. The increases in native grass populations indicate that these more desirable species can repopulate once weed infested areas.

In the area of synthesizing invasive plant data for Colorado - It is essential that we improve our ability to predict which non-native species will become invasive in order to prevent their introduction and spread. Early detection and eradication are our best tools to minimize the negative economic and ecological impacts of invasive species.

In the area of reducing insecticide use for termite control - The discovery that termites are attracted to CO2 can be used in the development of improved monitoring and pest management techniques for termites. The finding that termites contain a high concentration of norharmane means that termites can be used as a model system to study the effects of the toxin norharmane in human health.

In the area of developing disease models to reduce pesticide use - Enhancement of disease forecasting programs, expanded knowledge of plant pathogen biology, and improved timing of pest surveys can reduce the number of pesticide applications (by 1 spray), grower costs (by 50 to 100 dollars per hectare), and environmental exposure (by 10 to 20 percent less pesticide) for producers of susceptible varieties of dry beans when threatened by white mold.

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

In the area of enhancing the competitiveness of vegetables - This research verifies the occurrence of significant levels of phenolic and antioxidant compounds in Colorado grown vegetables including specific lettuce cultivars, demonstrating their potential to serve as good dietary sources of protection from oxidative stress and age-associated health problems such as cancer and heart disease.

In the area of enhancing safety of meat productes - Escherichia coli O157:H7 remains a pathogen of concern for the meat industry as it may be transmitted through consumption of undercooked ground beef and affect children and immunocompromised individuals. The results of these studies provide guidance in the selection of carcass spray-washing and decontamination interventions as well as beef jerky marination treatments to maximize microbial reductions without causing resistance development.

In the area of impact of seasonal patterns on food insecurity - In this high risk population, continued work is needed to identify risk factors for food insecurity and its relationship to eating patterns and growth. Results will be useful in developing strategies to reduce food insecurity and adverse effects on child development.

In the area of interaction of diet and exercise on human health - The data to date suggests 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.

In the area of impact of diet on obesity - Previous studies showing significant changes in these factors have primarily been among older, male, dyslipidemic subjects, this study suggests there are no beneficial effects of a 4-week ALA intervention on these inflammatory factors among young, healthy, overweight/obese subjects. The information we present at the conclusion of this study will help define guidelines for the consumption of plant-based omega-3 fatty acids in humans.

USDA Goal 4: Greater Harmony between Agriculture and the Environment

CSU Program: Agriculture and environmental quality

In the area of understanding forest conditions in the Rockies - The key impacts of our project include verification that the number of aspen stems established in the past 4 decades is probably much lower than would be expected based on historic trends. The paucity of new aspen trees probably relates to heavy browsing from elk, as the weather patterns were not unusual during this period, and the incidence of fire remained low for the entire 20th Century.

In the area of enhancing livestock grazing in riparian areas - Results from these studies suggest that grass-like (e.g. sedges, rushes) and willow plants provide greater streambank stability than grasses and forbs. Thus, grazing management that favors a diversity of life forms, including herbaceous and woody plants, is a recommended strategy to increase streambank stability and reduce NPS in montane riparian zones. Studies suggest that properly designed grazing systems can allow riparian systems to be grazed and still maintain high water quality.

In the area of reuse of wastewater on turfgrass - 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 the water reuse practice. We have found that modification of common management practices (increasing mowing height, for example) can also be used to reduce the negative impacts of salinity on turf quality by enhancing the plant's ability to respond to elevated soil salinity.

In the area of developing solutions to salinity problems in the Arkansas River valley - This project strengthens the data foundation and the modeling tools needed to characterize water conservation, salinization, waterlogging, and pollutant loading problems in the lower Arkansas River Valley and to guide the search for answers.

In the area of estimating carbon sequestration in soils - 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. 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.

In the area of new tools to manage water in the South Platte watershed - As a credible impartial party in water issues, the project is able to develop methodologies and software, that builds consensus on water issues and prevents costly legal battles. The tools developed have a proven track record with water managers dealing with the complex issues pertaining to water scarcity and high demand.

In the area of minimizing antibiotics in aquatic systems - Project provides information on concentrations of veterinary antibiotics present in the CAFO lagoons found in Northeastern Colorado. We have already documented the occurrence of these compounds in rivers in the area and we are attempting to locate the ultimate source.

In the area of reducing phosphorus loss of soil applied manure - This research indicates that soils with higher amounts of calcium carbonate are better suited to be sinks for excess P in manure. When producers are making decisions about where to apply manure, soil CaCO3 level is an important consideration. Surface water quality can be protected by choosing to apply manures to soils with higher CaCO3 contents (everything else being equal).

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

CSU Program: Community and rural development

In the area of community-based collaboration in natural resource management - Our survey of social capital in collaborative groups provides a self-evaluation tool for collaborative groups and

a replicable survey instrument for other researchers. The survey findings have important implications for groups that want to know how to build strong relationships among their members.

In the area of economics of mitigating salinity problems in irrigated agriculture - Waterlogging and salinization have contributed to the demise of ancient civilizations and continue to threaten the sustainability of irrigated agriculture today. The study in the lower Arkansas River Valley shows that reductions in aquifer recharge from ten to fifty percent would be expected to increase annual net returns in the region from $5.81 to $17.28 per acre, respectively.

In the area of innovations in fruit and vegetable marketing - Research for the wine industry will be used to assess the feasibility of cooperative crush facilities on the Western slope, guide business planning by wineries and help with strategic market planning for the whole industry. This type of analysis should allow them to continue with the 100% growth in market share the industry has experienced in past years.

In the area of use of valuation research in natural resources - Valuation research and benefit transfer research is being used by state and federal agencies as well as non-profit organizations for their economic analyses throughout the U.S.

In the area of rural communities and labor markets - Targeted marketing analyses of the wine industry in Colorado represent a high profile impact to producers and industry associations throughout the state.