Plan of Work

Colorado State University
Agricultural Experiment Station
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I. Program Descriptions

USDA Goal 1: An agricultural system that is highly competitive in the global economy. Through research and education, empower the agricultural system with knowledge that will improve competitiveness in domestic production, processing, and marketing.

CSU Program 1: Plant and animal improvement and new agricultural product development

Statement of Issue

Genetics and Breeding of Livestock and Crops

Significant opportunities exist for enhancing livestock through genetics and breeding. Research is needed on techniques such as sexing semen, early pregnancy tests, cryopreservation, cloning by nuclear transplantation, embryonic stem cells, gene mapping, tracking alleles through meiosis, etc. In most cases, these tools are used in concert with more traditional research approaches. Techniques being developed to map the human genome will be invaluable for mapping genomes of farm animals.

Genetic enhancement of plants for human use has been the key that has allowed emergence of agricultural societies. The modern role for genetic enhancement of plants is no less significant and demanding because we expect development of plants that will increase production, improve nutritional and processing characteristics, resist pests, and tolerate stress from heat, cold, salt, and drought. While traditional breeding programs have served us well in the past and will continue to have a necessary role in developing new varieties, the relatively recent advent of molecular genetics has added a new and powerful tool for plant improvement. Molecular genetics offers opportunities to engineer plants with specific characteristics that might never be practically achieved through sexual hybridization techniques. New research methodologies, in combination with traditional breeding methods, can enhance the safety and nutritional quality of plants. Molecular and whole plant improvement is one of the most cost effective and environmentally sound methods of enhancing the ability to produce food, fuel and fiber.

Development of new crops and enhanced utilization of conventional plant and animal materials

The agricultural and forestry industries have experienced a decline in profitability because of excess production of conventional commodities. This situation provides excellent incentive for the development

of new food and non-food uses of plant and animal materials. Both the primary products (such as starch, proteins and lipids) and the lower valued by-products (such as straws and slaughterhouse waste) of conventional agriculture may be considered as starting materials for these new uses. Opportunity also exists for the development of new crops that have attractive processing attributes or contain materials having industrial value.

In developing non-food uses, it will be necessary to target existing markets for commodities currently obtained from other sources, such as petroleum. Thus, processing methods will have to be developed that are competitive with these existing technologies. This will include development of effective techniques for purifying existing components and/or derived products. Both chemical and biochemical (i.e., enzymatic and microbial) conversion methods will need to be explored.

In the processing of unconventional crops and in the development of new products from conventional plant and animal materials, it will be necessary to develop new and/or improved processing technologies. This work will encompass a variety of operations including extrusion, extraction, fermentation, chemical and biochemical transformations, and the various processes needed to concentrate and purify the high value products that are derived from agricultural materials. Also of importance will be the development of improved methods of process control. This will involve the use of modern control strategies (such as adaptive control and expert systems) as well as the development of on-line sensors for the analysis of key components and/or quality attributes. As in all new product development work, it will be necessary to determine cost/benefit ratios and to analyze marketing and distribution systems in order to assess the commercial feasibility of potential products.

Performance Goals:

1. Develop improved crop cultivars
2. Enhance understanding of animal reproduction
3. Develop and evaluate new agricultural commodities and products

Output Indicators:

1. Release of new plant genetic resources such as cultivars and germplasm
2. Development of new products or alternative uses
3. Develop new technologies to enhance animal reproductive efficiency

Outcome Indicators:

1. Adoption rates of released plant cultivars by producers resulting in greater yields, lower production costs, reduced use of pesticides, and improved environmental quality.
2. Reduced environmental impact by use of pest tolerant plant cultivars.
3. Improved quality of end products generated from crops.
4. More economical production of feeds and chemicals from agricultural byproducts
5. Improved cattle production by predetermining offspring
6. Improved economic return to producers, production efficiency, product quality and composition, and consumer acceptance

Key CSU Program Components:

Reproductive efficiency of livestock. Develop information and methods to improve reproductive efficiency including increasing pregnancy rate, decreasing embryonic mortality and decreasing prenatal mortality.

Animal genetics and breeding. Determine biological mechanisms required for genetic engineering of animals including embryo stem cell technology, cloning and developing transgenic animals. Develop technology and methods for animal breeding. Determine the biochemical and physiological processes controlling important animal traits.

Plant breeding and gene expression technology. Develop improved varieties of economically important crops. Improve and develop new technologies to facilitate insertion of genes into economically important plants. Determine the biochemical and physiological processes controlling important plant traits.

Genome mapping. Map characteristics of animals and plants to aid in both traditional and molecular genetic methods of manipulating animal and plant germplasm.

Alternative crop, livestock, and food enterprises. Identify alternative crops suitable for production in Colorado that contain components of commercial value. Develop production, processing, and marketing approaches for alternative agricultural commodities. Develop chemical and biochemical processes for converting major crop constituents and residues to higher value, alternative products.

Internal and External Linkages:

Colorado Wheat Administrative Committee
Colorado Dry Bean Administrative Committee
Colorado Potato Administrative Committee
National Cattlemen's Beef Association
Colorado Cattlemen's Association
Colorado Livestock Association
Colorado Woolgrowers Association
Colorado Apple Administrative Committee
Colorado Wine Industry Development Board
Colorado Corn Growers Association
Colorado Wheat Growers Association
Colorado Department of Agriculture
Colorado Department of Natural Resources
Colorado Certified Seed Growers Association
Colorado Certified Potato Growers Association
Colorado Organic Producers Association
Rocky Mountain Turfgrass Research Foundation
GreenCo
Colorado Golf Course Superintendents Association
National Renewable Energy Laboratory
USDA-Agricultural Research Service
USDA-Natural Resource Conservation Service
USDA-Forest Service
Colorado Cooperative Council
Colorado Farm Bureau
Rocky Mountain Farmers Union
Colorado State Grange
National Science Foundation
National Institutes of Health
US Environmental Protection Agency
Colorado State University departments involved include animal sciences, biology, chemical and bioresource engineering, food science and human nutrition, horticulture and landscape architecture, physiology, and soil and crop sciences.

Multistate Components:

Colorado State University contributes to four multistate projects in this program (W112, W171, W150, W006).

Integrated Research and Extension Activities:

This program contains integrated research and extension projects in the following areas:

1. Research and development of new crops
2. Plant and animal genetic resources including cultivar development

Target Audiences:

Crop and livestock producers, ranchers, farmers, foresters, agribusiness firms; local, state, and federal agencies involved in agriculture and forestry.

Program Duration:

Greater than 5 years

CSU Program 2: Systems for Producing, Processing, and Marketing of Agricultural Products

Statement of Issue

Integrated Animal, Plant, Range and Forest Systems

Efficient animal and plant production systems are a result of information developed in several disciplines including animal and plant genetics, nutrition, physiology, range management, economics and marketing. As agriculture becomes more complex, technology must be developed which allows producers to optimize production and maximize profitability using environmentally sound methods. Advances in computer technology and animal and plant biology have provided the ability to successfully develop realistic models.

Further research is needed to understand interrelationships among individual variables in production systems, to develop mathematical models that accurately describe these interrelationships, and to produce models that are effective in real world situations. Of specific importance is the incorporation of biological and economic models to create a total decision making tool. This type of technology not only optimizes economic return, but it can enhance natural resource use and environmental sustainability.

Research in integrated systems relies upon research results, data and information developed by other program areas. The development of models to synthesize other research and of systems to deliver research information is the focus of integrated systems objectives and scientist effort.

Biology and Management of Plant Growth

Crop production is vulnerable to environmental stress in Colorado because rapidly changing weather systems combined with a wide range of altitudes often produce severe fluctuations in temperature and precipitation. Such stresses are an ongoing concern due to severe fluctuations, and especially if predictions about global warming and UV-B radiation materialize. Basic research on the physiology, biochemistry and biophysics of plant stress adaptation and resistance mechanisms is needed to identify specific gene control systems for application to plant biotechnology and to conventional breeding programs. Basic knowledge is also needed to develop new approaches to improve management techniques.

Over two thirds of the shortfall between record crop yields and long-term average yields can be attributed to environmental stresses such as drought, heat, cold, and salinity. Adaptation to these stresses exists in some cultivars and species, but breeding for this is hampered by lack of knowledge about how stresses impact plant growth. Mechanisms controlling growth at the physiological and metabolic levels need to be understood in relation to stress adaptation.

In the major agricultural regions of the state, annual precipitation is less than potential evapotranspiration during the growing season for most crops. Irrigation from developed surface and ground water resources is used to offset this water deficit on a wide range of crops. Although irrigated crops occupy only about 26% of the cultivated cropland in Colorado, they account for approximately two- thirds of the total value of crop production. High costs of electric power and natural gas, ground water depletion, and declining prices for feed grains and beef have forced reductions in water application in areas where ground water is used for

irrigation. Competition by municipalities and industrial interests will likely cause similar reductions on land irrigated with developed surface water. Research to increase our understanding of crop water use efficiency, plant response to water deficits and microclimate changes, and cultural practices that increase stress resistance will promote more effective use of water resources and lessen the impact of water conservation efforts on the agricultural economy. This research will also aid in the development of strategies to minimize the impact of water conservation measures on plants in urban settings.

The diversity of plant material in use for other than food crops is relatively narrow compared to the vast pool of woody and herbaceous plant species available. Increasing the diversity of commercially available plants best suited for the region is needed. Plant species that are adaptable, attractive and readily producible must be tested for their suitability to the region, especially in light of the impending needs for water conservation. Water conservation through creative landscaping must be investigated. Germplasm activities including plant exploration, preservation, and characterization will be fundamental for breeding and development of landscape plants. New techniques in plant molecular genetics must be applied. Plant responses to environmental and biological stresses must be understood to create screening techniques, which select for tolerance to these stresses.

Biology and Management of Animal Production

Opportunities exist to improve biological efficiency in livestock. Simply increasing the reproductive rate – marketable units per breeding animal -- results in great improvements in efficiency. Examples include lowering morbidity and mortality, raising larger litters or arranging for twins in monotocous species. Another opportunity is producing the right product for the market in a timely fashion. Problems include too much fat on beef carcasses, a glut of cull cows for hamburger in late fall vs. a shortage in midwinter, and obtaining male offspring when a maternal line of female replacements is desired. Improving feed efficiency and growth rates, for example with steroid implants, represents a third category of opportunities.

Improved management decisions based on sound information can reduce inefficiencies such as over-finishing fed animals and retaining nonpregnant breeding animals. Biotechnology involving transgenic animals is a powerful technique that will help us to understand how genes are expressed to produce the animals and animal products of interest. A significant amount of genetic variability is already available to improve efficiency, and more can be created. With increased biological efficiency, fewer animals are needed; this provides major opportunities, for example in decreasing use of grain and reducing pollution.

Animal Health and Well-Being

The cost of mortality and morbidity associated with biotic and abiotic stress and disease continues to be one of the largest contributors to efficiency loss in animal production. In addition, growing concerns about animal welfare identify an urgent need to develop and adopt production practices that contribute both to efficiency and welfare. Modern animal agriculture places increasing emphasis on disease prevention rather than treatment, and development of herd management techniques rather than treatment of individual animals.

Researchers have made progress in the basic molecular biology and genetics of the animal immune system, as well as in the ability to manipulate the microorganisms responsible for producing disease and their metabolic products. Recombinant immunologics are commercially available, and highly specific inexpensive diagnostic tools have also entered the marketplace. Thus, researchers can develop an inherent resistance to disease, an enhanced acquired immunity, or a combination of both. A better understanding is needed about the relationships between biotic and abiotic stress as they are influenced by management systems in a multidisciplinary approach to animal systems.

Performance Goals:

1. Develop improved systems for plant and animal production, processing, and marketing.
2. Enhance ability of plant and animal production systems to tolerate environmental stresses.
3. Develop approaches for preventing and curing animal diseases.

Output Indicators:

1. Systems developed for integrated management of resources (land, plant, livestock, people).
2. Increased efficiency in plant and livestock production systems.
3. Models developed for enhanced management of production systems.
4. Improved methods for treating and preventing animal disease.

Outcome Indicators:

1. Models predict response of plant and livestock production systems.
2. Reduction of animal disease will increase cattle performance, reduce mortality, and profitability
3. Disease control will enhance exports of cattle and sheep
4. Increased profitability from plant and livestock enterprises.
5. More environmentally sound management of private, state and federal lands.

Key Program Components:

Cropping systems. Develop cropping systems for irrigated and dryland production regions of Colorado. Determine the effect of existing and alternative cropping systems and urban landscape schemes on the water use and energy balance within systems. Develop cultural management systems for major turf, woody and herbaceous species and quantify the effects of irrigation water, pesticides and plant nutrients on growth and development.

Modeling of production systems. Develop bio-economic mathematical models at the animal and plant levels to integrate biological, ecological and economic systems. Develop production decision models that integrate natural resource management, animal and plant production and marketing technologies, and financial management including risk assessment.

Plant adaptation to stress. Determine the physiological control mechanisms in plants that facilitate adaptation to stress. Develop technology that can be applied by growers to overcome losses from environmental stresses. Determine the relationship between plant water use efficiency and physiological responses by plants to soil water deficits and atmospheric stresses. Evaluate new turf, woody, xerophytic, and herbaceous plants for urban and rural environments.

Animal nutrition and growth. Develop information and methods to improve efficiency of animal growth. Increase understanding of factors influencing nutritional requirements of animals including effects of environment and genetics.

Animal well-being. Evaluate the effects of stress from management and the environment on clinical disease, subclinical disease and animal well-being. Develop techniques for rapid diagnosis of infectious disease. Determine the pathogenesis and control of disease in the neonate.

Internal and External Linkages:

Colorado Wheat Administrative Committee
Colorado Dry Bean Administrative Committee
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Colorado Livestock Association
Colorado Woolgrowers Association
National Cattlemen's Beef Association
Colorado Apple Administrative Committee
Colorado Corn Growers Association
Colorado Department of Agriculture
Colorado Department of Natural Resources
Colorado Certified Seed Growers Association
Colorado Certified Potato Growers Association

Colorado Wheat Growers Association
Colorado Wine Development Board
Rocky Mountain Turfgrass Research Foundation
GreenCo
Colorado Golf Course Superintendents Association
Colorado Organic Producers Association
National Renewable Energy Laboratory
USDA-Agricultural Research Service
USDA-Natural Resource Conservation Service
USDA-Forest Service
Bureau of Reclamation
Bureau of Land Management
Colorado Cooperative Council
Colorado Farm Bureau
Rocky Mountain Farmers Union
Colorado State Grange
National Science Foundation
National Institutes of Health
US Environmental Protection Agency
Colorado State University departments involved include animal sciences, chemical and bioresource engineering, forest sciences, horticulture and landscape architecture, microbiology, physiology, rangeland ecosystem sciences, statistics, and soil and crop sciences.

Multistate Components:

Colorado State University contributes to five multistate projects in this program (W173, W168, W130, W106, NC140).

Integrated Research and Extension Activities:

This program contains integrated research and extension projects in the following areas:

1. Integrated resource management for beef and sheep production.
2. Crop production systems involving forages, fruits, vegetables, and horticultural crops.
3. Ecology of Rocky Mountain forests

Target Audiences:

Crop and livestock producers, ranchers, farmers, foresters, agribusiness firms; local, state, and federal agencies; environmental organizations; and non-governmental organizations involved in agriculture and forestry.

Program Duration:

Greater than 5 years.

CSU Program 3: Safe and Effective Management of Pests

Statement of Issue

Management of insect, disease, nematode and weed pests is crucial in sustainable production of food, fiber, and timber. Pests and pest management activities impact production cost, product quality and safety. Concerns about environmental quality and food safety are targeted to pesticides, frequently without sufficient consideration of their positive impacts. Researchers need to explore non-chemical alternative means of pest control, while continuing to decrease risks associated with pesticide use.

Safe and effective management of pests is dependent upon knowledge of pest biology and ecology. Integrated pest management should combine as many appropriate control measures as necessary into cost-

effective and environmentally-sound programs. These include: (a) plant genetic resistance, (b) biocontrol measures, (c) cultural practices, and (d) safe and judicious use of pesticides.

Performance Goals:

1. Develop pest control strategies based on pest biology and ecology.
2. Improve biological control approaches to pest management.
3. Enhance use of integrated pest management in plant production systems.

Output Indicators:

1. Improved understanding of pest populations and their ecology.
2. Develop more accurate methods of chemical application.
3. Identify new and improved agents for use in biological control

Outcome Indicators:

1. Increased adoption rate of integrated pest management and biological control approaches will reduce environmental impact of pesticide use.
2. Reduced crop loss due to weeds and pests will reduce cost of production.
3. Enhanced biodiversity in crop production systems.
4. Improved strategies for pest control.

Key Program Components:

Pest biology and ecology. Define the biology and ecology of key pest species to better understand and develop control strategies.

Integrated pest management. Develop and enhance integrated pest management programs that decrease and rationalize pesticide use. Improve identification and selection of biological control agents.

Risk assessment/communication. Improve methods for assessing and communicating the risks and benefits of pesticides and their alternatives to both producers and the general public.

Internal and External Linkages:

Colorado Wheat Administrative Committee
Colorado Dry Bean Administrative Committee
Colorado Potato Administrative Committee
Colorado Cattlemen's Association
Colorado Livestock Association
Colorado Woolgrowers Association
Colorado Apple Administrative Committee
Colorado Corn Growers Association
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National Science Foundation
National Institutes of Health
US Environmental Protection Agency
Colorado State University departments involved include animal sciences, chemical and bioresource engineering, forest sciences, horticulture and landscape architecture, microbiology, physiology, rangeland ecosystem sciences, statistics, and soil and crop sciences.

Multistate Components:

Colorado State University contributes to three multistate projects in this program (W187, W189, and NC202).

Integrated Research and Extension Activities:

This program contains integrated research and extension projects in the following areas:

1. Biological and ecological basis for weed management
2. Biology and control of insect pests in crops

Target Audiences:

Crop and livestock producers, ranchers, farmers, foresters, agribusiness firms; local, state, and federal agencies involved in agriculture and forestry and pest management activities; commercial pest managers.

Program Duration:

Greater than 5 years.

USDA Goal 2: A safe and secure food and fiber system. To ensure an adequate food and fiber supply and food safety through improved science based detection, surveillance, prevention, and education.

And

USDA Goal 3 A healthy and well-nourished population. Through research and education on nutrition and development of more nutritious foods, enable people to make health promoting choices.

CSU Program 4: Food Safety and Nutrition

Statement of Issue

Food Safety

Few issues have greater impact on the entire agricultural community than that of the safety and quality of the food supply. Areas of concern include microbiological safety, pesticide residues and natural toxins that can occur from production to consumption of the food. Innovative biotechnology or new processing and packaging methods may contribute to safety and quality concerns. Facilities, equipment, and rapid, sensitive methods for the detection and monitoring of all components of food must be available. Public concerns about these issues must be addressed scientifically.

Food safety and consumer protection are vital issues for government, industry, and consumer groups. Today a sophisticated food processing and delivery system supplies consumers with a greater variety of food and a higher level of safety than ever before. While the food supply in this country is recognized as high quality, we must continually monitor and guard against contamination by chemical, microbiological, and natural toxins. The mere complexity of our present-day food system has led consumers to question

various practices and assumptions, and these questions must be rationally answered. New products, processes, and biotechnological advances require a continual upgrade of our knowledge base regarding the toxicology and analysis of possible contaminants in our food supply.

Nutrition and health

The physico-chemical properties of the components of food and fiber commodities and the nature of their interactions determine quality, organoleptic characteristics, and applications. Knowledge of these properties and the manner in which they are affected by conventional or new production technologies is extremely inadequate. Furthermore, the relationships between molecular structure and function are critical to ensure innovative formulation/ fabrication, chemical and processing control, rational application of biotechnology, and effective development of new food and non-food products that meet the specific needs of particular markets. Research methods and databases are required for the physical, chemical, and colloidal polymer properties of foods and biomaterials and their components, such as polysaccharides, proteins and lipids.

Nutrition is crucial to both health maintenance and disease prevention. The role of nutrients, both at deficient and excessive intakes, in health promotion and disease prevention has been recognized for many years. The requirements for nutrients at the cellular level are strikingly different, both quantitatively and qualitatively, from those for the body as a whole. Cellular nutrition and the interaction between the genome and nutrients are providing new insights to disease and new approaches and treatments in health maintenance and disease prevention.

Nutrition is involved in both health promotion and disease prevention. About 40 required nutrients contribute to health maintenance. These are important in reproductive success, growth, resistance to disease, brain development and function, physical performance, tissue integrity and hence optimal health. In addition, nutrition is recognized increasingly as playing a role in reducing the dietary risk of such chronic diseases as obesity, heart disease, diabetes, hypertension, cancer and osteoporosis. For most people, adequate intake of essential nutrients and reducing nutrient excesses are most important in health promotion and reducing the dietary risk of chronic disease, respectively.

Chronic diseases, all of which have dietary components, limit lifespan and quality of life today. Heart disease and cancer are major causes of all deaths. Obesity contributes to both heart disease and cancer. Diabetes and hypertension contribute to heart disease and stroke. Osteoporosis results in many fractures in the elderly that are life threatening and in many cases life-limiting. The public's interest in these matters is extremely high, as evidenced by many feature articles in the major national news sources, both print and TV. Thus, health concerns increasingly influence food choices and hence the market for agricultural commodities and processed food items.

Performance Goals:

1. Improved safety of foods for consumers
2. Enhanced approaches to improve human health through nutrition

Output Indicators:

1. Improved assessments of adequate nutrition.
2. Improved methods to detect pathogens in meat.
3. Higher quality meat and plant products.
4. Enhanced databases useful to food safety research and outreach.

Outcome Indicators:

1. Translation of nutrition research to exercise and daily living, health and disease prevention, and community and food production.
2. Reduced incidence of foodborne illness and healthier communities.
3. Expanded domestic and international marketing opportunities

4. Reduced probability of contamination of food raw materials and products.
5. Improved economic return and enhanced marketability of products.
6. Results incorporated into HACCP systems.

Key Program Components:

Improved processes for food processing. Develop new or improved processes to prevent contamination and minimize deterioration. Define processing parameters that can remove harmful biological and/or chemical components. Determine effects of extrusion and other cooking processes on the nutritional and flavor properties of meat products.

Safety aspects of product development. Employ hazard analysis critical control point strategies to identify and monitor critical control points in production, processing, and distribution of food. Develop methodologies to assess relative risks of various components of food products considered to be harmful. Monitor and evaluate new developments in production, processing, packaging, and preparation practices to determine their impact on food safety and quality.

Diet and health and nutrient bioavailability. Determine important relationships between diet and health. Increase our understanding about human obesity and develop improved methods for its prevention and treatment. Determine the effects of plant breeding and food processing on the bioavailability of vitamins and minerals, and on the digestibility of protein, complex carbohydrate and dietary fiber. Investigate the development of unique food products or ingredients to address specific nutritional or health problems.

Internal and External Linkages:

Colorado Wheat Administrative Committee
Colorado Dry Bean Administrative Committee
Colorado Potato Administrative Committee
Colorado Cattlemen's Association
Colorado Livestock Association
Colorado Woolgrowers Association
Colorado Apple Administrative Committee
Colorado Corn Growers Association
Colorado Department of Agriculture
National Cattlemen's Beef Association
Colorado Organic Producers Association
USDA-Agricultural Research Service
Food and Drug Administration
Colorado Farm Bureau
Rocky Mountain Farmers Union
Colorado State Grange
National Science Foundation
National Institutes of Health
Colorado State University departments involved include animal sciences, chemistry, and food science and human nutrition.

Multistate Components:

Colorado State University contributes to five multistate projects in this program (W122, W143, NC167, W177, W191).

Integrated Research and Extension Activities:

This program contains integrated research and extension projects in the following areas:

1. Improving food safety for consumers
2. Enhancing quality and safety of meat products

Target Audiences:

Consumers, local, state, and federal agencies involved in food safety, human nutrition and related issues; food manufacturing, processing, and distribution firms; dietitians and other human nutrition professionals; educators involved in human nutrition and wellness programs; food and processing and meat packing firms.

Program Duration:

Greater than 5 years.

USDA Goal 4: Greater harmony between agriculture and the environment. Enhance the quality of the environment through better understanding of and building on agriculture and forestry's complex links with soil, water, air, and biotic resources.

CSU Program 5: Agriculture and environmental quality

Statement of Issue

Natural Resources and Ecosystem Management

An increasing world population is placing greater demands on our natural resources. Public concern for a quality environment has increased as agriculture has become more complex and population pressures have increased. Natural resources must be conserved and their capacity maintained or improved in order to meet the needs of future generations. The long-term viability of agriculture and forestry production is tightly linked to proper use and protection of our soil, air and water resources. Production agriculture and forestry are often named as major contributors to the deterioration of natural ecosystems and environmental quality.

Development of management practices that are compatible with a high quality environment requires new methods of study that involve entire agroecosystems. Quantitative relationships between agriculture, natural resource use, and environmental quality must be defined. This will require a more thorough understanding of basic biological/ecological processes, as well as computer-aided systems management research. Continuing to use natural resources to produce agricultural, range, and forestry products requires new multiple use strategies which are realistic in terms of biological, economic, social and environmental constraints. Transport and fate of pesticides, fertilizers, and other agricultural chemicals, as well as threatened and endangered species, biodiversity, habitat, wetlands, and water are all issues of concern. Knowledge must be developed to understand and evaluate competitive land use impacts and interactions on agricultural, range, and forest lands. This research provides the basis for developing agricultural and forestry management systems that are more compatible with conservation and environmental goals. This program intends to provide workable compromises instead of burdensome regulatory programs.
Concern for the quality of surface and subsurface water supplies has reached national prominence. Protecting the quality of ground and surface water supplies is an issue of local and national concern. Agriculture has been identified as the largest contributor to non-point pollution in the U.S. Clearly, protecting water quality will require reducing the use and mitigating the impacts of agrochemicals while maintaining an economically viable production system. Renewed effort is needed to identify and implement best management practices, as well as develop databases and models to determine the fate and transport of contaminants at the field or even larger scales.

Global climate models indicate that significant changes in climate are likely in the next few decades due to the increase in "greenhouse" gases. Changes in the variability of climate could occur as well as changes in the mean condition. This change in climate could have significant impact on the diversity, productivity and distribution of plant, animal and microbial systems.

The global environmental change is likely to modify temperature, precipitation, evaporation, wind, radiation and sea level. Present understanding of the effects of climate and climate variation on plant, animal and microbial ecosystems are not adequate to allow an assessment of the impacts of global change.

Knowledge must be developed to determine the sensitivity of these systems to global change and to evaluate the effects at macro and micro environmental levels. The recent emphasis on the potential for soils to serve as a sink for atmospheric carbon dioxide warrants an expansion of tillage and cropping systems research. The increase in basic knowledge will allow scientists to predict future conditions for agriculture, forestry and related natural resources.

Water: Quality, Quantity, and Management

Assessing the extent of groundwater contamination and the means of mitigating contamination have generated a call for research and monitoring programs. In Colorado, surveys of wells in the San Luis Valley and the South Platte Valley have found that significant numbers exceed the drinking water standard for nitrate. Problems of ground water contamination from pesticide have been less well documented within the state, but monitoring studies are beginning. Shallow aquifers in areas of high chemical usage could be vulnerable to pesticide contamination. Colorado conditions, which include low precipitation, high altitudes and both high and low temperatures, are different from those under which many studies of chemical transport, transformation, and fate have been conducted.

The agricultural sector in Colorado is dependent on the efficient use of water. Maximizing precipitation capture in dryland agriculture is critical to sustainability in much of the state. Availability of high quality surface and groundwater for irrigation use and proper management of both are essential. Increased competition between the urban and agriculture sectors for limited high quality water supplies will be encountered, and conversion of irrigated land to dryland farming will continue. It is therefore critical that irrigation efficiency be improved as urban water needs grow. The principles of water capture and storage in soils are common to both dryland and irrigated agriculture and form the basis for research in efficient use of water for both systems.

Performance Goals:

1. Develop approaches for natural resource and ecosystem management.
2. Propose technical, institutional, or social solutions to water quality and quantity problems in Colorado.
3. Develop technologies for managing agricultural and municipal wastes.

Output Indicators:

1. Input to state and national policy processes.
2. Production and distribution of decision-support software packages
3. Improved practices to improve water quality by reducing erosion, nutrient or pesticide movement.
4. New sensors for environmental monitoring

Outcome Indicators:

1. More scientific basis for policy decisions
2. Greater options for evaluating management choices and environmental impact.
3. Improved prediction of environmental processes such as climate, solute transport, water management, and water allocation policy.
4. Provide accessible climate and related data to clientele for application to technical and policy issues.
5. Enhanced capability for environmental monitoring.
6. Improved environmental quality and ecosystem sustainability.

Key Program Components:

Soil/water conservation. Identify crop and soil management systems that maximize precipitation use efficiency; minimize erosion by wind and water; increase soil organic matter and fertility status; improve soil physical characteristics such as aggregation and infiltration; ensure long-term food supplies; make use of animal and human waste products; and result in maximum economic benefits to farmers and the general public.

Ecosystems. Improve knowledge of the basic processes underlying the structure and function of cropland, forestland, and rangeland ecosystems. Quantify the response of important forage species to a variety of stresses including herbivory, drought, and climate change. Develop and refine the tools of systems technology (agroecological simulation models, resource allocation models, management models) to manage cropland, forests, and rangelands.

Irrigation/drainage systems. Design and implement irrigation and drainage systems to optimize water use efficiency. Evaluate the contamination of groundwater and surface water supplies (agricultural and urban). Develop conjunctive use models to manage both the surface irrigation system and the groundwater system. Develop best management practices with regard to water quality protection under Colorado conditions – in the areas of nitrogen fertilizer, pest, irrigation water, grazing and feedlot manure management.

Water quality monitoring. Develop approaches for designing and implementing water quality monitoring programs to assess the impacts of agriculture on water quality and to detect changes over time. Study Colorado watersheds and major Colorado aquifers to define potential areas that can be managed for increased water yields and evaluate strategies that would aid in protection of aquifer recharge areas to protect against urban encroachment.

Movement of constituents in soil and water. Improve sampling techniques and experimental methodology for accurate and rapid assessment of spatially variable solute transport properties at large scales. Develop screening tools, including indices and models, for assessing the local vulnerability of Colorado ground water to agricultural chemical contamination. Conduct experiments to validate or improve contaminant fate and transport models in natural and agricultural systems.

Internal and External Linkages:

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National Renewable Energy Laboratory
USDA-Agricultural Research Service
USDA-Natural Resource Conservation Service
USDA-Forest Service
Colorado Cooperative Council
Colorado Farm Bureau
Rocky Mountain Farmers Union
Colorado State Grange
Environmental Protection Agency
Department of Energy
US Geological Survey
Bureau of Land Management
Bureau of Reclamation
Colorado State University departments involved include agricultural and resource economics, atmospheric sciences, bioagricultural science and pest management, chemical and bioresource

engineering, civil engineering, forest sciences, rangeland ecosystem sciences, sociology, and soil and crop sciences and the Natural Resources Ecology Laboratory.

Multistate Components:

Colorado State University contributes to six multistate projects in this program (W128, W170, W184, W188, W190, S275).

Integrated Research and Extension Activities:

This program contains integrated research and extension projects in the following areas:

1. Water quality and quantity management
2. Animal waste management

Target Audiences:

Crop and livestock producers, ranchers, farmers, foresters, agribusiness firms; local, state, and federal agencies involved in agriculture and forestry; local, state and federal agencies involved in managing public lands; local, state, and federal agencies involved in environmental protection wildlife, fisheries, endangered species, water, and other natural resources; environmental organizations; private sector businesses managing or consulting on environmental issues and natural resources; firms manufacturing products used in natural resource management.

Program Duration:

Greater than 5 years.

USDA Goal 5: Enhanced economic opportunities and quality of life for Americans. Empower people and communities, through research-based information and education, to address economic and social challenges facing our youth, families, and communities.

CSU Program 6: Rural and community development

Statement of Issue

Fundamental economic and social shifts in society are affecting the viability and competent functioning of both rural and urban American families, and negatively affecting the development of quality human capital for the future. Such shifts are reflected in the trends toward increases in: necessity for off-farm income; unemployment and underemployment; two-earner families, many of whom have simultaneous responsibilities for elder care and child care; diversity in family structures; and family violence.

A growing number of children are growing up in at-risk environments with increasing rates of divorce, substance abuse and addiction, suicide, illegitimacy, teenage pregnancy, school drop-out, and poverty-level incomes. At the opposite end of the age spectrum, increased family and societal resources are needed for health, financial, housing, and emotional support of the aging population. Consumer health issues include nutrition as well as consumer contact with clothing and household textiles (products produced from agricultural and forestry commodities) and related medical problems.

Since the 1920s, we have attempted to cope with important problems of agriculture via agricultural policy and programs. Policies have ranged from land grants to price and income supports to exports-enhancement. Whatever the involvement of the government, it has been significant affecting resource uses, farm organization and structure, productivity of enterprises, marketing of commodities, etc. Furthermore, changing trade patterns, balances and agreements such as NAFTA as well as dynamic economic conditions throughout the world (e.g., financial crises) continue to have an impact on U.S. and Colorado agriculture. Colorado producers, processors, and others involved in agribusiness need to anticipate and understand the coming adjustments and be prepared to accommodate and capitalize upon them.

The policies and programs of government(s) have had significant effects on the organization and management of farms and ranches, the costs of production, the quantity and quality of output, the disposition of the products of agricultural enterprises and finally the economic welfare of farm and ranch families. Furthermore, all this is affected by foreign trade patterns. Effects of domestic agriculture policy and international trade policies have been so important that they have been/should be the subjects of careful analyses and the objects of educational programs. At the national level, credible research is on-going. In both public and private institutions, issues of domestic and international policy, alternative policies and programs, and consequences of policies are being studied and reported to the public. But at the state level, specifically in Colorado, virtually no research has been undertaken.

Performance Goals:

1. Evaluate impact of agricultural and natural resource policy on crop, livestock, range, and forest production systems.
2. Identify the impact of economic and social factors on rural and community development, including individual and family issues.

Output Indicators:

1. Modified management systems for small businesses and workforce preparation.
2. Better understanding of interactions within the family and with social processes in rural areas.
3. Development of policy alternatives for environmental issues.

Outcome Indicators:

1. Prescriptive policies that reduce government waste will improve equity, preserve the environment, create and preserve jobs, and reduce institutional conflicts.
2. Community development and job creation
3. Training programs designed to meet needs of constituents and local industry.
4. Improved local decision making.
5. Better targeted more efficiently delivered social services.

Key Program Components:

Marketing. Evaluate alternative approaches to export market assessment and to assess statistical and institutional approaches of relevance to Colorado products. Identify markets and conduct feasibility studies for selected new corps or products.

Agricultural and natural resource policy. Evaluate impact of public policy on agricultural production systems and interrelationships with natural resources. Assess the consequences of the changing structure of agricultural enterprises on rural communities and producers. Determine the social and economic impact of environmental regulations and policies. Determine the relationships between cost and benefit for assessing public and private use of federal land. Evaluate the impact of regulations resulting from policy decisions.

Rural families. Identify the impacts of economic, social, demographic, technological, and environmental changes on rural families and to develop strategies to alleviate adverse impacts of and stress resulting from the changes. The goal is to empower individuals and families to achieve optimum well-being.

Consumers. Develop understanding of relationships between textiles and the user. Investigate opportunities for developing local textile-based business. Evaluate impact of plant materials on human environment.

Internal and External Linkages:

Colorado Department of Agriculture
Colorado Department of Natural Resources

GreenCo
Colorado Golf Course Superintendents Association
National Renewable Energy Laboratory
USDA-Agricultural Research Service
USDA-Natural Resource Conservation Service
USDA-Forest Service
Colorado Cooperative Council
Colorado Farm Bureau
Rocky Mountain Farmers Union
Colorado State Grange
Colorado State University departments involved include agricultural and resource economics, design and merchandising, forest sciences, horticulture and landscape architecture, human development and family studies, and rangeland ecosystem science and the Natural Resources Ecology Laboratory.

Multistate Components:

Colorado State University contributes to seven multistate projects in this program (W133, W167, W175, W193, NC222, NC223, NE162).

Integrated Research and Extension Activities:

This program contains integrated research and extension projects in the following areas:

1. Benefits and costs of resource policies.
2. Market analyses of Colorado products.

Target Audiences:

Consumers, local, state, and federal agencies involved in rural or community development and related issues; firms involved in fabricating, manufacturing or distributing agriculturally related products; firms supporting the development of agriculture product processing and distribution; financial institutions involved in community development; social service agencies and youth organizations.

Program Duration:

Greater than 5 years.

II. 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 22 departments on the Colorado State University campus as well as at 10 off-campus research centers. Programs at the research centers are administratively responsible to the Director of the CAES and coordinate with one or more academic departments. Each year, the off-campus research centers hold a public meeting where research results are presented and proposed programs are discussed. Public input is solicited on all proposed programs. It should be noted that many of the programs discussed involve scientists located on the Fort Collins campus as well as at the off-campus research centers.

The CAES is also an active participant in biannual meetings of an Advisory Committee convened by the Vice-Provost for Agriculture and University Outreach. CAES programs are discussed and input is solicited on future priorities for research activities. In addition, the CAES regularly participates in meetings held by CSU Cooperative Extension where current and future program needs are discussed. A variety of joint research programs are conducted with USDA-ARS programs in Fort Collins, Akron, and other locations as well as collaborative programs with USDA-FS, USDA-NRCS and USDA-NASS. Experimental studies are also conducted in cooperation with individual farmers or ranchers.

Beginning in 2000, the CAES in coordination with the CSU Cooperative Extension will hold regional listening sessions to solicit further input on research priorities and program needs. Each year, a listening session will be held in two of state's five regions (southeast, northeast, San Luis Valley, southwest, and northwest). Both CAES and CSU Cooperative Extension programs will be modified to reflect the input received where appropriate and feasible. All sessions will be open to the public and advertised in the local media prior to the meeting.

III. Peer Review

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.

IV. Equal Employment Opportunity Reporting

We adopt by reference the Colorado State University's procedures for reporting civil rights compliance with Equal Employment Opportunity requirements. A biennial report is filed by Dana Hiatt, Director of Equal Opportunity at Colorado State University, with the Colorado Commission on Higher Education, which forwards the report to the U.S. Equal Opportunity Commission. The CAES is committed to enhancing the diversity of the faculty, staff, and students at Colorado State University.

cated and projected resources for AES programs at Colorado State University

AES Research Program

SDA Goal	CSU Program	FY99 Funds	FY99 FTE	FY00 Funds	FY00 FTE	FY01 Funds	FY01 FTE	FY02 Funds	FY02 FTE	FY03 Funds	FY03 FTE	FY04 Funds	FY0 FT
1	1	2,459,126	11	2,532,900	11	2,608,887	11	2,687,154	11	2,767,768	11	2,850,801	11
1	2	3,641,229	16	3,750,466	16	3,862,980	16	3,978,869	16	4,098,235	16	4,221,182	16
1	3	2,604,231	10	2,682,357	10	2,762,828	10	2,845,713	10	2,931,084	10	3,019,017	10
2 & 3	4	744,007	5	766,328	5	789,317	5	812,997	5	837,387	5	862,509	5
4	5	2,959,468	16	3,048,252	16	3,139,700	16	3,233,891	16	3,330,907	16	3,430,835	16
5	6	717,948	5	739,486	5	761,671	5	784,521	5	808,057	5	832,298	5
	State+USDA	13,126,009	63	13,519,789	63	13,925,383	63	14,343,144	63	14,773,439	63	15,216,642	63

Integrated Research and Extension Program

SDA Goal	CSU Program					
1	1	589,713	607,404	625,627	644,395	663,727	683,639
1	2	1,120,543	1,154,159	1,188,784	1,224,447	1,261,180	1,299,016
1	3	1,507,447	1,552,671	1,599,251	1,647,229	1,696,645	1,747,545
2 & 3	4	60,274	62,082	63,944	65,863	67,839	69,874
4	5	345,963	356,342	367,032	378,043	389,384	401,066
5	6	216,006	222,486	229,161	236,035	243,117	250,410
	State+USDA	3,839,946	3,955,144	4,073,798	4,196,012	4,321,893	4,451,549
	USDA	2,648,675					

Multistate Research Program

SDA Goal	CSU Program					
1	1	411,394	423,735	436,448	449,541	463,027	476,918
1	2	184,447	189,981	195,680	201,551	207,597	213,825
1	3	174,952	180,201	185,607	191,175	196,910	202,817
2 & 3	4	324,948	334,697	344,738	355,080	365,732	376,704
4	5	355,449	366,113	377,096	388,409	400,061	412,063
5	6	473,184	487,379	502,001	517,061	532,572	548,550
	State+USDA	1,924,374	1,982,106	2,041,569	2,102,816	2,165,900	2,230,877
	USDA	911,913					

USDA Funding in FY99

Hatch	1,450,413	Multistate	911,913
McIntire-Stennis	286,349	Total	2,648,675

: A given project can contribute to both integrated and multi-state programs. Actual expenditures shown for FY99. An increase of 3% per year was assumed for expenditure
Y00 to FY04.