National Program 215 (Formerly NP205)

Rangeland, Pasture, and Forages Action Plan 2007-2012

Goal: Develop and transfer economically viable and environmentally sustainable production and conservation practices, technologies, plant materials and integrated management strategies, based on fundamental knowledge of ecological processes, that conserve and enhance the Nation's diverse natural resources found on its range, pasture, hay and turf lands.

Importance of Pasture, Forage, Turf and Range Lands

Our Nation's grass and shrub lands including range, pastures, hay and turf lands provide forages, open spaces and ecological services that contribute significantly to our agricultural, environmental, economic, and social well-being. Rangeland, pasture, and forages together comprise about 55% of the total land surface of the United States, about a billion acres. Privately owned lands comprise about 45% of this total, or about 640 million acres. These lands represent the largest and most diverse land resources in the U.S. Rangelands and pastures include the annual grasslands of California, the tundra rangelands of Alaska, the hot arid deserts of the Southwest, the temperate deserts of the Pacific Northwest, the semiarid cold deserts of the Great Basin, the prairies of the Great Plains, the humid native grasslands of the South and East, and the pastures and hay lands within all 50 states from Hawaii to Maine and Alaska to Florida.

The Nation’s 30 million acres of turf lands are found around our homes, schools, municipal and commercial buildings, in our parks, greenbelts and recreational areas, and along our roadsides, airports and right-of-ways. These lands contribute to our well-being in many ways including beautifying our towns and cities, enhancing property values, providing vital environmental services and contributing to the economy an estimated $40 billion a year.

These lands are the primary forage base for our livestock grazing industry in the U.S. and are utilized by more than 60 million cattle and millions of sheep and goats. Forage-livestock systems are the foundation of an industry that contributes more than $70 billion in farm sales annually to the U.S. economy. The estimated value of hay production alone is $11 billion, our third most valuable crop to U.S. agriculture, behind only corn and soybeans. The publicly owned rangelands in the western U.S. are also important, providing forage on 260 million acres for 3 million beef cattle and sheep. Nearly 70% of dietary protein and 40% of dietary calories for the U.S. population are of animal origin, and forage resources are crucial for sustained production of our animal-based products.

The functions of these lands are of increasing importance as watersheds and as habitat for a set of biologically diverse plants and animals. Maintaining adequate supplies of clean water for urban areas, irrigated agriculture, and environmental needs is a critical function of rangeland, pasture, and forage-producing ecosystems. Rangelands and pastures also provide forage and habitat for numerous wildlife species, including 20 million deer,

500,000 pronghorn antelope, 400,000 elk, and 55,000 feral horses and burros. Associated with these functions is an array of additional demands placed on these natural resources, including camping, hiking, fishing, hunting, and other recreational activities. This multitude of uses--from grazing lands to watersheds, critical habitats, and recreational areas--require an improved understanding of basic ecological processes and the effect on these processes on grazing, livestock production, and management practices.

Science-based solutions to these needs must be economically viable, socially acceptable and enhance the environment. The overall goal of this national program is to provide the appropriate technologies and management strategies to sustain our rangelands and pastures.

Harvested and conserved forages provide a dietary resource for continuity of livestock production. This is especially important during periods of cold or drought when nutrient-rich plants are not available. Harvested and conserved forages also provide an important source of roughage and nutrients for dairy cattle in confined animal feeding operations. To meet this demand, nearly 200 million tons of forage crops are harvested each year from 73 million acres in the U.S., which is 24% of the cropland. About one-half of these crops provide the forage requirements of dairy cattle. The remainder, along with rangeland and pasture, supplies the forage needs of beef cattle, sheep, goats, horses, and other livestock.

Relationship of This National Program to the ARS Strategic Plan: Outputs of NP215 research support the "Actionable Strategies" associated with the objective and performance measure shown below:

Objective 5.1: *Provide Science-Based Knowledge and Education To Improve the Management of Forest, Rangelands, and Pastures.*

Forest, rangeland, and pasture ecosystems provide a number of goods and services that are critical to maintaining a healthy and livable environment. Among those are clean water, clean air, productive soils, carbon storage, biodiversity, scenic vistas, and recreational opportunities. In addition, they are an important source of food, fiber, and forest products. Even though these systems are managed less intensively than conventional farmlands, sound scientific management is critical in maintaining their goods and services. ARS will provide the knowledge base to develop and evaluate the effectiveness of ecosystem management strategies that will give the greatest long-term benefits from our public and private forests, rangelands, and pastures, including the mitigation of global change.

Performance Measures 5.1.1: Develop ecologically based information, technologies, germplasm, and management strategies that sustain agricultural production while conserving and enhancing the diverse natural resources found on rangelands and pasture lands. **Actionable Strategies:** Develop improved germplasm for use in renovation and restoration of degraded pasture and rangelands. Develop protocols and

practices to manage pasture and rangelands in an economical and environmentally sustainable manner.

Scope of Research

The Rangeland, Pasture, and Forages National Program has four science-based program components:

1. Rangeland Management Systems to Improve Economic Viability and Enhance the Environment,
2. Pasture Management Systems to Improve Economic Viability and Enhance the Environment,
3. Sustainable Harvested Forage Systems for Livestock, Bioenergy and Bioproducts, and
4. Sustainable Turf Systems.

Beneficiaries of this National Program

Many entities will benefit from this national program, which addresses such an important and pervasive natural resource base. It will benefit the Nation's livestock producers who utilize both harvested and grazed forages in their agricultural operations and the action agencies such as the Natural Resource Conservation Service and Cooperative Extension that provide technologies and knowledge to these producers. This program also will benefit federal land stewardship agencies such as the Bureau of Land Management, Forest Service, National Park Service, Fish and Wildlife Service, Bureau of Indian Affairs, and U.S. Geological Survey (USGS), that are responsible for almost a billion acres of publicly owned lands. Beneficiaries include state land management agencies responsible for state-owned grazing lands and resource managers, policymakers, and both rural and urban community organizations that need information and technologies to evaluate and manage their rangeland resources. Finally, the public at large will benefit through improved management of the Nation's range, pasture, forage and turf lands through greater economic opportunities, access to high quality food, fiber and recreational opportunities, and enhanced environmental services.

Program Cooperation

ARS is uniquely positioned to play an important national leadership role in research to understand and manage the Nation's range, pasture, hay, and turf lands. To effectively play this role, the program must promote close cooperation between ARS locations and National Programs, and with other federal, state, local agencies, universities and the private sector.

Other ARS National Programs making significant contributions to improve the productivity, profitability and environmental sustainability of the Nation’s range, pasture, forage and turf lands include: Water Quality and Management; Bioenergy; Crop Protection & Quarantine; Soil Resource Management; Global Change; Integrated

Agricultural Systems; Animal Production Systems; Food Safety; and Plant, Microbial, and Insect Genetic Resources, Genomics, and Genetic Improvement.

ARS Locations Conducting NP 215 Research

East	Central	West
Beaver, WV	College Station, TX	Albany, CA
Beltsville, MD	Cheyenne, WY	Boise, ID
Booneville, AR	El Reno, TX	Burns, OR
Madison, WI	Ft. Collins, CO	Corvallis, OR
Raleigh, NC	Langston, OK	Dubois, ID
St. Paul, MI	Lincoln, NE	Las Cruces, NM
Tifton, GA	Mandan, ND	Logan, UT
University Park, PA	Miles City, MT	Prosser, WA
	Woodward, OK	Reno, NV

Component 1. Rangeland Management Systems to Enhance the Environment and Economic Viability

America's rangelands support an increasingly large number of activities and services, including recreation, watershed protection, livestock protection, wildlife habitat, renewable and non-renewable energy production. There is increasing interest from traditional users, especially livestock producers and public land managers, to balance economic and conservation goals among those traditional and emerging activities, goods, and services.

Problem Statement A: Need for economically viable rangeland management practices, germplasm, technologies and strategies to conserve and enhance rangelands ecosystems.

Research Needs: The research needs identified for this problem area are addressed in the following research objectives:

Objective A.1. **Develop management and monitoring strategies and decision-support tools that conserve natural resources while maintaining economic objectives. (**Boise, Burns, Cheyenne, Las Cruces, Reno, and Woodward with Beltsville and Tucson contributing)

Anticipated Products and Potential Benefits

- Develop estimates of carbon sequestration potential of Southern Plains mixed-grass prairie under alternative grazing intensities.
- Provide state-and-transition models and scientific criteria aiding in identifying Ecological Site Descriptions.
- Transfer to land management agencies monitoring tools and techniques, including very large scale aerial (VLSA) imagery, that reduce agency monitoring costs and

increase statistical-adequacy of monitoring data collected on public lands in the SW, Idaho, Nevada and Wyoming.
- Improved remote-sensing tools for use by action agencies to monitor and assess juniper encroachment using Light Detection and Ranging (LiDAR) for quantifying current juniper cove and expansion trajectory.

Objective A.2. Determine impact of livestock grazing, fire, mechanical treatments, and drought on ecological integrity and watershed structure and function. (Boise, Burns, Cheyenne, Dubois, Ft. Collins, Miles City, Reno, Woodward)

Anticipated Products and Potential Benefits

- Improved predictions of juniper impacts and juniper-control treatments on understory vegetation and hillslope-hydrology and erosion, and use information to develop improved infiltration and erosion parameter values for the Rangeland Hydrology and Erosion Model (RHEM) related to juniper communities and provide juniper management guidelines.
- Improved input datasets for the Erosion Risk Management Tool (ERMiT) and Rangeland Hydrology and Erosion Model (RHEM) for use by action agencies in predicting post-fire and erosion rates.
- Provide post-fire management guidelines based on improved understanding of fire impacts on hillslope hydrology and erosion and mechanisms of post-fire stabilization in the sagebrush-steppe ecosystem.
- Guidelines for evaluating and managing different post-fire livestock grazing management strategies based on an improved understanding of impacts on vegetation recovery, soil stability, habitat and water quality in the sagebrush steppe and salt desert ecosystems.
- Improved management criteria for evaluating livestock impacts on stream water quality, supported by peer-reviewed journal articles describing impacts of livestock on stream suspended sediment and coliform bacteria concentrations.
- Grazing management guidelines based on improved understanding of indirect impacts of grazing on hydrological responses in the Great Basin.
- Models that predict productivity, CO_2 fluxes, and species responses from yearly weather patterns.
- Guidelines on grazing management developed from long-term response data on the sagebrush steppe.
- Guidelines on selecting management options for controlling woody and invasive weed expansion to improve wildlife conservation based upon an improved understanding of the impacts on vegetation dynamics and wildlife habitat in ecosystems experiencing an expansion of pinyon, juniper, and introduced invasive weeds.
- Guidelines for fire management including patch burning to modify vegetative states to meet ecological, grazing and wildlife objectives based on an improved ecological knowledge on the role of seasonality and frequency of burning in shortgrass steppe and north and southern mixed-grass prairies.

- Guidelines for timing and intensity of post-fire grazing including estimates of fire effects on grazing animal distribution.
- Rangeland management strategies that reduce ecological and economic risks from climatic extremes in the Great Plains.
- Improved knowledge of the long-term grazing and livestock exclusion impacts on plant community stability in Great Plains rangelands.

Objective A.3: Identify factors such as landscape position, species composition, land use history, management strategies, and climatic variables that can be used to predict and minimize the risk of degradation of rangeland ecosystems. (Cheyenne, Las Cruces, Reno)

Anticipated Products and Potential Benefits

- Models to aid land managers in identifying southwestern arid rangeland sites that are most susceptible to invasion by undesirable species and evaluating the potential for successfully preventing degradation with current technologies.
- Guidelines on improving the establishment of native forage plants and inhibiting weed establishment based on an improved understanding of seed and seedbed ecology of both native and introduced forage and weed species that compete in rangeland seedbeds.
- To improve management of rangeland dynamics particularly those associated with ecological and economic risk in a time of global change provide an improved scientific understanding of the role of elevated atmospheric CO2 in shaping competition among native and introduced invasive grasses.
- Management recommendations for maintaining the condition of healthy oak woodlands and recovery of declining oak populations in eastern and central California.

Problem Statement B: Need for improved livestock production systems for rangelands that provide and use forages in ways that are economically viable and enhance the environment sustainable.

Research Needs: The research needs identified for this problem area are addressed in the following research objectives:

Objective B.1: **Develop monitoring and decision-support tools and management strategies for land managers. (**Boise, Cheyenne, Ft. Collins, Las Cruces, Miles City, Woodward)

Anticipated Products and Potential Benefits

- New version of iFARM that has increased tactical and strategic predictive ability of forage and animal production for land managers in the western Great Plains.
- Decision-support tools to aid livestock producers in maintaining profitability and ecological health over space and time by successfully managing the impacts of drought and invasive weeds.

- Science-based, low-input livestock grazing systems using diverse livestock genetics and foraging behavioral traits to select livestock capable of sustained performance to achieve economic and environmental objectives in arid southwestern ecosystems.
- A GPS-based animal tracking system which overcomes the cost, data-storage and battery-life constraints limiting research applicability of current technology and an affordable ear tag type device that can autonomously control rangeland livestock movements within a larger secure perimeter.
- Economically viable and environmental sustainable livestock grazing strategies, based on improved understanding of livestock behavior and vegetative productivity, that respond to fire, western juniper and weed invasions, predation, and other landscape-scale disturbances in the sagebrush steppe that responding documented by peer-reviewed journal articles describing cattle-habitat use and activity budgets.

Objective B.2: Develop and evaluate germplasm for improving forage quality, availability, and production. (Logan)

Anticipated Products and Potential Benefits

- Release of a new, taller cultivar of forage kochia to enhance fall and winter grazing by livestock and wildlife.
- An improved cultivar of Siberian wheatgrass with improved seedling vigor.
- Improved populations and evaluations of spreading-type alfalfa and sainfoin for a variety of rangeland conditions.
- Identification and characterization of thick spike wheatgrass, western wheatgrass, and Idaho fescue germplasm from new sources and development of breeding populations leading to new germplasms andcultivars.
- Improved germplasms/cultivars of tall and intermediate wheatgrass.
- Identification of native germplasm/ecotypes for private and public land managers and plant breeders that will have broad adaptation and appropriate genetic diversity.
- Identification of plant traits that maximize successful incorporation of the best plant materials into integrated weed management strategies for rangelands of the western U.S.

Objective B.3. Reduced economic losses to the livestock industry caused by rangeland poisonous plants and enhance food and feed safety. (Logan)

Anticipated Products and Potential Benefits

- Develop strategies to reduce pine needle poisoning and abortions, effectively treat affected livestock and improve the harvesting of forage in areas where pine needles may be consumed to enhance food and feed safety and the economic well-being of livestock producers and rural communities.
- Provide management guidelines to reduce or prevent snakeweed infestations and reduce incidence of poisoning and abortions to enhance food and feed safety and the economic well-being of livestock producers and rural communities.

- The prevention of broom snakeweed poisoning in livestock will enhance the economic well-being of livestock producers and strengthen the economies of the communities in which they live.
- Develop management strategies to prevent poisoning from lupine and predict years and sites of high risk reduce lupine-induced "crooked calf syndrome" to enhance food and feed safety and the economic well-being of livestock producers and rural communities.
- Provide an understanding of absorption over time, body distribution, clearance time, and elimination of the important steroidal alkaloids found in Veratrum to diagnois and treat poisoned animals.
- Develop management strategies based upon improved risk assessment to prevent larkspur poisoning to enhance food safety and the economic well-being of livestock producers and rural communities.
- Develop management strategies and risk assessment models to reduce and treat livestock poisoning and potential metabolite contamination of feed and food supplies from toxins produced by Astragalus and Oxytropis genera. These strategies and models will be based on an improved understanding of pyrrolizidine alkaloid toxicity in neonates and fetuses; improved diagnostic techniques to identify, monitor and prognose the outcome of livestock poisoning; to enhance food safety and the economic well-being of livestock producers and rural communities.
- Identification of potential biomedical applications of poisonous-plant toxins that have been identified, isolated, characterized and evaluated in the process of developing livestock prevention, diagnostic, and treatment practices.

Objective B.4: Assess near- and long- term animal productivity, well-being and product quality under alternative rangeland management strategies. (Boise, Las Cruces, Logan, Miles City)

Anticipated Products and Potential Benefits

- Predictions of nutrient intake relative to physiological state for grazing beef cattle in the northwestern Great Plains.
- Strategic nutritional management strategies for beef cattle in the northwestern Great Plains.

Problem Statement C: Need for improved rangeland restoration, rehabilitation and mitigation practices, germplasm, tools and strategies to restore rangeland integrity in a manner that is economically feasible and environmentally acceptable.

Research Needs: The research needs identified for this problem area are addressed in the following research objectives:

Objective C.1. Understand mechanisms of weed invasion and develop management strategies that can be used to restore rangelands that have been degraded by weeds and other disturbances. (Boise, Burns, Ft. Collins, Las Cruces, Miles City, Reno, Woodward)

Anticipated Products and Potential Benefits

- Improved aerial based technologies and assessment techniques to evaluate efficacy of landscape revegetation treatments.
- Fungal endophyte enhanced native plant materials that can be used to revegetate arid southwestern rangelands more efficiently.
- Economically efficient and environmentally sustainable weed control strategies based on the management of sheep and cattle grazing.
- Improved models for forecasting the probability of successful grass seedling establishment and guidelines for improving the establishment of grass on degraded rangelands based on improved understanding of seedbed ecology including soil conditions and thresholds of temperature and moisture critical to seedling establishment.
- Better weed control strategies based on improved scientific understanding of invisibility as a factor in ecological successional management under various biotic and abiotic conditions affecting the establishment and persistence of invasive weeds.
- Improved characterization of genetic diversity of economically important invasive weeds to determine genetic commonalities that enhance invasiveness in the Great Basin and Mojave eco-regions and the volcanic tablelands of northeastern California and gaining a better understanding of the relative roles of phenotypic plasticity versus genetic adaptation to identify weeds with narrow and static genetic variability that would be more prone to control than those plants that are genetic "moving targets."
- Improved targeting of invasive-weed control programs through better predictions of the relative vulnerability or resilience of specific plant taxonomic associations to weed degradation under changing environmental and using forecasted outcomes to set priorities for allocation of limited resources for weed management and restoration.
- Improved management strategies that incorporate knowledge of natural seed predation and dispersal agents to enhance establishment of forage plants and inhibit invasive weeds.
- Management guidelines for the formulation of optimal seeding mixtures to meet multiple objectives for rangeland restoration of retired cropland; manual on restoring diversity in near monocultures of introduced perennial grasses.
- Management guidelines on when follow-up treatment is required after juniper control and which practices are most likely to be successful.
- Technology to assist in selecting appropriate plant species for post-fire rehabilitating and determining optimal timing for rangeland restoration treatments. Supported by peer-reviewed journal articles describing climate-based decision tools for rangeland revegetation planning.

Objective C.2: **Develop and evaluate plant materials for rangeland repair, revegetation, and restoration.** (Logan, Reno, Woodward, Boise, and Burns)

Anticipated Products and Potential Benefits

- Improved cultivars/pre-variety germplasms of bluebunch wheatgrass, thickspike wheatgrass, Idaho fescue, slender wheatgrass, green needlegrass, bottlebrush squirreltail, Indian ricegrass, Snake River wheatgrass, and basin wildrye. Improved populations of bottlebrush squirreltail, needle-and-thread, thurber's needlegrass, green needlegrass, Indian ricegrass, Snake River wheatgrass, thickspike wheatgrass, intermediate wheatgrass, basin wildrye, basalt milkvetch, small burnet, cicer milkvetch, Utah sweetvetch, globemallow, western prairie clover, and Searls' prairie clover.
- Develop potential sand bluestem cultivars with capability to germinate and establish on drought prone sites in the Southern Plains.
- Characterization of the acetohydroxyacid synthase (AHAS) gene structure in a core panel of rangeland grasses and an identification of gene(s) involved in tolerance to AHAS-inhibiting herbicides.
- Experimental and/or improved plant materials developed through combinations of conventional breeding methods and molecular tools including molecular genetic linkage maps, EST libraries, and BAC genomic DNA libraries to identify molecular markers associated with functionally important trait variation in crested wheatgrasses (*Agropyron* spp.), bluebunch wheatgrass (*Pseudoroegneria spicata*), *Leymus* wildryes, *Elymus* spp., basalt milkvetch (*Astragalus filipes*), and *Dalea* spp.
- Documentation describing quantitative functional differences between populations to assist in developing plant materials of *Pseudoroegneria spicata* and *Elymus* spp. for land managers.
- Improved understanding of specific plant traits that can be targeted in controlling weeds through the application of rangeland management practices.
- Documentation concerning whether utilizing plant materials from multiple functional groups can assist in resisting weed invasion on rangelands currently being repaired.

Component 1 Resources

Research objectives of 12 ARS CRIS projects coded to NP215 address the research needs of Component 1. ARS lead scientists for these projects are:

Boise: Stuart Hardegree
Burns: Anthony Svejcar
Cheyenne: Justin Derner
Dubois: Gregory Lewis
Las Cruces: Debra Peters
Logan: Lynn James, vice-Jerry Chatterton
Mandan: Jonathan Hanson
Miles City: Lance Vermeire
Reno: William Longland
Woodward: Phil Sims, Timothy Springer

Component 2. Pasture Management SystemsTo Improve Economic Viability and Enhance the Environment

There is a need to develop and transfer sustainable technologies, germplasm, management practices and integrative strategies to improve the conservation and use of pasture agro-ecosystems to support livestock production and other natural resource values.

Problem Statement D: Need for appropriate plant materials to improve the economic viability and enhance the environment in pasture-based livestock systems.

Research Needs: The research needs identified for this problem area are addressed in the following research objectives:

Objective D.1: **Collect or develop and evaluate new plant cultivars that are biologically diverse, tolerant of biotic and abiotic stresses, more competitive, improved quality, and are easier to establish and maintain in pastures**. (College Station, Logan, Woodward, Booneville, Lexington, Madison)

Anticipated Products and Potential Benefits

- Release tall fescue, orchardgrass, alfalfa, and kura clover germplasm with improved forage yield, palatability, and persistence.
- Release birdsfoot trefoil, spreading type alfalfa, and foxtail germplasm with improved forage production and quality, persistence under grazing, and salinity tolerance.
- Identify and characterize traits that enhance selection efficiency and result in improved plant populations of *Bromus*, *Dactylis*, and *Alopecurus.*
- For semi-arid conditions, provide guidelines on the optimum irrigation levels for grass seed production for irrigated and semiarid pasture grass species.
- Identification of superior genotypes of orchardgrass and meadow bromegrass that are winter hardy and form an advanced synthetic population for large-scale testing on high mountain deserts.
- Determination of whether there is a need for novel endophytes and soft leaves in tall fescue grown in the semiarid West.
- Identification of superior warm-season grass species for use as mid-summer forage in the Intermountain Region.
- Develop grass germplasm with improved performance in high pH soils and breeding material tolerant to stalk-feeding insects.
- Identify and evaluate Texas bluegrass genotypes (*Poa arachnifera* Torr.) to find plant materials better adapted to the Southern Plains, humid southern and southeastern U.S. to use in developing reliable perennial cool-season forages.
- Produce novel hybrids using Texas bluegrass (*Poa arachnifera* Torr.) and other bluegrass species to produce novel forage and low-input turf-type germplasm for further field scale evaluation and release.

- Develop a diallel population of sand bluestem (*Andropogon hallii* Hack), using diverse genetic material collected from the southern and southwestern Great Plains to use in later genetic studies.
- Develop 3 to 5 diverse populations of little bluestem [*Schizachyrium scoparium* (Michx.) Nash] with increased forage and seed production.
- Release one new novel endophyte tall fescue cultivar for the Midwestern-Eastern transition zone.
- Release one new endophyte-free tall fescue cultivar for use by the Equine industry that is persistent in the Midwestern-Eastern transition zone.
- Release cultivars of kleingrass and dallisgrass with improved forage yield, persistence, and seedling vigor for the southern U.S.
- Knowledge of the feasibility of successfully integrating existing cultivars of cool-season perennial grass cultivars with emphasis on smooth bromegrass, orchardgrass, and *Lolium/Fescue* hybrids into near year-round forage production systems in the southern Great Plains.
- Availability of new cool-season perennial grass cultivars of smooth bromegrass, orchardgrass, and western wheatgrasses that are adapted to the southern Great Plains and can be integrated into near year-round forage production systems.
- Availability of additional bluegrass hybrid populations for use in ongoing breeding programs directed at development of productive and persistent perennial cool-season grasses that are adapted to the southern Great Plains.
- Winter wheat cultivars that can be grazed with less risk of frothy bloat and health problems associated with high nitrate concentrations.
- Identify native legumes and naturalized grasses with the potential to contribute to intensively managed pasture systems for pasture-based dairies.
- Improved understanding of plant traits and responses that contribute to improved under grazing, and knowledge of potential value of new germplasm in pasture systems.

Objective D.2: Provide greater efficiency in developing improved germplasm though collecting and characterizing germplasm; improving physiological, biochemical, and genomic techniques to describe and identify useful genetic traits; and improving tools and methods for developing improved forages. (Beaver, Booneville, College Station, Corvallis, El Reno, Logan, Lexington, Madison)

Research Needs: The research needs identified for this problem area are addressed in the following research objectives:

Anticipated Products and Potential Benefits

- Develop and validate analytical tools to characterized plant chemical constituents and their resulting metabolites following consumption and metabolism by animals, particularly in tall fescue, that influence plant and animal performance.
- Identification of genes and molecular signaling components that are involved in drought and salinity stress tolerance in Lolium and Festuca and application of this information to improve grass genetic resources.

- Identification of genomic markers to identify genes that impact seed and foliage disease resistance in Lolium, Festuca, Poa, and Dactylis (ergot, stem rust, crown rust) and assist in selecting highly resistant germplasm.
- Determine if naturally produced microbial substances that inhibit the germination of Poa annua can be used to reduce the impact of this weed on grass seed production and turf quality.
- Identify molecular markers and construct linkage maps of ryegrass and bentgrass that identify regions that impact specific traits important in forage and turf systems.
- Identify genes and molecular mechanisms to improve gene stability and minimize escape of transgenes in forage and turfgrasses (Lolium spp.).
- Identify genetic traits in seed production systems that impact cultivar integrity, diversity and identity in Lolium and Agrostis.
- Improvements in identifying candidate genes for salt tolerance and other abiotic stresses that will improve selection efficiency in developing better adapted tall fescue, alfalfa, and meadow bromegrass.
- Genetically modified endophyte strains for quality trait evaluation in tall fescue grown in the Mid-South.
- Improved knowledge of how to manipulate plant flowering and maturation mechanisms to improve seed production in forage soybean and Lolium.
- Improved selection efficiency through increased knowledge of the genes associated with persistence, yield, and quality traits by providing EST sequence information for forage clover and tall fescue.
- Saturate the genomic region in buffelgrass controlling apomixis with additional markers to aid physical mapping of this trait.
- Improved selection efficiency by developing a genetic map of zoysiagrass to identify markers linked to salt tolerance and fall army worm resistance.
- PCR-based molecular markers to assist perennial cool season grass breeding, with emphasis on bluegrasses to expedite progress in conventional breeding of perennial cool-season grasses for forage production.
- Information regarding chromosome number, ploidy level, method of reproduction, and phylogeny of grasses (*Paspalum, Pennisetum, Chloris, Setaria* species, and others) to facilitate their genetic improvement through breeding.
- Characterize and compare genetic parameters within breeding populations (half-sib families) to development of tall fescue, orchardgrass, meadow bromegrass, and birdsfoot trefoil populations with improved grazing tolerance, and identification of most efficient selection protocols for grazing tolerance.
- On-farm participatory plant breeding efforts with Mid-West farmers to make faster progress in developing new and improved forage germplasm development by gathering on-farm performance data, and demonstrations of the value of using improved germplasm in pastures.
- Development of new selection techniques that target traits necessary for forage legumes to persist in permanent pastures and mixed swards under grazing in the Mid-West.

- Populations of endophyte-free tall fescue that tolerate the summer stress complex and selected under heavy grazing pressure will be developed.
- Identify germplasm of Neotyphodium endophytes that have the potential to enhance tall fescue persistence while lacking ergot-alkaloid toxins will be identified.
- Develop and evaluate a new novel endophyte-infected tall fescues steer weight gain, pasture carrying capacity, forage production and nutritive value for.
- Profile metabolites present in endophyte-infected and endophyte-free tall fescue under drought stress and develop a database of the metabolites produced as a result of drought stress on tall fescue by elucidating mechanisms conferring drought and salinity tolerances.
- Improved productivity in cool-season forages grown in the Mid-South through improved understanding of how rooting architecture and plant-derived biochemicals, *e.g*., tannins, carbohydrates, influence the interactions between nutrient acquisition by plants and nutrient availability in soils.
- Develop the tools and methods for improving the analysis of tall fescue multiple gene expression.
- Develop genomic profiling tools for genetic improvement of red clover.
- Develop a method for the digital evaluation of red clover hay color.
- Characterization of the genes that delay flowering in selected forages to support breeding programs to prolong vegetative development and forage quality.
- Improve animal performance by determining how the toxicant accumulation and metabolic relationships in tall fescue change under different pasture management regimes.
- Improved conservation of soil and water resources in tall fescue pastures through an improved understanding of the influence of tall fescue endophyte infection status on soil fauna contributions to soil macroporosity and aggregate development and the impact on nutrient and agricultural waste infiltration in sensitive watersheds.
- Develop and validate a survey/profiling methodology for identifying plant chemical constituents in forage plant materials, particularly tall fescue, and animal tissues, fluids, and excreta for tracking botanical composition of animal diets.
- Validated methods for trapping and analyzing the volatile compounds emitted by tall fescue and development of a database of volatile compounds induced in endophyte infected and endophyte-free clones of a selected tall fescue cultivar due to varied light, temperature, and water turgor pressures.
- A validated and affordable method for profiling and quantifying nonstructural carbohydrates in forage grasses.

Problem Statement E: Need for economically viable pasture-livestock systems for the Mid-South that enhance the environment.

Research Needs: The research needs identified for this problem area are addressed in the following research objectives:

Objective E.1: Provide improved forage-based cattle, small ruminant and horse production systems that meet economic and environmental objectives for the diverse environments found in the Mid-South. (Beaver, Booneville, Lexington, Raleigh)

Anticipated Products and Potential Benefits

- An assessment of the feasibility of producing grass-fed beef of acceptable quality and availability in the Mid-South based upon evaluating the yearly grazing cycle to determine where nutritional gaps occur and develop cost-effective forage and pasture improvements to reduce the need for harvested forages and other supplementation.
- For tall fescue grazing systems, including complementary grazing, intensive grazing, backgrounding, and stockpiling, provide management, assessment and decision-support tools to cattle, horse and small ruminant producers that include economically and environmentally viable recommendations on using grazing, supplement and treatment options to reduce losses from fescue toxicosis while achieving production objectives.
- Provide profitable productions strategies for the humid Southeast that combine grazed and stored gamagrass and switchgrass in ways that reduce input costs, create new market opportunities for bioenergy feedstocks, and improve risk management while enhancing the environment including increasing wildlife habitat diversity.
- Compare animal performance and pasture productivity of gamagrass and switchgrass with the conventional tall fescue-bermudagrass system.
- Provide sustainable forage-based small-ruminant production systems for the Mid-South that include recommendations on internal parasite control practices, and recommendations on forage combinations, grazing systems and supplementation strategies to meet weight gain, carcass characteristics and meat quality objectives defined by specialty market demand.
- Grazing systems that optimize goat and lamb production including identifying options to reduce the incidence of internal parasites.
- Enhanced conservation and enhancement of water quality through the application of pasture and grazing management practices derived from a better understanding of the interactions of landscape and land use on the partitioning, fate, and transport of nitrogen, phosphorus, and microorganisms (e.g., *Cryptosporidium parvum*) associated with livestock feces and urine.
- Decrease nutrient losses while maintaining or increasing forage productivity by providing parameters on the effects of grazing systems and buffers on runoff of sediment and plant nutrients to be used in the Arkansas P index, a decision-support tool for choosing management option that minimizes the loss of P from grasslands receiving nutrients from animal waste.

Objective E.2: Provide improved pasture management practices to improve and maintain forage production and quality cost effectively while enhancing the environment. (Beaver, Booneville, Lexington, Raleigh)

Anticipated Products and Potential Benefits

- Improve inorganic and organic fertilizer use efficiency in pastures by developing a tractor-drawn implement with the capacity to incorporate dry poultry litter under a perennial pasture surface.
- Improved economic and environmental viability of Appalachian farms by providing guidelines for selecting combinations of forage crop adapted to the highly variable local pasture and silvopasture environmental conditions (highly variable seasonal, light intensity, water and soil microenvironments) to provide desired agroecosystems services (dry matter and nutritive value for small ruminants including year-round forage supplies, carbon capture and storage, plant biochemical factors, and water quality).
- Develop an economically viable Bermudagrass forage system for cattle and horses that provides reliable warm-season forages the upper transition zone of the Mid-South.
- Determine which forage species and mixture of species best optimizes Mid-South pasture agroecosystem functions (forage production and carbon storage, nitrogen retention, and soil trace gas fluxes).
- Guidelines for improving the performance of growing horses based upon an improved understanding of factors influencing forage intake and utilization in the Mid-South.
- Validated microhistological analytical methods that are an appropriate technique for measuring horse diet selection on mixed forage species pastures in the Mid-South.
- A validated digital photographic pasture assessment tool for monitoring horse pasture usage and condition in the Mid-South.
- Management protocol particularly for horse pastures to control toxic tall fescue encroachment of bluegrass pastures based on maintaining the competitiveness of bluegrass while restricting tall fescue encroachment.
- A tractor-drawn implement with the capacity to incorporate dry poultry litter under a perennial pasture surface to improve inorganic and organic fertilizer use efficiency in pastures in the Mid-South including.
- Guidelines for improving inorganic and organic fertilizer use efficiency in pastures in the Mid-South to decrease nutrient losses while maintaining or increasing forage productivity.

Problem Statement F: Need for economically viable forage-livestock systems for the Great Plains.

Research Needs: The research needs identified for this problem area are addressed in the following research objectives:

Objective F.1: Develop forage-based livestock production systems that will lower production costs, reduce the need for harvested feedstuffs, increase marketable yields of animal products, and enhance the environment. (El Reno, Mandan, Woodward)

Anticipated Products and Potential Benefits

- An assessment of the feasibility of producing grass-fed beef of acceptable quality and availability in the Great Plains based upon evaluations the yearly grazing cycle to determine where nutritional gaps occur and develop cost-effective forage and pasture improvements to reduce the need for harvested forages and other supplementation.
- Establish the value of under intensive short-duration grazing during spring and fall in near year-long forage production systems. Identify and evaluate existing cultivars of annual and perennial grasses that can be grown in sequence with conventional forage species to fill gaps in time when forage is not available.
- An improved pasture-based system for growing and finishing cattle on the northern Great Plains that combines the use of clovers (for reducing N fertilization), cool-season grasses, and nutrient supplementation to maximize the grazing season and weight gain efficiency.
- Cost-effective management practices to produce beef on an all-forage diet contains higher concentrations of conjugated linoleic acid (CLA) and omega-3 fatty acids to meet consumer demand.
- Improved management practices to increase forage production and quality of warm-season grasses in the Southwestern Plains while reducing input costs in the southern Plains by determining interactions between legume establishment, grass-legume forage production, nitrogen accumulation, and nitrogen use from legume species and commercial nitrogen sources in the production.

Objective F.2: Develop cost effective management practices that improve pasture establishment, persistence, and forage quality while enhancing the environment. (Booneville, El Reno, Langston, Mandan, Woodward)

Anticipated Products and Potential Benefits

- Crop rotation guidelines for assessing the biological and economic feasibility of replacing inorganic nitrogen fertilizer in forage, grain, and biomass crops planted after forage crops of annual and perennial legumes, especially vetches, pigeon pea, forage soybeans, red clover, grass pea, lablab, and Trifoliums.
- Detailed comparisons of beef cattle performance on alternative cool-season perennial forage grasses (smooth bromegrass, tall wheatgrasses, and tall fescue) to winter wheat, the conventional cool-season forage in the southern Great Plains.
- Guidelines for selecting select annual legumes such as mung bean, peas, and pigeon pea for the Southern Plains that can produce forage alone or in combination with grasses during the summer to fill gaps in available forages for grazing and to reduce input of inorganic nitrogen fertilizers while protecting the soil from erosion in between wheat crops.
- Guidelines on the feasibility of using combinations of perennial warm-season grasses (sand bluestem (*Andropogon hallii*) and yellow bluestem (*Bothriochloa ischaemum*) and cool season grasses (winter wheat (*Triticum aestivum*) and Texas bluegrass (*Poa arachnifera*) to provide a profitable forage-livestock production system for the southern mixed-grass prairie and its associated marginal farm that also meets environmental goals.

- Guidlines on optimum methods and timing for winter based seeding of eastern gamagrass in the Southern Plains to enable high-density, spring stand establishment.
- Develop management guidelines for the application rates and timing of nitrogen fertilizer on sand bluestem pastures to optimize economic returns and environmental benefits.
- Develop management practices that limit the effects the southern cornstalk borer (*Diatraea grandiosella* Dyar) in eastern gamagrass.
- Develop low-input techniques for increasing forage production and extending the grazing season on degraded or unimproved pastures warm-season pastures on underserved, resource-limited small farms in the Southeastern Plains by assessing under grazing pressure the productivity and persistence of nontraditional warm and cool season grass and legume mixtures of rye grass, tall fescue, bromegrass, wheatgrasses, and small grain cereals, Lespedeza, crownvetch, hairy vetch, birdsfoot trefoil, white and rose clover.
- Guidelines to improve establishment success of annual cool-season grasses and legumes that are self-seeded or over-seeded into established pastures based on an increased understanding of the causes of poor grass and legume establishment in established pastures.
- Improved management practices that increase carbon sequestration and decrease greenhouse emissions from pastures on the northern Great Plains.
- Guidelines on using Altai wildrye for winter cattle grazing to fill gaps in forage availability and reduce supplemental feed costs in the northern Great Plains.
- Determine the usefulness of accumulated temperature (degree-days) as an aid to timing of pasture management operations such as fertilizer application and harvesting, in order to minimize competition in cool and warm season grass mixtures during seasonal transitions.
- Develop and evaluate a low-cost reflectance sensor for real-time estimation of protein content and digestibility of bermudagrass and other warm-season forages, suitable for determining start dates for feeding of supplements to livestock and making grazing management decisions.

Problem Statement G: Need for economically viable pasture-livestock systems for the Northeast and North Central States that enhance the environment.

Research Needs: The research needs identified for this Problem Area are addressed in the following research objectives:

Objective G.1: Develop new management and supplementation practices to optimize the utilization of mixed-species cool-season pastures by grazing dairy cattle to produce products tailored to meet traditional and niche markets of the Northeast and North Central states. (Madison, University Park)

Anticipated Products and Potential Benefits

- Identify forage management indicators based on an improved understanding of the interactions among soil fertility, sward management, and environment factors

on plant phenology and morphology and the interrelationship between plant structure and forage quality in grasses and legumes commonly used in the region.

- Supplementation guidelines to improve pasture performance and grazing dairy cattle performance based on improved knowledge of the physical characteristics of forage plants in alternative improved pasture strategies of combining mixture of cool-season forages.
- Develop methods to manipulate plant diversity and sward composition to achieve improved ecosystem functions based on data on CO2 fluxes, soil carbon sequestration, and greenhouse gas emissions under various pasture management strategies at multiple scales.
- Guidelines for dairy pastures for selecting and establishing forage mixtures (grasses, legumes, forbs) adapted to producer objectives and microenvironments on the farm.

Component 2 Resources

Research objectives of 13 ARS CRIS projects coded to NP215 address the research needs of Component 2. ARS lead scientists for these projects are:

Beaver: David Belesky. Joyce Foster
Booneville: David Brauer
College Station: Byron Burson
Corvallis: Gary Banowetz
El Reno: Bradley Venuto
Langston: Paul Bartholomew
Lexington: James Strickland
Lincoln: Kenneth Vogel
Logan: vice-Jerry Chatterton
Madison: Michael Casler
Raleigh: Joseph Burns
Tifton: Jeffrey Wilson
University Park: Matt Sanderson

Component 3. Sustainable Harvested Forage SystemsFor Livestock, Bioenergy and Bioproducts

Bioenergy production has the potential to increase farm profits and to utilize crop surpluses while conserving soil and water resources and reducing our dependence on foreign oil. However, improvements in germplasm, management practices and production systems are needed to increase the economic viability and environmental sustainability of using harvested grasses, alfalfa, and other forages for bioenergy, and bioproducts in a way that is compatible with livestock production and conservation objectives.

Problem Statement H: Need for improved plant materials that enhance the environment while improving the economic viability harvesting and using grasses and forage legumes for livestock, bioenergy and bioproduct production.

Research Needs: The research needs identified for this problem area are addressed in the following research objectives:

Objective H.1: **Provide the scientific knowledge, technologies and germplasm needed to develop plant materials that can be produced economically and efficiently converted to high-value products while enhancing the environment.** (Albany, Lincoln, Madison, St. Paul, Peoria)

Anticipated Products and Potential Benefits

- Develop new analytical tools such as complete cell wall solubilization techniques that will decrease analysis time and enrich the amount of information available from each sample for characterizing chemical composition and structure of plant cell walls.
- Identification of cell-wall features in indigestible residues that must be altered to improve forage utilization by determing key metabolic processes between cell wall matrix components and their impact structural polysaccharide degradation.
- Provide germplasm information including reliable genetic marker systems and maps for biomass energy crops on bioenergy traits including the effects of expression and suppression of genes involved in metabolic pathways governing cell wall synthesis and composition.
- Improved plant breeding methods for producing hybrid cultivars of cross-pollinated perennial grass species.
- Determine the feasibility of increasing abiotic stress tolerance (drought, temperature, radiation) in forages through up/down regulation of soluble carbohydrate metabolic genes (e.g., increased trehalose synthase gene expression).
- Apply knowledge from metabolic pathways of polyphenol oxidase/o-diphenols and o-quinone interactions with proteins to develop unique forage plants with improved nitrogen use efficiencies during harvest, storage and utilization of forages in dairy systems.
- Develop and apply computer simulations to quantify the value of forage condensed tannins and o-diphenols for improving protein utilization by dairy cattle to evaluate the economic and environmental benefits of producing and feeding polyphenol-containing forages on dairy farms and on-farm nitrogen cycling.
- Provide guidelines on how physical forage traits, including particle size of temperate perennial grasses, influence intake and digestion and interact with chemical traits to effect animal performance.
- Develop reliable molecular genetic tools including marker systems and maps and gene function characterization for switchgrass.
- Identify markers and germplasm for improved biotic and abiotic environmental stress tolerance including characterize forage pests and pathogens.

Objective H.2: Develop improved grass and forage legume germplasm and varieties that can be more efficiently converted into livestock, bioenergy, and bioproducts

products that can be produced in a variety of environments. (Albany, Corvallis, Lincoln, Madison, Raleigh, St. Paul, Tifton)

Alfalfa and Other Forage Legumes

Anticipated Products and Potential Benefits

- Improved switchgrass cultivars, and germplasms for use in public and private breeding programs, that produce improved biomass for energy in the mid-continent U.S.
- Improve energy availability by increasing cell wall digestibility by genetically modify alfalfa using selection and molecular biology based on knowledge of genetic modifications that will increase cell wall digestibility and germplasm that incorporates these beneficial modifications.
- Develop a gene expression atlas for *Medicago* species using whole genome transcript profiling. Identification of gene expression patterns during plant development that are specific to plant organs and plant species.
- Develop breeding methodologies based on an improved understanding of the heterotic control of forage yield in *Medicago* species to improve yield and persistence in alfalfa.
- Develop unique alfalfa germplasm using combinations of conventional breeding and genetic manipulation including up- and/or down- regulation of novel genes to alter total biomass accumulation and other characteristics of alfalfa.
- Provide information on GMO alfalfa gathered through field trial responses of alfalfa developed through conventional breeding and genetic manipulation to determine the impacts of altering soluble sugar concentrations, lignin, and cell wall cross-linking and biosynthesis on plant digestibility and agricultural fitness traits.
- Alfalfa management decision support information for producers using existing and new alfalfa cultivars and germplasm Techniques for harvesting and storing the novel alfalfa that provide optimum quality and yield for its intended use.
- Identification of alfalfa genes for fungal disease resistance and DNA markers and methods for selecting elite parental material for cultivar development based upon genome synteny of alfalfa with the closely related model *M. truncatula* and identity of DNA markers associated with the genes/QTL which can be used to develop disease resistant alfalfa cultivars.
- Characterization of genes involved in aluminum tolerance and their affect on tolerance in alfalfa.
- New alfalfa germplasm that is tolerant to stresses related to in-season manure application Develop alfalfa germplasm tolerant to manure application during the growing season.
- Recommendations for reducing damage from brown root rot and reducing the amount of the pathogen in soils. SY: Samac 0.1 Develop molecular assays for identification of the pathogen causing brown root rot of alfalfa.
- Increase the environmental and economic benefits of alfalfa by develop new alfalfa germplasm based on an increase understanding of the mechanisms

controling of biological nitrogen fixation capacity and resilience and nutrient acquisition by *Medicago* species to optimize soil fertility.

Grasses

Anticipated Products and Potential Benefits

- Provide improved grass germplasm (switchgrass, bermudagrass, Pennisetum, and Pearl millet) that increases the efficiency of conversion of harvested forages into bioenergy and livestock products.
- Identify genes and develop molecular tools that will increase biomass of cool-season grass plants (Lolium spp.) to improve forage quality and source material for bioenergy production.
- Determine the influence of method of forage preservation [hay vs. baleage vs. silage (direct cut or wilted)] on fermentation characteristics, nutritive value and quality (intake and digestion) of gamagrass and switchgrass.

Problem Statement J: Need for economically viable, energy efficient and environmentally enhancing production systems for establishing, growing, maintaining, harvesting, treating, storing and transporting forages for livestock, bioenergy, bioproducts and conservation objectives.

Research Needs: *T*he research needs identified for this problem area are addressed in the following research objectives:

Objective J.1: Provide improved management practices that enhance the environment and increase the economic viability of growing, harvesting, and storing forage grass and legumes for bioenergy and byproduct systems. (Corvallis, El Reno, Lincoln, Mandan, Madison, Peoria, St. Paul, Tifton, University Park)

Anticipated Products and Potential Benefits

- Provide information to optimize forage breeding programs and management practices by measuring in the field the effects of genotype x environment interactions on the viability of using herbaceous biomass for to liquid and gaseous fuel.
- Quantify soil carbon sequestration and other environmental benefits of herbaceous biomass crop production systems by determining the short term (<5 and 10 years) effects of switchgrass (C-4 grass) and Poa and Lolium (C-3 grasses) managed as a biomass energy crop in the Great Plains and Pacific Northwest respectively.
- Guidelines to determine when biomass can be harvested from lands in conservation practices such as CRP and buffers without adversely affecting their ability to accomplish conservation objectives.
- Guidelines for selecting cultivars of *Miscanthus*, sorghums, sudan grasses, sorghum x sudan hybrids, switchgrass, eastern gamagrass, alfalfa, bermudagrass, and *Trifoliums* for bioenergy production in the southern Great Plains.

- Technologies will be developed that will be utilized by biomass biorefineries and their feedstock producers to most economically and energetically efficiently harvest, store, and convert biomass energy crops to liquid fuels and synthetic gases.
- Information on the economic cost of different methods of harvesting and storing biomass feedstocks on farms using available hay technology will be determined.
- Provide guidelines on conversion efficiency and economic values of farm scale gasification units.
- Increase the economic viability of producing switchgrass for bioenergy by developing affordable tools and practices that increase switchgrass establishment success, improve inorganic and organic fertilizer use efficiency, and reduce the time period required for newly established switchgrass fields to reach full production potential.
- Provide management and economic guidelines on using alternative harvesting and storage technologies to improve switchgrass conversion efficiency for biomass feedstocks grown in the central Great Plains and Midwest.
- Technical and economic guidelines for selecting pre-and post harvest, storage and transportation practices for switchgrass, alfalfa and other forages to improve feedstock conversion efficiency for both liquid fuel and synthesis gas production.
- Management strategies for integrating the production of forage-feedstock for bioenergy use with forage-livestock systems.
- Develop management guidelines for optimizing the composition of grass, legume, and grass-legume biomass crops to provide appropriate feedstocks for the efficient production of liquid fuels and syngas.

Objective J.2: Provide improved management practices that enhance the environment and increase the economic viability of growing, harvesting, and storing alfalfa and other forages for livestock production and other objectives. (Corvallis, Lincoln, Madison, St. Paul)

Anticipated Products and Potential Benefits

- Provide new management practices for using alfalfa and other perennial forages to improve nutrient cycling for more cost-effective fertility management and improved water quality based on improved understanding of alfalfa's role in on-farm N fixation rates, soil N use, and below-ground N accumulation.
- Guidelines for using of green manures and crop chemicals to reduce foliar diseases and crown rot in alfalfa to enhance yields and persistence.
- Provide guidelines for improving the balancing of dairy rations when using damaged or improperly stored hay and silages.
- Provide additional management options for harvesting and storing sub-optimal quality alfalfa to maximize its utility in dairy cattle.
- Develop alternative stand establishment techniques for interseeding alfalfa and red clover into corn and winter cereal crops to reduce costs while improving forage and crop yields and meeting environmental goals.

- Guidelines on the establishment, management, harvest, storage, and utilization of annual forages (crabgrass, annual ryegrass, cereal grains, legumes) for lactating dairy cows and developing dairy heifers.

Component 3 Resources
Research objectives of 12 ARS CRIS projects coded to NP215 address the research needs of Component III. ARS lead scientists for these projects are:

Beltsville: Gary Bauchan, Nichole O'Neil
Corvallis: Gary Banowetz
El Reno: Bradley Vanuto
Lincoln: Kenneth Vogel
Madison: Michael Casler, Rod Hatfield
Mandan: Jonathan Hanson
Prosser: George Vandamark
St. Paul: Deborah Samac
Tifton: Jeffrey Wilson
University Park: Matt Sanderson

Component 4. Turf Plant Materials

There is a need to develop and transfer technologies, germplasm, management practices and strategies to increase the sustainability of turf systems to meet economic, environmental and social objectives.

Problem Statement K: Need for improved germplasm that is adapted to biotic and abiotic stresses and meets the economic and environmental objectives of turf producers and users.

Research Needs: The research needs identified for this problem area are addressed in the following research objective:

Objective K1: Identify, characterize, and develop grass germplasm suitable for turf uses with improved water-use efficiency, drought tolerance, and salt tolerance using conventional and molecular methods to improve the germplasm enhancement process. (Beltsville, Corvallis, Logan, Madison, Tifton)

Anticipated Products and Potential Benefits
- New drought-tolerant, turf-type cultivars and/or germplasms of crested and native *Elymus* wheatgrasses for use in low-maintenance landscapes, and genetic markers associated with turf quality, rhizome development, plant height, seed dormancy, seed shattering, and salt tolerance.
- Utilize *Dicanthelium* as a model species to identify heat stress tolerance genes to enhance germplasm in forage and turf grass systems.

- Identification of genes and molecular signaling components that are involved in drought and salinity stress tolerance in Lolium and Festuca and application of this information to improve grass genetic resources.
- Identification of genomic markers to identify genes that impact seed and foliage disease resistance in Lolium, Festuca, Poa, and Dactylis (ergot, stem rust, crown rust) and assist in selecting highly resistant germplasm.
- Identify molecular markers and construct linkage maps of ryegrass (*Lolium* spp.) and bentgrass (*Agrostis* spp.) that identify regions that impact specific traits important in turf systems.
- Identify genes and molecular mechanisms to improve gene stability and minimize escape of transgenes in forage and turfgrasses (Lolium spp.)
- Screen *Lolium* and *Festuca* for heat/drought tolerance.
- Develop genomic markers to identify genes that impact seed and foliage disease resistance in *Lolium*, *Festuca*, *Poa*, and *Dactylis* (ergot, stem rust, crown rust) and assist in selecting highly resistant germplasm.
- Identify genes and molecular mechanisms to improve gene stability and minimize escape of transgenes in turfgrasses (*Lolium* spp.).
- Identify genetic traits in seed production systems that impact cultivar integrity, diversity and identity in *Lolium* and *Agrostis.*
- Identify genes for foliar disease resistance (brown patch, dollar spot) and develop markers for selecting highly resistant *Lolium*, *Agrostis*, and *Festuca* germplasm.
- Develop mapping population for staygreen in *Pennisetum.*
- Evaluate variability for nitrogen-use efficiency in *Pennisetum.*
- Characterize *Pennisetum* for tolerance or resistance to chinch bug, foliar diseases, root knot nematode, weed competition and rapid germination, and seed molds; and, identify molecular markers for foliar disease and root knot nematode resistance.
- Screening of turf-type *Poa pratensis* and related species to determine genetic and physiological basis for drought tolerance, water-use efficiency, salt tolerance, and sexual reproduction to identify populations for use in turf breeding programs.
- Monitor and characterize intra- and interspecific introgression of Kentucky bluegrass transgenes for biotechnology risk assessment and breeding research.
- Germplasm collection trips to Central Asia will make plant materials available for evaluation in the western U.S. to identify new populations for low-maintenance turf.
- Construct comparative maps to align genomes of selected forage and turf plants with cereal food crops and utilize this information to improve grass genetic resources.

Component 4 Resources

Research objectives of 5 ARS CRIS projects coded to NP215 address the research needs of Component 4. ARS lead scientists for these projects are:

Beltsville: Scott Warnke
Corvallis: Gary Banowetz

Logan: vice-Jerry Chatterton
Madison: Michael Casler
Tifton: Jeffrey Wilson