FY 2004 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 1*: Plant and animal improvement and new agricultural development*

Key Themes: Development of improved protective fabrics

Short Description – A study examining the Ultraviolet Protection Factor (UPF) of cotton fabrics dyed with colorants of plant and insect origins was conducted. Three cotton fabrics were dyed with three natural colorants. Fabrics were characterized with respect to fabric construction, weight, thickness and thread count. Influence of fabric characteristics on UPF was studied. Role of colorant concentration on the ultraviolet protection factor was examined via color strength analysis. A positive correlation was observed between the weight of the fabric and their UPF values. Similarly, thicker fabrics offered more protection from ultraviolet rays. Thread count appears to negatively correlate with UPF. Dyeing with natural colorants dramatically increased the protective abilities of all three fabric constructions. Additionally, as the colorant concentration in the fabric increased the UPF values also improved. A study was also conducted to develop a microscopic method for predicting the Ultraviolet Protection Factor (UPF) of fabrics by calculating percent cover using a digital stereo microscope. An equation was developed to predict the UPF of fabrics using the parameters of percent cover, thickness and weight. UPF values obtained by this method correlate well with UPF values of fabrics measured by a UV transmittance analyzer.

Impact - Dyeing cotton fabrics with natural colorants increases the ultraviolet protective abilities of the fabrics and can be considered as an effective protection against ultraviolet rays. Predicting UPF via a stereo microscope is a novel and inexpensive method to rate fabrics according to their UVR protective capability.

Source of Federal Funds – Multi-State Hatch Act Funds

Scope of Impact – National and International

Key Themes: Develop improved potato cultivars

Short Description – The major objectives of the Colorado Potato Breeding and Selection Program are: (1) to develop new potato cultivars (russets, reds, chippers, and specialty) with increased yield, improved quality, 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; and (3) to evaluate promising selections for potential seed export (interstate and international). Additional breeding emphasis is placed on identifying germplasm and developing cultivars that have: (1) improved nutritional quality and other consumer characteristics; (2) immunity to Potato

Virus Y; (3) resistance to late blight (foliar and tuber); (4) resistance to storage rots [dry rot (Fusarium and early blight) and bacterial soft rot]; and (5) resistance to powdery scab. Cultivars with these characteristics will help assure that the potato industry in Colorado will remain productive and in a competitive position. Advanced selections/recent releases undergoing commercialization include Rio Grande Russet and Colorado Rose. Exclusive release or public release for Fremont Russet and Durango Red is being evaluated.

Impact - Colorado's certified seed potato program recorded a total of 2771 ha of Colorado developed cultivars or clones representing 55% of the seed acreage accepted in 2004. Yields were excellent with the crop demonstrating relatively low levels of disease. At an average price of $198/mt for certified seed and an output of 25.8 mt/ha usuable as seed, this represents approximately $13.7 million in sales generated by Colorado developed cultivars. Additional value is derived from significant out of state seed potato sales.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Development of new wheat cultivars for the Central Great Plains

Short Description – Two new hard red winter wheat cultivars were released in fall 2004. This first of these, named 'Hatcher', combines high dryland yields in eastern Colorado, resistance to Biotype 1 Russian wheat aphid (RWA), and improved milling and baking quality relative to other available RWA-resistant cultivars. The second of the new cultivars, named 'Bond CL', combines resistance to Biotype 1 RWA, the Clearfield herbicide tolerance gene, and excellent bread baking quality. Bond CL is a doubled-haploid line developed using the wheat x maize hybridization method. The search was continued for germplasm with resistance to the new biotype of RWA identified in 2003 (designated as 'Biotype 2'). Biotype 2 resistance identified in 2003 was confirmed and crosses were made with these materials for both breeding purposes and mapping population development. We also screened over 5,000 Iranian landrace selections and have identified many accessions with biotype 2 resistance. In spring 2004, additional virulent RWA biotypes were identified in Colorado and wheat production areas in adjacent states. Significant genotype x environment interaction was revealed between environments, which is useful to facilitate interpretation of variety response in Colorado and refining variety recommendations.

Impact - CSU-bred wheat cultivars account for nearly 60% of Colorado's 2.4 million acres (2004 crop) with the remaining acreage planted almost exclusively with cultivars from university breeding programs in adjacent states. Estimates from Colorado wheat industry leaders indicate that quality enhancements from these cultivars 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). Russian wheat aphid resistant cultivars developed at CSU are currently planted on over 25% of the Colorado acreage (2004 crop). Farmers who plant these cultivars and experience RWA biotype 1 infestations would save approximately $14 per acre in insecticide costs and $22 per acre in reduced yield (average 25% yield reduction), a total benefit of over $23 million per year.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – Region Specific

Key Themes: Development of improved dry edible bean cultivars

Short Description – Breeding efforts have identified two new black bean lines that will be increased for Foundation seed and public release in 2005. 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. 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 2004 will facilitate our forecast model validation efforts in the spring of 2005 with growers and crop consultants in relation to scouting calendars and the timing of more effective integrated pest management programs.

Impact - The dry edible bean crop contributes between $40 and $60 million in farm gate value to the agricultural economy of Colorado. There is a need to provide producers and processor with updated information on cultivars and pest control to maximize economic return and reduce pesticide use. Currently, cultivars released by this project are produced on approximately 40% of the acerage in the state. These cultivars increase yield by 5 to 10% over cultivars they replaced.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – Region Specific

Key Themes: Beef cattle genetics

Short Description – Economically relevant traits are directly related to the cost or income resulting from the production of beef. Expected progeny differences (EPD) for these traits simplify animal selection by focusing genetic improvement and easing quantification of each traits effect on profitability. In the past, genetic evaluation procedures for stayability, one of the economically relevant traits, have been developed. The stayability EPD is a tool for selecting breeding stock that will produce offspring with longer, more productive life spans. This EPD has been adopted by several U.S. beef breed associations and their breeders. A prototype of this evaluation has also been delivered to an additional association and was subsequently accepted for regular implementation in the current year. The stayability EPD is calculated from data recorded on those cows that produce a calf at 2 years of age and are still in the herd at age 6. Developing methods for measuring correlated traits at earlier ages, as opposed to waiting 6 years for observations to be recorded, would increase accuracy of EPD for younger animals. Accuracy of EPD is a key factor influencing the rate of genetic improvement with increases in accuracy resulting in faster genetic improvement of animals through selection. To be useful, early indicators must be heritable and genetically related to stayability. An evaluation of measurements at earlier ages was completed with two industry datasets. These analyses estimated a heritability of .21 for stayability to 3 years of age and heritability of .26 for stayability to 4 years of age. Both indicate a significant genetic contribution in lifespan to these ages. The rank correlations between EPD for stayability to 3 years of age and EPD for stayability to 6 years of age was .63; while the rank correlations between EPD for stayability to 4 years of age and EPD for stayability to 6 years of age was .66. The rank correlations indicate a

strong positive relationship between the underlying genetic mechanisms controlling stayablity to these ages. For every percentage point increase in inbreeding of the individual, stayability decreased .56 percent in preliminary results. By accounting for inbreeding, accuracy of evaluation of stayability would be increased further.

Impact - Simulation of U.S. cow-calf production systems show that a herd-wide increase in stayability of 2 percent would increase profitability 79 dollars per bull. Given U.S. beef cow numbers of over 32 million, and an average of 1 bull per 30 cows, this 2 percent increase would produce nationally an increase in profitability of over $84 million. Efforts to identify and calculate EPD for other economically relevant traits will further improve economic viability of U.S. beef production.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – National

CSU Program 2: *Plant and animal production systems*

Key Themes: Beef cow-calf production systems

Short Description – A prototype web-based decision support system has been developed to quantify the productive and economic implications of using various sires within the context of a cow-calf system. The background to the system is recognition that producers can readily identify the economically relevant traits (ERTs) that impact their production system but real-life selection decisions involve choosing among candidates that are favorable with respect to some attributes but typically have below average merit for at least one ERT trait. Determining the overall net merit of each individual with varying genetic merit across the portfolio of economically relevant traits is problematic. Clear evidence for the difficulty in valuing concurrent genetic change for all the traits influencing system performance is the lack of published information quoting the annual value of genetic change to the cow-calf component of the beef industry. Although it may be relatively straightforward to quantify the change in value of a calf as a result of selection, the impact of such change on cow-calf system profitability requires knowledge of changes in herd age structure, time preference and nutritional requirements of the breeding cows and their replacements. The decision support system is linked to a database of bull EPDs. The user can enter information relating to the whole herd performance of their current production system and then use simple database filters to select individual sires that might appeal to them. The downstream implications of using each of those sires, within the context of the users own production system, can then be quantified. In a maternal context it is assumed that the daughters of the bull in question are retained as replacements and flow through the various age groups of the foundation herd. The herd size can be rescaled to ensure that the annual feed consumed by the improved herd is identical to the annual requirements of the unimproved herd. Thus the animal numbers are scaled appropriately to account for the fact that most productive changes alter the nutritional requirements of the herd. The value of any change in income must also account for the change in scale in order to predict the whole system influence. The genetic evaluation of cattle in the US is likely to move to an across-breed system over the next few years. The resultant EPDs will therefore be comparable on a single base, facilitating the comparison of animals of different breeds or breed crosses. The performance of crossbred animals will be influenced by heterosis or hybrid vigor for all the ERTs. Subsequent versions of this decision

support system will take advantage of across-breed EPDs and knowledge of heterosis while maintaining the same functionality, look and feel. Decision support tools such as that being prototyped in this project, offer the evaluation of concurrent changes in the context of whole system productivity and profitability. The potential impact of such a tool if adequately funded and communicated is therefore enormous. To date, the prototype tool has been demonstrated to all the major US beef breed associations and to many individual breeders and groups of breeders. In conjunction with the development of multi-breed evaluations, such a decision support system may become recognized as one of the major milestones in livestock improvement, along with performance recording, progeny testing, genetic evaluation and artificial insemination.

Impact - The national cow-calf herd includes over 30 million breeding cows. An improvement in productivity equivalent to 1 lb weaning wt per cow is worth at least $20 million per year in perpetuity. Selection over recent decades has considerably changed the nature of the national beef herd, but the value of such change in terms of genetic improvement is unclear. Some of the trait changes have been favorable while others have been unfavorable.

Source of Federal Funds – Hatch Act Funds

Scope of Impact –National

Key Themes: Development of dryland cropping systems

Short Description – A study was conducted in 2000 to 2004 to assess the feasibility of dryland cropping systems in southwestern Colorado and southeastern Utah. Precipitation was below normal every year of the study, except in 2004. Winter wheat after a 14-month fallow period produced the best seed yield in the driest years, 2000 and 2002, compared to more intensive crop rotations. This was due to more available soil moisture at planting, particularly with minimum- or no-till practices and adequate nitrogen fertilization. In years with timely precipitation, cropping systems which produced one crop per year or two crops per three years generally outperformed winter wheat-fallow. In general, spring crops performed poorly due to dry conditions in May, June, and July. Safflower depleted soil moisture more than corn or pinto beans. The data suggest that winter wheat-safflower-fallow is preferable to winter wheat-safflower-bean in the project area. Chickpea did not do as well as expected in rotation with winter wheat. Chickpea showed promise in other trials but more research is needed to develop cultivars and management practices that are best suited to the environment of southwestern Colorado. Organic chickpea production appears to be profitable in southwestern Colorado.

Impact - This study shows that minimum and no-till management practices can save valuable soil moisture in dry years and curtail soil erosion which is a major concern in southwestern Colorado. The results also point to potential economic benefits of crop diversification and the need for long-duration research on cropping systems.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Dryland cropping systems for the Central Great Plains

Short Description – No till practices permit cropping system intensification beyond the long-term standard system of wheat fallow because no till improves capture and retention of the incident precipitation. Results from this project from 1986 to 1997 showed that cropping systems with 3 and 4 year rotations were superior to 2 year wheat fallow systems with 70% increases in annualized grain production and 25 to 40% increases in return to land, labor, capital, and management. In 1998, the wheat-fallow treatment was dropped and the wheat-corn or sorghum-fallow became the standard of comparison, with three and four year continuous crop rotations being added. Data show that soil quality is being improved by the adoption of no-till intensive cropping systems. Farmer interest continues to be strong as demonstrated by demand for dryland cropping systems information and by practice adoption rates. Dryland corn acreage increased from 23,700 in 1986 to an average of 257,000 over the last 5 years (1999-2003), reflecting an 11-fold increase. Sunflower acreage increased from 63,000 in 1991 (first year of records) to 195,000 in 2001, but dropped to 130,000 in 2002 and 2003. Overall summer crop acreage has increased by about 500,000 in Colorado since 1986.

Impact - Conversion of about 1,500,000 acres in Colorado from wheat-fallow to wheat-summer crop-fallow has increased net return by $22.275 million per year, based on an increased return of $14.85/acre as documented by the most recent economic analysis. Recently herbicide costs have decreased, which will increase the profit of no-till systems relative to tilled fallow systems. Intensive cropping systems build soil organic carbon and improve soil quality. These systems also improve both air and surface water quality because they provide high amounts of year around cover that reduces soil erosion by 80 to 99%.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – Region Specific

Key Themes: Application of precision agricultural techniques for irrigated crop production

Short Description – The use of precision agriculture technology is expanding in the US and Colorado. Implementation of various concepts of precision agriculture holds promise of increasing net return and enhancing environmental quality. Our interdisciplinary precision agriculture research program is in its eighth year. This project's research goal is to use production level (high,medium,and low) management zone (MZ) to increase returns and enhance environmental sustainability of N fertilizer management. We initiated a new project to evaluate the use of remotely sensed imagery to develop N algorithms to allow real-time N fertilizer management. Considerable effort was spent on integration of the sensors with computer processing units and tractor mounting applications to facilitate 'on the go' GNDVI (Green Normalized Difference Vegetative Index) readings. Preliminary results suggest that we are able to delineate MZ within fields using GNDVI readings that are similar to MZ delineated using our proven soil color based methods. Initial analysis indicates the GNDVI readings are sensing N stress in the plants.

Impact - The adoption of variable rate N application can increase net returns by $7-12 per acre to corn producers as compared to the traditional uniform N fertilizer management. This emerging technology also holds promise for improved environmental stewardship by users because inputs are applied at the rate needed to the portion of the field needing the input(s).

Source of Federal Funds – Hatch Act Funds

Scope of Impact – Region Specific

Key Themes: Availability of ground water for irrigated crop production

Short Description – In Colorado there is increased scrutiny of the amount of groundwater depletions caused by well pumping in alluvial aquifers. The impact of these depletions on river flows has prompted renewed interest in the methods used to calculate them. Water managers are attempting to reconcile the desire to make use of the large amount of storage in the alluvial aquifer with the need to protect more senior surface water rights. In order to manage conjunctive use of surface and groundwater, the project South Platte Mapping and Analysis Program (SPMAP) project has developed tools to evaluate four components: 1) water demands, 2) water supplies, 3) depletions of groundwater, and 4) impacts to rivers due to depletions of groundwater and resulting augmentation requirements. Groundwater in the South Platte Basin in Colorado is used as a supplemental water supply when surface water supplies are unable to meet demand. The first step in modeling a groundwater/surface water system is calculating the water demand for the system. In agricultural systems, the demand is normally determined using either crop evapotranspiration (ET) or an estimate derived from multiplying well pumping by a factor (PDF). A SPMAP module allows users to determine crop consumptive use, irrigation water requirements, and depletions of groundwater using both ET and PDF methods and compare the estimates of groundwater depletions calculated by both methods. The model is scaleable, allowing the user to compute consumptive use for an entire basin or for an individual field. Scenarios can be run to reflect expected land-use or water supply changes. In additon to determining water demands, supplies and depletions, lag time from when a well is pumped or water is recharged to a recharge site and when a depletion or accretion happens in the river needs to be calculated via a separate module.

Impact - The SPMAP models are used in the South Platte to determine augmentation requirements for over 80 percent of the wells in the basin (more than 3,500 wells). The consumptive use model is now also being applied to the Middle Rio Grande Conservancy District in New Mexico.

Source of Federal Funds – Hatch Act Funds

Scope of Impact –Region Specific

Key Themes: Forage production and water use by mountain meadows

Short Description – The quantity and quality of forage produced from grass dominated mountain meadows can be improved by interseeding legumes. However, the success of this practice is often limited by the strong competitive effects exerted by the existing vegetation. Suppression of the existing vegetation prior to seeding generally results in significant improvement in seedling establishment. The objective of this study was to evaluate the establishment success of birdsfoot trefoil that was interseeded into a mountain meadow in which the existing vegetation was suppressed by Roundup herbicide using different application methods. Three methods were tested: broadcast spray, band spray, and band wipe, each at 2 application rates. All 6 method/rate combinations of applying Roundup herbicide improved birdsfoot trefoil establishment compared to the unsprayed

control which averaged only 4 plants per square meter. The best establishment, 43 plants per square meter, occurred when all vegetation was suppressed using a broadcast application of herbicide. This was predictable since competition was reduced to its lowest level using this method. There was no significant difference between the 2 application rates. Applying Roundup in bands resulted in half the seedling density compared to broadcast spraying, but the input of herbicide was reduced by half while maintaining about a third of the normal hay crop.

Impact - Birdsfoot trefoil can be successfully interseeded into mountain meadows by first suppressing the existing vegetation with Roundup herbicide. Applying Roundup in bands reduced the amount of herbicide used by half, which has both economic and environmental benefits while achieving acceptable plant establishment and maintaining a partial hay crop.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Watermelon production systems for the Arkansas Valley

Short Description – In the Arkansas Valley of Colorado, watermelons, a major vegetable crop, are increasingly being produced using black plastic mulch and subsurface drip irrigation. Plastic mulch has many proven attributes including increased yield and accelerated crop development. Unfortunately, plastic mulch is expensive and requires a significant amount of labor for application and removal from the field. Disposal of the used mulch in landfills or via incineration is also problematic. As a means to maintain watermelon productivity and reduce production costs, experiments were conducted to evaluate alternative mulching methods. Seeded and seedless watermelon varieties were transplanted or direct seeded into straw mulch, soybean residue, bare ground or plastic mulch. Differences in yield and earliness among the different methods were examined. Transplanting or direct-seeding seeded watermelon and transplanting seedless watermelon into soybean residue, bare ground, or plastic mulch produced yields that were statistically similar. Overall, transplanting was the superior method of establishment for seedless watermelon in any mulch type. Yields for both melon types grown in straw mulch were consistently the lowest, largely due to competition from volunteer wheat late in the growing season. For both melon types, earliness was enhanced by transplanting into plastic mulch. In most instances the advantage was only 3-4 days over direct-seeding or transplanting into the other mulches.

Impact - Watermelon is one of the most profitable crops for Southern Colorado growers. Direct seeding or transplanting watermelon into bare ground or an existing crop residue may reduced the need for using costly plastic mulch. Plastic mulches can increase the cost of production by approximately $625 per hectare.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

CSU Program 3: *Safe and effective management of pests*

Key Themes: Role of carbon dioxide in root-insect interactions

Short Description – Elevated concentrations of carbon dioxide (CO2) prevented neonate larvae of the western corn rootworm, Diabrotica virgifera virgifera LeConte, from locating the roots of growing corn in behavioral bioassays conducted in soil tubs. When CO2 was pumped into one end of a soil tub, significantly more larvae were recovered from soil at the treated end than from soil around a growing corn plant at the opposite end of the tub. In controls with ambient air pumped into one end of a soil tub, significantly more larvae were recovered from the soil around the corn plant than from soil on the treated side. Larvae were unable to locate the roots of corn seedlings when CO2 generating materials were mixed into the soil. The CO2-generating granules produced soil CO2 concentrations between 15.8 and 18.5 mmol/mol (compared with 1.7-2.6 mmol/mol in control tubs), and this was sufficient to prevent larvae from locating corn roots. In field trials, organic and inorganic CO2 generating treatments resulted in root ratings that were significantly lower than for the control plants.

Impact - Western corn rootworms are among the most damaging pests in corn, responsible for more than $1 billion annually in the United States in combined damage and control costs. Volatile attractants can be used to monitor adult populations to assess damage potential, and can also be combined with pesticides to minimize the amounts required for control.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – National

Key Themes: Management of Russian wheat aphid

Short Description – Russian wheat aphid remains the most significant pest of small grains in Colorado. Current research emphasizes plant resistance and Russian wheat aphid management within the larger context of dryland cropping systems. A sixteenth year of monitoring flights with suction traps was completed. Suction traps are operated at each of the three dryland agroecosystem study sites to provide a long-term record of Russian wheat aphid activity. Pest and beneficial insect monitoring was continued at three cropping system study locations in eastern Colorado. Crop performance was mixed as growing conditions for summer crops improved and insect activity increased similarly. Carabid beetles and spiders, important generalist predators, were monitored in two and three year rotations at each locations. More than 50 species of carabid beetles have been identified, with location and year having greater influence than cropping system on species composition and activity. More than 20 species of spiders in seven families have been identified, with gnaphosids and linyphiids being the most generally dominant groups. Nine Russian wheat aphid resistant barley lines were compared for agronomic performance to imidacloprid-protected cultivar Otis under dryland conditions at five Colorado locations. Two lines containing distinct sources of resistance have been selected for joint release by the Agricultural Research Service in cooperation with Colorado, Idaho and Nebraska. Unusual Russian wheat aphid damage was observed on resistant winter wheat varieties in southeast Colorado in 2003, leading to the identification of Russian wheat aphid Biotype 2. A field survey for Russian wheat aphid Biotypes 1 and 2 was conducted, with 43 of the 91 usable samples being identified as Biotype 1 and the remainder as Biotype 2. Methods for biotype characterization have been formalized, and Biotypes 1, 2 and "Montezuma" have been characterized with these methods.

Impact - Russian wheat aphid resistant varieties have allowed producers to grow wheat without insecticides. Roughly 25% of Colorado wheat acres are planted to resistant varieties, with this figure approaching 50% in areas with more consistent aphid infestations. The use of resistant varieties reduces losses to Colorado growers from RWA by $27 million in a single year with average total direct losses above $11 million per year since 1987.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – Region Specific

Key Themes: Predicting plant disease outbreaks using weather data and models

Short Description – 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 2004 will facilitate our forecast model validation efforts in the spring of 2005 with growers and crop consultants in relation to scouting calendars and the timing of more effective integrated pest management programs. Bacterial wilt was confirmed in dry bean samples submitted to our laboratory by collaborating scientists in western Nebraska, and efforts are underway to confirm the preliminary identifications and conduct pathogenicity trials in the greenhouse. Iris Yellow Spot Virus is a tospovirus of onion that is transmitted by thrips such as the Onion Thrips. The virus has spread rapidly in Colorado from 7% in 2001 to 73% of fields in 2003 (Front Range & West Slope), and was present in most onion fields in these production regions in 2004.

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 - 2 sprays), grower costs ($300 to $500 per hectare), and environmental exposure (by 10 to 20 percent less pesticide) for producers of vegetable crops such as dry bean, potato and onion. 2003 generated more experiences with priority pathogens and their diseases, which in turn has enhanced the validity of disease forecast strategies and overall integrated pest management successes in Colorado.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Invasion of rangeland by knapweed

Short Description – Several of the most problematic invasive plants on western rangelands are knapweeds (Centaurea spp. L.). Diffuse knapweed (C. diffusa Lam.) is currently abundant in Colorado, while others such as spotted knapweed (C. maculosa auct. non Lam.) are abundant in nearby states and just getting started in Colorado. The ability of natural resource managers and ecologists to predict where invasive, exotic plants are likely to disrupt native systems requires a better understanding of invasion ecology. A two-part study was conducted to explore components of diffuse and spotted knapweed invasion ecology. A field experiment was conducted to study the resistance of a late-seral native foothills rangeland to invasion by diffuse knapweed and conditions

that promote invasion. Greenhouse experiments were conducted to evaluate the relative benefit of native soil communities to two native plants and two knapweeds and to study plant growth in soil from knapweed infestations and adjacent native rangelands. The native rangeland studied was not absolutely resistant to diffuse knapweed invasion. Disturbances that ensure diffuse knapweed seed incorporation and weaken native vegetation increase susceptibility to invasion. Greenhouse studies indicated that the native soil community is more beneficial to spotted knapweed than to the other plants studied, and that soil from diffuse and spotted knapweed infestations does not prevent growth of two native plants or promote knapweed growth.

Impact - Research has shown that native undisturbed rangeland can be susceptible to invasion by diffuse knapweed. This susceptibility to invasion is increased with minor disturbances that weaken the native community and create opportunity for seed to find safe sites for germination and establishment. These results are important for future management decisions regarding control efforts of diffuse knapweed. Since diffuse knapweed can gain a foothold in undisturbed or slightly disturbed rangelands, management strategies should target what would be considered healthy rangeland sites to remove diffuse knapweed at early stages of colonization, when complete removal may be possible.

Source of Federal Funds – Hatch Act Funds

Scope of Impact –Region Specific

Key Themes: Biological control of invasive plants

Short Description – The host-plant preference was explored for a flower-feeding beetle (Brachipterolus pulicarius: Kateridae) that was inadvertently introduced into North America. It is a specialist on two host plants, yellow and Dalmatian toadflax (Linaria vulgaris and L. genistifolia dalmatica: Scrophulariaceae) and is found much more commonly on yellow toadflax than Dalmatian toadflax. The beetle was found to prefer yellow toadflax both in small scale laboratory experiments and in field releases. The preference for yellow toadflax may depend on the source of the beetles: beetles from Dalmatian toadflax spent less time and laid fewer eggs on yellow toadflax in the lab than beetles from yellow toadflax did. However, this was not observed in field experiments. In laboratory experiments, we determined that offspring from beetles collected from both host plants grow larger on yellow toadflax, thus in these ecological (not quantitative genetic) experiments, preference and performance appear to be correlated. We also discovered that the beetle aggregates to conspecifics. Molecular studies indicate that beetle populations on the two host plants are not genetically differentiated from each other, but are isolated by distance across wide spatial scales.

Impact - The beetles are sometimes sold by biological control suppliers and they are often released in Dalmatian toadflax stands in hopes of slowing the spread of the weed. Given that the beetles are both vagile and strongly prefer the other species, it is unlikely that they stay in the area released. Our results suggest that managers and private land owners would be well advised to spend their time and money on other methods of controlling Dalmatian toadflax. The information on the beetle preference and performance in the toadflax system is being incorporated in to a Forest Service manual on management of yellow and Dalmatian toadflax.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Herbicide resistance weeds in irrigated cropping systems

Short Description – Herbicide resistant weed management continues to be a significant issue for potato, onion, sugar beet and dry bean producers. Selection pressure is high in crops like corn and wheat where there are many other options for alternative modes of action. Producers that rely on other crops for their incomes must deal with these resistant weeds using a limited number of herbicide modes of action. Until recently potato, dry bean and onion growers did not have new modes of action to help manage triazine and acetolactate synthase (ALS) resistant weed populations. Based on research results from this project potato, dry bean and onion growers will have new products with modes of action that were not available two or three years ago. Sulfentrazone now has a Section 3 label that includes applications to potatoes and dry beans for 2004 field season, while flumioxazon has a Section 3 label for potatoes and onions for the 2005 field season. Field research results from this project have been used to support these new registrations and provide information to develop directions for use. This project has also supported the Colorado onion industry by providing data necessary to support a Section 18 label for fluroxypyr to control volunteer potatoes in dry bulb onions. Volunteer potatoes are not only highly competitive with the onion crop, but can also serve a source of late blight inoculum. This project has also provided data to support a Section 18 label for fomesafen to control ALS resistant common waterhemp, which appears to be moving into eastern Colorado from western Kansas.

Impact - Sulfentrazone and flumioxazon will not only provide potato growers with a new mode of action for weed control and resistance management, but could potentially save as much as $14 per acre in weed control costs. This could save the potato industry in Colorado $1.1 million per year. The impacts to the dry bean industry are also significant because this new product should improve late season nightshade control and provide a strategy to help control ALS resistant common waterhemp with to separate modes of action. For onion growers with significant volunteer potato problems, conventional control methods resulted in a yield loss of 20-40%. Incorporating fluroxypyr in a weed management program could reduce yield losses to as little as 8-10%. Fortunately, there are a limit number of acres where onions are planted after potatoes.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

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

CSU Program 4: *Food Safety and Nutrition*

Key Themes: Food insecurity in low income families

Short Description – This study evaluated the seasonality and prevalence of food insecurity among low income families with young children in rural southern Colorado, and 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. Most households (70.3%) were identified to be food secure at the first visit. At the second visit 45/59 families completed the food security assessment; of these families, 29 households (64.4%) were food secure while 16 (35.5%) were food insecure. In relation to ethnicity, 21 (40.4%) Latino/Hispanic households were food insecure in the first visit and 12 (30.0%) were food insecure in the second visit. Among non-Hispanic White households, 3 (20.0%) were food insecure in the first visit and 2 (18.2%) were food insecure in the second visit. Of the 45 families evaluated for food security at 2 visits food security status did not change for 31 (68.9%); 20 remained food secure and 11 remained food insecure at both visits. Food security status changed for the remaining 14 families with 5 becoming food insecure at the second visit and 9 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 – Hatch Act Funds

Scope of Impact –National

Key Themes: Evaluation of food safety educational materials

Short Description – Pregnant women, solid organ and bone marrow transplant patients, cancer patients and persons with HIV/AIDS are at increased risk for contracting certain foodborne illnesses, such as listeriosis and toxoplasmosis, possibly leading to damaging outcomes. To raise risk awareness and promote prevention of such diseases among these audiences, 22 food safety educational materials prototypes were developed using the Health Belief Model. Five prototypes targeted pregnant women, 5 HIV/AIDS, and 12 bone marrow, solid organ transplant, and cancer patients. Each prototype addressed food safety recommendations differently, using various approaches, formats and writing styles. Participants preferred formats with more detailed information to briefer formats. These materials are available on the web sites of the three universities involved.

Impact - The 12 sets of research-based educational materials developed specifically for pregnant women, HIV/AIDS patients, cancer patients, solid organ transplant patients and bone marrow transplant patients are accessible through the internet. They provide useful educational tools for educators and health care providers who work with these patients. They also can be downloaded directly by concerned patients and their care givers.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – National

Key Themes: Educational program for food safety

Short Description – The overall aim of this interdisciplinary project was to improve the safety of food for Coloradans. Through literature review and laboratory experiments we have furthered the understanding of how Escherichia coli O157:H7, Listeria monocytogenes and Salmonella spp. survive on food products processed using various decontamination and minimal heat treatments. A task force with representatives from state and local health departments, cooperative extension and the Colorado Farmers Market Association developed guidelines for preparing and offering food samples to consumers at farmers markets. The findings learned in research studies have been converted into information and recommended procedures for use by producers, processors, retailers and consumers. Outreach efforts have included the development of six consumer fact sheets, one bulletin and numerous newspaper articles. In addition, some 30 food safety trainings were conducted for producers, processors, retailers, food service managers, and/or consumers and have maintained a listserv for food safety professionals, a public website for professionals and interested consumers, and a quarterly newsletter, SafeFood News, sent electronically to listserv participants and posted on the website.

Impact - Producers, processors, retailers and consumers are increasingly concerned about the safety of commercial and home-prepared foods relative to the presence of pathogenic bacteria. This interdisciplinary project provided a system for responding to newly developed, emerging and troublesome food safety concerns of Colorado producers and consumers with researched recommendations that minimize risk and promote food safety and quality.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – National

Key Themes: Reducing microbial contamination during meat processing

Short Description – In efforts to comply with regulatory criteria established by the United States Department of Agriculture Food Safety and Inspection Service, the beef industry employs carcass decontamination technologies based on application of steam-vacuuming as well as pre- and post-evisceration spraying with hot water and/or organic acid solutions or exposure to steam. These decontamination strategies are intended to reduce levels of spoilage and pathogenic microorganisms, and are followed by cooling of carcasses. Cold temperatures and drying of the carcass surface during cooling may also contribute to microbiological control; however, cold-air chilling may also result in loss of carcass weight which is economically undesirable. A study was conducted to investigate the effectiveness of simulated chilling without spraying and spray-chilling with water and chemical solutions (similar to those used, approved or proposed for use on carcasses before chilling) in reducing Escherichia coli O157:H7 contamination on beef carcass tissue. Water, sodium hydroxide and sodium hypochlorite were less effective spray-chilling treatments for reducing attached pathogen populations than peroxyacetic acid, acidified sodium chlorite, ammonium hydroxide, lactic acid and cetylpyridinium chloride. The decontaminating effect observed for spraying with water, sodium hydroxide and sodium hypochlorite was most likely the result of injury of pathogen cells due to evaporative cooling afforded by the combination of moisture and low temperature. Cetylpyridinium chloride and lactic acid were the most effective spraying treatments reducing pathogen populations by almost 5 log CFU/cm2 after 24 h of chilling.

Impact - Escherichia coli O157 H7 is a pathogen of major concern because it affects children and immunocompromised individuals, and is generally transmitted through consumption of undercooked ground beef. Spray-chilling with approved chemicals should be considered as an in-cooler intervention and another hurdle in the multiple-step decontamination system employed in U.S. packinghouses.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – National

Key Themes: Increased food safety for home processed products

Short Description – The overall aim of the studies was to generate research data and consumer recommendations to enhance the safety of dried meats, fruits and vegetables by controlling through inactivation pathogenic bacteria during processing and storage. Experiments were conducted with beef, apples, tomatoes, parsley, peaches, carrots and potatoes to assess the effectiveness of various pre- and post-drying treatments. Results generally showed that a blanching or acid-dip pre-treatment enhanced inactivation of L. monocytogenes, E. coli O157:H7, and Salmonella during drying and product storage. Taste panels conducted with consumers showed no differences in acceptance between dried foods produced using traditional methods and those produced using pre-treatments that enhanced inactivation of pathogens.

Impact - In the past, most home-drying procedures were based on empirical evidence and not evaluated for their influence on bacterial destruction during drying and storage. Such procedures may not be as effective as desired for pathogen inactivation and may lead to sublethal stress and development of resistance of pathogens to food preservation methods. Consumers can now dry foods at home with the confidence they are using research-based methods that effectively destroy pathogenic bacteria, if present.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – National

Key Themes: Human nutrition and exercise

Short Description – An elevation of blood insulin concentrations is associated with increased risk for various chronic diseases. Because low glycemic index (GI) foods generally stimulate less insulin secretion, much attention is being given to the use of these slowly absorbed carbohydrates in the prevention and treatment of obesity and type 2 diabetes. Because of the heightened insulin sensitivity associated with recovery from acute exercise, it is possible that prior exercise could favorably blunt the blood glucose and insulin responses to high GI carbohydrates. Therefore we tested the hypothesis that the glycemic and insulinemic responses to a moderately high glycemic index (GI) food consumed following an exercise bout would be lower than when the same food is consumed without prior exercise. An acute bout of prior exercise had no effect on the glycemic index of a carbohydrate rich food (energy bar) compared to that of the same food determined under the standard no-exercise conditions. However, exercise resulted in a lower 2-h insulin response to the CHO bar.

Impact - Elevated blood insulin concentrations have been linked to increased risk for pro-inflammatory diseases such as obesity, diabetes, cardiovascular disease, and cancer. Individuals with insulin resistance, who exhibit higher risk for these chronic diseases, are often encouraged to consume slowly absorbed carbohydrates that lower the requirements for insulin. We have shown here that engaging in aerobic exercise prior to ingestion of a rapidly available carbohydrate reduces the insulin requirement by 30% compared to when the carbohydrate is consumed without exercise. These findings suggest that exercise is beneficial in reducing the insulin response to carbohydrate ingestion, which could potentially reduce chronic disease risk in insulin resistant individuals.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – National

Key Themes: Obestity and omega-2 fatty acids

Short Description – 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 is 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 and insulin, glucose and insulin resistance in abdominally obese males and females. Roughly 100 subjects have been screened and 56 subjects have completed the protocol (42 females and 14 males). 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. Although, they are abdominally obese, their markers of inflammation and insulin and glucose are not elevated. We expect if we recruited older subjects, over 50 years, we may see elevations in these factors and thus the potential for reducing them with this 4 week intervention.

Impact - The information obtained from this study will help define guidelines for the consumption of plant-based fatty acids in humans. This dietary intervention will also allow us to gain more insight into future testing of genetic polymorphisms that may underly the response to these plant-based fatty acids.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – National

USDA Goal 4. Greater Harmony between Agriculture and the Environment

CSU Program 5. *Agriculture and environmental quality*

Key Themes: Farmers willingness to use animal manure

Short Description – Little is known about producers' willingness to use manure. Past studies have focused on substitutability for fertilizers. This study surveyed 273 crop producers in a cattle-dense region of the Great Plains about whether and why they apply manure, focusing on how pressures (number of livestock owned and number of acres of corn grown) or preferences (farmers' perceptions of the problems and benefits associated with manure use) affect their adoption. The current study is

the first published positive study of the manure adoption decision. That is, the willingness to apply is empirically examined, which should provide a first step toward closing in the uncertainty involved in economic policy analyses of the manure management problem. Secondly, a focus on pressure and preference variables takes the current study beyond implicitly treating manure as though crop producers only view it as a nutrient substitute with some special transportation and application costs. Finally, manure management was examined in the context of beef production, an important source of problems in most of the western half of the U.S., which has received relatively little treatment in the economic manure literature. After testing several models, it was concluded that the best model to determine producers' willingness to pay for livestock manure in Eastern Colorado was a function solely of the price of the manure. As price increased, demand decreased. Owning livestock did not impact producers' willingness to pay for manure.

Impact - This project has environmental, economic, and policy impacts. The goal is to use these results to increase both the utilization of manure and the transportation distance for manure, thus minimizing the pollution potential from Concentrated Animal Feed Operations (CAFO) near water bodies. The relationship between manure price and demand will be linked to future work on manure supply in order to better understand and improve the economics of manure utilization.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Animal antibiotics in the environment

Short Description – The focus of the project in 2004 was the continued development of analytical methods for measuring veterinary antibiotics in animal waste lagoon water and manure. We have developed methods to measure five classes of antibiotics at environmentally relevant concentrations: (1) tetracyclines (tetracycline-TC, oxytetracycline-OTC, chlortetracycline-CTC, doxycycline-DXC, demeclocycline-DMC), (2) sulfonamides (sulfathiazole-STZ, sulfamethoxazole-SMX, sulfamethazine-SMT, sulfamerazine-SMR), (3) macrolides (tylosin-TLS, erythromycin-ETM, roxithromycin-RTM) (4) ionophores (monensin-MON, salinomycin-SAL, narasin-NAR) and beta-lactams (penicillin G, penicillin V, amoxicillin). A method using solid-phase extraction (SPE) combined with high-performance liquid chromatography/ion trap tandem mass spectrometry (LC/MS-MS) has been developed for determination of trace concentrations of these antibiotics in lagoon water and manure. A survey was conducted of 7 hog operations, 5 beef operations, 7 dairys, 4 sheep farms and 2 two turkey feed operations. The results of this occurrence survey indicate 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. 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 streams. Best Management Practices for the animal agriculture industry will be considered on how to minimize the release of antibiotics to the environment.

Impact - This research will provide needed information on the occurrence of veterinary antibiotics in waste lagoons around the state of Colorado. This information coupled with occurrence data in streams and groundwater and knowledge of use patterns (human or animal) will allow us to estimate the degree that animal feed operations contribute antibiotics to the environment.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Phosphorus and water quality

Short Description – Phosphorus runoff from manured fields can contribute to nutrient enrichment of surface water bodies. Previous studies have utilized rainfall simulation methodology to document a relationship between soluble P in runoff and soil test P levels. However, this type of work has not been done on calcareous soils in semi-arid landscapes. This study evaluated the impact of calcium carbonate levels in soil on the relationship between soil test P and runoff P levels and, secondly, improved the protocol for rainfall simulation studies. We applied manure at eight application rates onto three sites within the Great Plains with soil CaCO3 levels of 1, 4, and 9%. Based on our results, we intend to add the CaCO3 content into the Colorado P Index so that this important effect will be considered in manure application rate decision-making. Soils with high CaCO3 levels sorb more P and, thus, produce less P in runoff from manured fields. We recommend the use of total dissolved P since its analysis is simpler.

Impact – Incorporation of our results into the Colorado P Index will directly influence all CAFOs in Colorado. In addition, other states with calcareous soils may choose to alter their P Indices accordingly. Specifically, we expect to improve the ability of CAFOs, USDA-NRCS staff, and consultants to predict the P runoff risk from a field and to recommend appropriate Best Management Practices to reduce runoff risk. In addition, since CAFOs are now required to utilize the P Index to determine whether manure should be applied on an N-basis or a P-basis, we expect that this will reduce the P Index on fields with high calcium carbonate contents, thus allowing N-based application on those fields. This will allow higher manure application rates and reduce manure transportation and spreading costs for both fuel and labor.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Salinity problems in the Arkansas Valley

Short Description – Salinity in Colorado's lower Arkansas River Valley is reducing crop yields and threatening the future of agriculture in the area. To assess the magnitude of the problem, soil salinity maps of fields in the area are being created by combining field data and remote sensing technology. For the past several years, soil salinity readings have been taken three times a year at over 60 locations in each field using an EM-38 probe. Since data collection using the EM-38 is time consuming and is expensive to collect such data for large areas, we are evaluating the use of 4m Ikonos multi-spectral satellite imagery to determine the severity of soil salinity and its impact on crop yield. Elevated levels of soil salinity affect the appearance and growth of corn crops, which can be detected using satellite imagery. By enhancing the image, we can separate the crop condition into several classes. Using spatially referenced ground data collected at the study area, each class in the satellite image is related to a level of soil salinity. These classes are used to create a signature file and classify other areas planted with corn. The accuracy of classifications was tested using remote

sensing on several fields with very encouraging results. For the fields that studied, the difference between soil salinity measurements taken with EM-38 and the satellite image is less than 15%, and part of this discrepancy could be a result of the errors that occur in EM-38 salinity maps.

Impact - Using remote sensing to determine soil salinity allows us to evaluate soil salinity over large areas (river basins) in an economical way. Changes taking place over years can be identified by using remote sensing data from multiple years, allowing us to determine the rate of change and identify problem areas before salinity gets to the point of significantly impacting yields. Estimated yield losses due to salinity in the valley range from 10 to 20%, resulting in an economic loss of $3 to $4 million from the two major crops (alfalfa and corn).

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Improved nitrogen management in precision farming

Short Description – Accumulated soil N is highly susceptible to leaching and can potentially threaten groundwater supplies. The use of site-specific management zones (SSMZ) for Variable rate application has been shown to be a simple and effective way to increase Nitrogen use efficiency. The SSMZs are defined as homogeneous sub-regions of a field that have similar yield limiting factors. It is hypothesized that SSMZs can be used to effectively characterize N uptake spatial variability and could establish the usefulness for variable N application using SSMZs across the field. A study was conducted over three site years under a continuous corn cropping system, with center-pivot sprinkler irrigation in northeastern Colorado. Results from the study indicate significant spatial dependence for both N uptake and grain yield. Considering that the N uptake spatial variability was relatively high, using mean N uptake values to target N application rates potentially could have resulted in some portions of the fields being under or over fertilized. The results supports our hypothesis that SSMZs have the potential to characterize spatial variability in N uptake. Using the SSMZ approach, the low and high productivity zones were consistently separable based on N uptake.

Impact - Variable rate application of nitrogen using site-specific management zones will optimize the nitrogen uptake and removal by the crop, decrease potential for under and over application of nutrients in different parts of the field, increase nitrogen use efficiency, and decrease potential for nitrate leaching. All this will have a significant impact on the environment and net return to the farmer.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Insect museum and water quality

Short Description – One Colorado's main biological collections is the C. P. Museum of Arthropod Diversity. The Museum, founded in 1870, includes more than 3,000,000-curated specimens, primarily representing more than 55,000 insect species.This repository represents a baseline of (historical) diversity information, in which species and genetic diversity are catalogued and stored,

especially being important in the rapid changing landscapes of Colorado. Since changes in biodiversity are unfolding in space and time, spatio-temporal information is crucial to document these changes in faunal patterns. Properly preserved, catalogued, and maintained specimens are the ultimate physical database for verification of reported data that are based on them and the populations from which they were samples. This information is crucial for efforts directly related to Colorado agriculture including identification of new pests, identification of emerging pests, and biocontrol releases and successes. During the last five years, research was designed to provide high quality baseline benthic macroinvertebrate and habitat data to aid the design and enhancement of aquatic habitats during storm water development and evaluate impacts as these canals that traverse landscape changing from agricultural to rural/urban. Both canals and small urban streams were unique in terms of the availability and quality of habitat. Storm events and canal operations controlled the development and persistence of the benthic macroinvertebrate communities. In the canals, lower flows favored those taxa more typically associated with standing water habitats, whereas peak flows favored rheophilic species. Variation of flow of both the urban streams and canals interrupted the life cycles of most of the benthic macroinvertebrates. However, it is clear that both aquatic systems can be redeemed as aesthetic resources with some ecological integrity.

Impact - The C. P. Museum of Arthropod Diversity, Colorado State University provides unique services and opportunities in biodiversity cataloguing and systematic needs for the state. It is the only expanding repository that represents a baseline of (historical) diversity information, in which insect and other arthropod species and genetic diversity are catalogued and stored.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – Region Specific

Key Themes: Restoration of metal mining sites

Short Description – A century of mining activities and several historic floods in the Leadville, Colorado area resulted in waste material (tailing) being deposited along the banks of the Arkansas River. The tailing deposits are devoid of vegetation and continually erode into the river, which may negatively impact water quality and riparian ecosystems. Greenhouse studies indicated that mountain willow (Salix monticola) was a more vigorous and possibly more metal tolerant riparian species than Geyer willow (S. gereriana) and that a fluctuating water table negatively affected the biomass of both willow species. Phytotoxic levels of Cd, Mn, and Zn in the leaf tissue and phytotoxic levels of Cu and Cd in the soil could have contributed to the stunted growth of the willows in this greenhouse experiment and past revegetation efforts. Mountain willow found growing around fluvially deposited mine tailings accumulated higher concentrations of metals in its leaf tissue than Geyer willow and leaf metal uptake increased from July through September for both species of willow. Another field study showed the effect of pre-rooted versus staked cuttings on the survival of mountain and Geyer willows grown on amended tailing along the Arkanasas River. Rooted willows had a high survival rate (90%) compared with survival of staked willows (66%) after 2 growing seasons. In addition, mountain willow produced greater above ground growth for both planting types compared to Geyer willow. However, both species of willows and planting types concentrated Cd, Mn, Pb, and Zn in their leaf tissue above levels considered toxic to plants which could be negatively affecting the willows.

Impact - Willows are important species for stream restoration projects as they help stabilize streambanks from high flow events and provide food and cover for herbivores and aquatic invertebrates. Results from these studies suggest that mountain willow is a better species to use in restoration projects than Geyer willow in montane areas. Also, the use of pre-rooted willows is an effective technique for successful revegetation of amended fluvial mine tailing deposits.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Entry of invasive plants into remote areas

Short Description – Exotic plants have a significant affect on rangeland ecosystems in the West and unless we increase our understanding of the controlling factors in these invasions this trend will continue into the future. Recreational trails into wilderness areas and national forests provide potential entry points and dispersal corridors for exotic plants. The trailhead represents a local reservoir for plants transported to the site by trail users. The most likely transport mechanisms include material on the outside of vehicles, on recreational equipments (boots, bicycles, etc.), and in the gut of recreational animals such as horses, dogs or lamas. While some propagules will be transported to points along the trail, there is a very high probability that a portion of any propagules brought by recreationists will be deposited at the trailhead. In 2004, native and exotic plants were sampled at nine trail heads in close proximity to Fort Collins, Vail, and Estes Park, Colorado U.S.A. The objective of this work was to understand if there is a pool of exotic species at trailheads and whether distance from a city and elevation influence the number of exotic plants found at trailheads. There were an average of 6 exotic plants on trailheads and 3 at the off-trailhead locations representing 26 and 38 percent of the species respectively. Smooth brome (Bromus inermis) was the most common exotic species at both trailhead and off-trailhead sites. It was present at 8 of the trailheads and 6 of the off-trailhead locations. The number of exotic species at trailheads was positively related to both distance from the closest city and elevation. The number of exotic species off-trailheads was negatively related to distance and positively related to elevation. Elevation explained most of the variability in both relationships. The most likely explanation for the role that elevation plays is related to water availability. As elevation increases, precipitation increases and potential evaporation decreases. It is possible that exotic species have the lowest probability of being successful at the driest locations and the highest probability at the wettest sites.

Impact - Trailheads in national forests and wilderness areas have a greater number of exotic plant species than adjacent undisturbed areas. This suggests that trail users are transporting plants with their recreational equipment and animals. It also implies that trailheads are local source areas from which exotic plants can enter wild lands via trail activity. This information will be useful to land managers because it indicates that trailheads are locations at which exotic plant control can be focused to lower the probability of invasions of wild lands.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Historic and current status of forest vegatation

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. A project has been examining several aspects of these changes, with a key focus on spatial and temporal patterns. A key component of this year's work has been characterizing spatial and temporal patterns in an intact, old-growth ponderosa pine forest in the Manitou Experimental Forest. This 9-ha stand has been stem mapped and remeasured at decadal intervals since the 1970s. This research revealed that the current stand density of 400 trees/ha was double that of 1860 (before Euro-American settlement), representing an increase in basal area of about 30%. Both fire and climate historically influenced tree establishment, and stand structure also played a major role in the location and timing of regeneration events. The patchy process of regeneration resulted in spatial independence and some segregation of size classes. Large (40-55 cm dbh), old trees exhibited some regularity in their spatial distribution at short distances. Contemporary patterns of mortality were mostly patchy, possibly as a result of density-dependent mortality as well as disease. The growth of individual trees depended in large part on the number and size of neighboring trees, with the greatest influence of trees within 14 m of the focal tree. The supply of soil N influenced tree growth at very small scales (< 2 m), but the effect of N was swamped by the effects of competition at larger scales. Although the natural processes driving them have changed considerably, both establishment and mortality have retained spatial patterns that are at least consistent with pre-settlement forests, and that may help to preserve elements of the heterogeneous structure attributed to historical ponderosa pine forests.

Impact - The key impacts of this project include verification that although this reference forest changed during the 20th Century, the changes were not as dramatic as found for ponderosa pine forests on other soils in other areas. Restoration treatments may be useful in stands of this type, but other areas that demonstrated major changes in the 20th Century should have a higher priority.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

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

CSU Program 6. *Rural and community development*

Key Themes: Community based collaboration for environmental management

Short Description – This project aims to increase understanding of the role of community-based collaboratives in managing Colorado rangelands, develop approaches to evaluating the social and environmental outcomes of collaboration, document local knowledge of rangeland users, and investigate the roles that science, local knowledge and other forms of expertise play in management decisions on rangelands. Research will provide a better understanding of the roles that science and local knowledge play in both collaborative and conventional management efforts and will identify mechanisms of successful knowledge integration and application. In 2004 a participatory research

relationship was initiated with the Northwest Colorado Stewardship (NWCOS), a multistakeholder collaborative group based in Moffatt County, Colorado. An interactive workshop was facilitated to help NWCOS participants develop a draft adaptive management plan for off-road vehicle use in BLMs Little Snake Resource Area. This process is intended to provide participants with hands-on experience with the adaptive management process and will not necessarily be incorporated into the BLMs planning process.

Impact – This research will inform policy on collaborative initiatives and on linking science, local knowledge, and resource management, assist collaboratives in monitoring their own progress and, help agencies and policy-makers assess the costs and benefits of investing in collaborative decision-making processes.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Economic impact of public policy decisions

Short Description – Public agencies often need economic valuation information about public and visitors' support or opposition to natural resource management such as forest thinning to reduce fire danger. 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. Another important research issue is whether there is uniform support across, between, and within different ethnicities for public forest fire prevention programs involving prescribed burning. Research conducted addresses both of these concerns in order to provide guidance to public agency staff and decision makers about the use of existing valuation literature in natural resource management trade-off analyses involving forest fire prevention. 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. This is true among visitors, as well as White and African American households. However, the results also conveys to managers that there is not uniform support for prescribed burning, with about 15% of households not only opposed to prescribed burning but they would require compensation for the smoke. This suggests resource managers and public officials need to be aware there are multiple publics that must be accommodated, rather than one public. There also appears to be some limited transferability of willingness to pay estimate across the western states of California, Colorado, and Montana. Research was also conducted on estimating the economic values lost and economic impacts associated with banning snowmobiles in Yellowstone National Park.

Impact - Valuation research and benefit transfer research is being used by federal agencies for their economic analyses throughout the U.S. For example, the USDA Forest Service (USFS) has a recreation values database on their website for use by agency personnel and others outside the agency for recreation benefit transfer. This research on the effect of forest fires on property values in Pine, Colorado as a result of the Buffalo Creek fire has stimulated the USFS to perform follow-up property value studies in Colorado and to fund CSU to investigate this relationship for more than 8,000 acres of forest fires affecting more than 1 million people in southern California. The research on recreation use at Grand Teton National Park (310,000 acres) is being used by the National Park

Service and U.S. Fish and Wildlife Service in their Environmental Impact Statement on elk and bison management in the Park and Refuge. The results of our economic study of the snowmobile ban in Yellowstone National Park (2,219,791 acres) will be utilized by the National Park Service.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – Regional

Key Themes: Land use change and conservation alternatives

Short Description – The extent and pattern of land use changes are studied at the rural-urban fringe, and in particular the mechanisms used to conserve these lands. A key initial effort completed is the development of a list of values that local communities recognize in land use planning efforts. From this list it will be able to ascertain what ecological, agricultural, and community values are trying to be protected. Also, this list is key because the US Internal Revenue Service requires that for an easement to qualify for conservation purposes, the conservation easements must yield significant public benefits that are consistent with public and private conservation programs. Initial data has been compiled for landscape analysis of development patterns, including parcel, elevation, roads, vegetation, and aerial photography for 5 counties in Colorado. To assess the benefits easements and other conservation tools produce, their viability and their contribution to landscape scale conservation efforts, a survey was developed to examine the motivations and perceptions of Larimer County landowners who have granted easements, development agreements or restrictive covenants and those who later purchased property which had been conserved in one of the aforementioned ways. It also examines the viability of different types of private land conservation using interviews, document research and a few of the items on the landowner, survey.

Impact - The typology of protected areas will provide a general framework in which to discuss private, as well as public, land use change and context. The landscape analysis will provide empirical data on which to develop a quantiatitve measure of different land use patterns (not just intensities), which has critical importance for understanding possible ecological effects, as well as economic (infrastructure) costs.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

Key Themes: Local food systems

Short Description – Work was completed on direct marketing and local food systems, focusing on market potential for value-added enterprises by farmers and ranchers. Past activities were related to marketing to chefs in Northern Colorado, new product development by beef producers on the West Slope and retailing of local products.

Impact – One cooperator in the program, Colorado Homestead Ranches, has grown sales by 50 percent per year, enhanced sales for other producers who sell through their retail outlet, and recently purchased a processing plant to sustain the direct market potential for numerous livestock producers on the West Slope.

Source of Federal Funds – Hatch Act Funds

Scope of Impact – State Specific

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. The meeting locations and dates are listed below.

D. Program Review Process

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

E. Evaluation of the Success of Multi and Joint Activities

The following are selected examples of the interactions 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. Major revisions and updates to the 167 page bulletin were made by 22 authors and editors from the multi-state area, and will be of value to bean workers and growers nationwide. We anticipate that more than 5000 copies will be sold in CO, WY and NE in the next year.

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.

Food safety education - Food Safety for High-Risk Groups, a 2-credit graduate-level academic course, was simultaneously taught via interactive video and web-based technology at three university campuses (Ohio, Colorado and Washington) on three different time zones. Students (n=37) registered for academic credit at their respective universities. Faculty at each university facilitated the class locally and each taught approximately 10 hours of instruction to all campuses. Lectures were delivered via video-conferencing. A central web site established at Ohio State allowed students to receive syllabus and assignment information, email instructors, participate in threaded discussions, view MP3 files of classes presented and submit assignments. Course outcomes were measured as examinations, class participation, an oral presentation, and a research paper. Class evaluations indicated high acceptance of the course content and methods of delivery. Students agreed their learning was above average compared to other classes and was enhanced by the opportunity to hear experts in the field from across the country.

F. Multistate Extension Activities

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 2000**	**FY 2001**	**FY 2002**	**FY 2003**	**FY 2004**
Plant and animal improvement and new agricultural development.	$266,695	$177,681	$330,514	$190,424	$204,387
Plant and animal production systems	$53,358	$100,476	$66,126	$162,713	$179,008
Safe and effective management of pests	$68,759	$95,173	$85,213	$72,190	$159,451
Food Safety and Nutrition	$88,657	$65,911	$109,872	$128,882	$111,040
Agriculture and environmental quality	$46,625	$76,823	$57,782	$131,378	$232,959
Rural and community development	$398	$81,699	$493	$18,605	$ 590
Total	$524,492	$597,763	$650,000	$704,192	$887,436

/s/ Lee Sommers — May 13, 2005

Director — **Date**

Form CSREES-REPT (2/00)