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NP 215 Action Plan for 2013-2018
Pasture, Forage and Rangeland Systems

Goal of National Program NP 215

To improve food and energy security while enhancing the natural resources base by developing and transferring economically viable and environmentally protective technologies for sustainable range, pasture, forage and turf production systems that are based on fundamental applications of ecological and agronomic processes, and that are flexible to mitigate and adapt to the uncertainties of changing climate and market conditions.

Importance of Pasture, Forage, Turf and Range Lands

Our Nation's range, pasture, and herbage-based forage and turf landscapes serve many critical functions. Farms and ranches produce high quality, nutritious, abundant, and safe food products, as well a fiber and wood products that are the basis of income for producers and their rural communities. Rural areas also provide significant ecosystems services such as clean air and water, wildlife habitat, and are a long-term repository for biodiversity. These systems comprise about half of the land surface of the United States and represent a large and diverse mix of ecological sites including annual grasslands of California, tundra rangelands of Alaska, hot arid deserts of the Southwest, temperate deserts of the Pacific Northwest, semiarid cold deserts of the Great Basin, prairies of the Great Plains, humid native grasslands of the South and East, and pastures and hay fields within all 50 states from Hawaii to Maine and Alaska to Florida.

The United Nations estimates that two-thirds of the world’s agricultural land is pasture, forage and rangelands that can sustainably produce high quality animal products, but which are unsuitable for the more intensive production of grains or vegetables for human consumption. Knowledge gained about the development of sustainable land management in the United States will aid people across the globe.

The Nation’s 30-40 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.

Pasture, forage and rangelands are the primary forage base for U.S. livestock grazing industries and are utilized by more than 60 million cattle and millions of sheep and goats. Forage livestock systems contribute more than $100 billion in farm sales annually to the U.S. economy. The estimated value of hay production is $13 billion, and is the third most valuable crop to U.S. agriculture, behind only corn and soybeans. The publicly owned rangelands in the western U.S. are also critically important, providing forage on 260 million acres for three 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 efficient production of food animal products.

The ecosystem services provided by these lands are of increasing importance. Watersheds in upland range and pasture regions are essential sources of clean water for urban areas, irrigated agriculture, and recreation. These lands provide forage and habitat for numerous wildlife species, including 20 million deer, one-half-million pronghorn antelope, 400,000 elk, 55,000 feral horses and burros, and hundreds of additional animal and bird species. Also, an array of additional demands are placed on these natural resource, including mining, oil and natural gas production, camping, hiking, fishing, hunting, and other recreational activities. Meeting these many demands requires an improved understanding of how basic ecological processes are affected by grazing livestock production, forage management and harvest, and other land management practices.

Harvested and conserved forages provide a dietary resource for continuity of livestock production that 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 - providing about half 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. Increased forage and food animal production efficiencies are needed to ensure the competitiveness and sustainability of food animal producers and to improve domestic and international food security.

Science-based solutions to these challenges must ensure that the contributions of all supply chain participants are productive, economical, and done in ways that are protective of natural resources and social capital to ensure that our range, pasture, and forage-based systems are sustainable. The overall goal of this national program is to provide the appropriate technologies and management strategies to sustain our rangelands and pastures and to improve the efficiency of forage and food animal production.

National Priorities Include Adaptation to Climate Change, Bioenergy, Food Safety and Food Security.

Bioenergy – Achieving the goal of producing 36 billion gallons of biofuel and reducing greenhouse gas production by 138 million metric tons a year by 2022 requires the development of advanced region-based, sustainable feedstock production systems that help enhance rural prosperity. Essential to meeting this goal is the development of improved grass and forage legume germplasm and biomass productions systems that will be used to produce biofuels and other forms of renewable energy. There is also a need to determine the long-term impacts of the widespread deployment of these biomass production systems on livestock production and natural resources associated with our rangelands, forests, pastures, and forages. The rising competition for land and water resources between existing agriculture, rural communities and urban areas, and emerging bioenergy could affect future supplies of fuel, food, and fiber produced on our rangelands, forests and pastures. Thus, there is a need to develop sustainable long-term many-objective strategies to maintain the economic productivity and environmental health of our rangelands, forests, and pastures under increasingly intensive use.

Adaptation to Climate Change – In addition to providing cultural and aesthetic value, well-managed forests, rangelands, pastures and turf provide habitat for wildlife, help control flooding, reduce soil erosion, protect wetland and watershed function, improve

water quality, store carbon, and contribute directly to our nation's need for fuel, feed and fiber. To maintain present production and meet increasing future demands of our forest, rangeland, and pasture production systems, we will need to understand how changing climate and extreme weather could impact the productivity and resilience of these systems. Managers need decision-support tools to help them implement management systems that mitigate greenhouse gases and which are sufficiently flexible to adapt to climate variability and change. Forest, rangelands, and pastures have the potential to serve as large carbon sinks that can sequester greenhouse gas emissions from other industries. There is a need to quantify this potential and develop climate-change mitigation strategies that can be used to enhance rural prosperity and ecosystems services. Equally important in forests and rangelands is the need to develop inventory and monitoring tools to help control the spread of invasive weeds which negatively impact wildlife habitat, biodiversity, and lead to increased risk of wildfires; and to determine the effects of climate change on the spread of poisonous plants.

Food Security and Safety – Food production based on forages produced on rangelands, pastures, and harvested hay fields makes a significant contribution to food security by providing high quality and nutrient dense meat and dairy products. These production systems need to utilize technologies and management systems that increase production efficiencies and result in products that meet high standards of food safety and nutrition. At the same time, these production systems must protect natural resources from pathogens, chemical contamination, and invasive pests. Of particular concern is the need to manage poisonous plants so that grazing lands can achieve their potential while minimizing forage and food contamination. There is also a need for a greater understanding of how forage diets can be modified through plant improvement, selection, and supplementation to increase animal production efficiencies and nutritional value of meat and dairy products.

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

Forest, rangeland, and pasture ecosystems provide a number of goods and services that are critical to maintaining a healthy and livable environment those in rural communities and the greater population as a whole. 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, fuel and fiber, and provide a renewable source of bioenergy feed stocks. Even though these systems are managed less intensively than conventional farmlands, sound science-based 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 adverse affects caused by global climate change.

Performance Measure 5.1.1: *Develop Practices and Technologies to Improve Rangeland Productivity and Ecological Services*. **Actionable Strategies**: Develop

rangeland livestock grazing systems that can meet producer, land manager, and global food security objectives while being adaptable to changing environmental and climatic conditions. Develop management strategies and practices that enhance and conserve rangeland ecosystems to provide multiple ecosystem services under changing environmental and climatic conditions. Develop science-based understanding of how soils, plants, animals, climate and human activities interact to affect rangeland ecosystem structure and function over multiple scales and time to improve the effectiveness of land management under changing conditions.

Performance Measure 5.1.2: *Develop Practices and Technologies to Improve Pasture Productivity and Ecological Services*. **Actionable Strategies**: Develop pasture-based livestock production systems that can meet producer, environmental, and global food security objectives while being adaptable to changing environmental and climatic conditions. Develop management strategies and practices that enhance and conserve pasture ecosystems that provide multiple ecosystem services even under changing climatic conditions. Develop science-based understanding of how soils, plants, animals, climate and human activities interact to affect pasture ecosystems structure and function over multiple scales and time to improve the effectiveness of land management under changing conditions.

Performance Measure 5.1.3: *Develop Sustainable Harvested Forage Systems for Livestock, Bioenergy and Bioproducts*. **Actionable Strategies**: Develop improved plant materials for harvested forage and biomass production systems that will increase the efficiency of livestock and bioenergy production systems while enhancing the environment. Develop improved harvested forage and biomass production systems that increase economic and energy efficiency while enhancing the environment to meet national energy and food security goals.

Performance Measure 5.1.4: *Develop Improved Germplasm and Management Practices for Sustainable Turf Systems*. **Actionable Strategies**: Develop improved turf germplasm and management practices that meet the objectives of turf producers and users under changing climatic and environmental conditions**.**

Scope of Research

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

1. Improved Rangeland Management for Enhanced Livestock Production, Conservation, and Ecological Services,
2. Improved Pasture Technologies and Management for Enhanced Livestock Production, Conservation, and Ecological Services,
3. Improved Harvested Forages for Enhanced Livestock, Bioenergy, and Bioproducts Production, and
4. Turf Improvement and Management.

Beneficiaries of this National Program

Our research is designed to 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 Extension that provide technologies and knowledge to these producers. This program also will benefit federal land stewardship agencies including 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 the management of hundreds of millions of acres of publicly owned lands plus provide aid to private land owners. 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 that provide greater economic opportunities, access to high quality food, fiber, clean air and water, 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 our 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, with other federal, state, and local agencies, and with 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; Food 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
Beltsville, MD	El Reno, OK	Cheyenne, WY
Booneville, AR	Langston, OK	Boise, ID
Lexington, KY	Lincoln, NE	Burns, OR
Madison, WI	Mandan, ND	Corvallis, OR
St. Paul, MN	Woodward, OK	Dubois, ID
Tifton, GA	Ft. Collins, CO	Miles City, MT
University Park, PA	Las Cruces, NM	Prosser, WA
	Logan, UT	Reno, NV

Research Components and Problem Statements

Increasing world population, drought, flooding, urbanization, and increased fuel and energy costs continue to tax energy and food production capabilities. Climate variability and increased food demand dictates the need for development and transfer of innovative technologies, management practices and integrative strategies to improve the conservation, efficiency and use of pasture, forage, turf and rangelands. Complex problems such as these require effective collaborative strategies in and out of ARS to best manage and leverage expertise and resources. Solutions will be effectively determined with cooperation with other federal agencies, academia, and other key industry stakeholders.

Component 1. Improved Rangeland Management for Enhanced Livestock Production, Conservation, and Ecological Services

Meeting the challenges associated with increasing food production and addressing ecosystem services on rangelands, including restoring rangelands currently in poor condition, requires a combination of management strategies to renew, maintain and enhance desirable rangeland. Climate change, bioenergy development, recreational activities, preserving natural resources, social interests, and a growing population all make management of rangelands challenging and complex. Maintaining and improving rangelands is important for rural prosperity in the western U.S., but it is also an issue of global significance with implications for international food security and climate change mitigation.

Problem Statement A: Developing economic livestock grazing systems for rangelands that meet global food security objectives while being adaptable to changing climate and varying environmental conditions and preserve the natural resources integrity.

This problem area focuses specifically on developing rangeland management strategies and practices for increasing food production through flexible livestock grazing systems that are economically viable, environmentally sound, and adaptable to changing conditions. This research will build a wealth of ARS research experience that dates back at least one hundred years. Much of the proposed focus is on improving grazing and forage utilization efficiencies, improving restoration techniques, incorporating potential climatic variability into management strategies, advancing our use of landscape analysis, and developing decision tools that are useful to managers.

Research Needs Addressed

- Stockpiled grasses, legumes, forbs, and shrubs to extend the grazing season in the fall, winter, and early spring to enhance environmental sustainability and economic profitability
- Efficient strategies for producing livestock on forage-based diets and management strategies that target the reduction of invasive cool-season grasses
- Management strategies that balance production and conservation goals
- Determine relationships between climate change and livestock gains
- Fuel management strategies and post-fire grazing
- Reduce livestock losses associated with poisonous plants

Objective A.1. *Develop sustainable rangeland livestock production systems that are economically viable, conserve natural resources, and are adaptable to changing environmental conditions.*

Challenges associated with sustainable rangeland production systems include rising costs associated with feed grains and uncertain environmental conditions, which increase the need to produce livestock more efficiently on forage-based diets. This can be accomplished by improved forage use efficiency by livestock, extended grazing season, and genetically improved plant materials to maintain forage yield and nutritional quality. ARS has made valuable contributions to the development of plant materials for restoration uses and increased production. However, additional research is needed to understand how stockpiled forages maintain forage yield and nutritional quality in the

dormant season. Additionally, identification of animals that are more efficient at using nutrients from forage-based diets, and strategies that improve forage utilization and resultant livestock production through strategic protein supplementation would increase sustainability of livestock production systems.

Anticipated Products and Potential Benefits

- A1.a: Improved grasses, legumes, forbs, and shrubs and management practices that maintain forage yield and nutritional quality into fall, winter, and early spring to meet animal nutritional needs.
- A1.b: New environmentally acceptable perennial grass cultivars and hybrids with superior persistence, seasonal forage accumulation, height, forage quality, and salt-tolerance characteristics in cool climatic environments.
- A1.c: Guidelines to use less feed concentrates for livestock for grass-fed operations.
- A1.d: Identification of animals that are more metabolically efficient at utilizing nutrients from rangeland forages.
- A1.e: Strategies to improve forage utilization and livestock production through protein and post-rumen amino acid supplementation.
- A1.f: Strategies to enhance the value, use and efficiency of residual dormant forages to lower energy costs and improve the economic sustainability of livestock producers.

Objective A.2. *Develop livestock grazing practices and systems for efficiently managing plant communities to enhance ecosystem services within a wide spectrum of ecological and climatic conditions and objectives.*

Most rangelands have traditionally been managed to provide food and fiber through management practices that achieve sustainable forage and livestock production. Yet, there is an emergent need to manage these lands for multiple ecosystem goods and services. Determining tradeoffs associated with changing management from principally forage and livestock production to a blend of production and conservation goals remains an open frontier. Compounding the uncertainty of determining the most appropriate tradeoffs is the reality that provision of multiple ecosystem services from rangelands involves applying management practices on numerous complex landscapes. Using livestock as “ecosystem engineers” for managing plant communities, rather than simply as products from rangelands, offers an opportunity to enhance ecosystem services within a wide spectrum of ecological and climatic conditions and for varying management objectives.

Anticipated Products and Potential Benefits

- A2.a: Targeted grazing strategies to reduce invasive cool-season grasses and promote desirable perennial cool-season grasses.
- A2.b: Description of cattle and wildlife interaction effects on livestock and wildlife distribution and performance, and vegetation dynamics.
- A2.c: Description of temperature and precipitation influence on livestock performance.
- A2.d: Grazing management strategies to influence fuel management and land use post-fire.

Objective A.3. *Improve production and reduce livestock losses on private and public rangelands where poisonous plants grow.*

Poisonous plants interfere with the optimum use of rangelands and contribute to livestock losses on private and public rangelands. These losses can be reproductive- (abortions), structure- (anatomical deformities), and production-related (reduced growth and efficiency) as well as direct mortality. Economically, these losses exceed $300 million for livestock producers annually. Needed are management strategies to minimize the impact of poisonous plants and improved diagnostic tools that can be used by veterinarians and land managers to identify poisoned livestock, determine effective decisions for treatment, and risk assessment of feed and food contamination. Enhancing the ability of livestock to graze rangelands containing poisonous plants should lead to more productive and economical use of these lands.

Anticipated Products and Potential Benefits

- A3.a: Forage grasses adapted to avoid uptake of selenium and other heavy metals associated with phytoxic soils from mining activities which will prevent livestock poisoning.
- A3.b: Identification of genes and genetic markers associated with uptake of selenium, heavy metals and other toxic compounds in perennial grasses grown on phytoxic soils contaminated by mining activities.
- A3.c: Recommendations and grazing strategies for producers to reduce livestock losses from poisonous plants.
- A3.d: Improved diagnostic techniques for laboratories and veterinarians.

Problem Statement B: Need for management strategies and practices that enhance and conserve rangeland ecosystems to provide multiple ecosystem services including forages for livestock, soil conservation, water quality, control of invasive species, recreation and wildlife habitat conservation under changing environmental conditions.

This Problem Area focuses specifically on maintaining and enhancing rangeland ecosystem structure and function under changing conditions that can simultaneously provide forages suitable for livestock grazing along with the full spectrum of other ecosystem services essential to ecosystem health and rural communities including water resources, soil conservation, wildlife habitat, biodiversity, recreational opportunities, and heritage values.

Research Needs Addressed

- Tools to integrate climate patterns into restoration decisions.
- Increase desirable perennial vegetation.
- Management strategies for increasing desirable perennial vegetations.
- Methods to critically evaluate rangeland management and restoration practices.
- Consistent methods to classify site potential of rangelands.
- Technologies to improve the success of rangeland seeding.
- Sound methods to select appropriate plant materials for revegetation.

- Characterize dynamic capacities of changing landscapes to supply production demands for ecosystem goods and services (including livestock demands and capacities), and describe characteristics that are associated with these changes.

Objective B.1. *Develop strategies and practices for conserving healthy rangelands and restoring degraded lands under changing environmental conditions to meet a variety of ecosystem services objectives.*

Challenges associated with rangeland management involve both preventative actions to contain or limit the impact of emerging problems, such as invasive weeds, drought or over-grazing, as well as remedial strategies where ecosystem function has been degraded. ARS has made valuable contributions to linking a science-based knowledge of ecosystem dynamics with strategies and practices for impacting plant community structure and composition. However, the dynamic nature of the management environment underscores the importance of additional research to modify existing strategies and practices to maximize effectiveness and to explore new approaches for addressing developing problems.

Anticipated Products and Potential Benefits

- B1.a: Weather and climate application technology and strategy toolbox for both restoration and education purposes.
- B1.b: Science based management strategies for restoring sagebrush, salt desert, mixed prairie, and riverine ecosystems based on accurate current and historical wildlife, plant community and livestock grazing demographics.
- B1.c: Management strategies which identify and reduce risks to rangeland ecosystems.
- B1.d: Monitoring guidelines for evaluating restoration and management practices based on ecological site landscape position, and climatic variation.
- B1.e: Ecological site classifications which managers can use to improve both current management and adaptation to climate change.
- B1.f: Guidelines for seed coating and dispersion technologies that can improve establishment of desirable plants in rangeland seeding projects.

Objective B.2. *Develop decision support tools usable at multiple scales including landscape levels for inventorying and assessing rangelands; and, for selecting, implementing, and monitoring conservation and restoration practices.*

Rangelands are sensitive, complex, heterogeneous lands that are distinctly classified by the kind and amount of vegetation. Rangelands respond differently to management actions and natural disturbances. In addition, the soils and ecosystem processes that determine the distinctiveness of a particular site vary across temporal and spatial scales. This complexity requires support tools to inventory, assess, and implement accurate and effective conservation and restoration practices. In many cases, rangelands may not be functioning at their full potential, suggesting the need to develop conservation and restoration practices specific to a particular site, the underlying conditions, and historical land-use. Understanding how abiotic and biotic thresholds dictate and limit the application of conservation and restoration practices is a critical step towards increasing the effectiveness of rangeland management.

Anticipated Products and Potential Benefits

- B2.a: Decision support systems for using improved native and introduced plant materials to enhance or restore rangelands that fundamentally differ in disturbance and land-use history.
- B2.b: Inventory of current and historical land-use disturbance in the semiarid steppe ecosystems in North America and similar ecosystems around the world and develop quantitative indicators of biotic and abiotic thresholds to optimize rangeland restoration and management strategies.
- B2.c: Rangeland hydrology and erosion models applicable for optimizing the enhancement of disturbed sagebrush steppe rangelands following fire, juniper encroachment and annual grass invasion, allowing assessment of hydrologic impacts, management alternatives, and conservation benefits.
- B2.d: Accurate databases of the capacity for different landscapes to provide for a variety of ecosystem services, including livestock production for the development of best management practices for all stakeholders.
- B2.e: Web-based tools to assess management and monitoring information by ecological site for western rangelands for the implementation of best site level management objectives in specific ecosystems.
- B2.f: Web-based tools linking soil microbial profiles to vegetation, ecological site, and land condition.
- B2.g: Decision support tools to determine where on the landscape specific conservation practices will be most effective.

Problem Statement C: Need for greater fundamental understanding of ecological processes and interactions so science-based management practices, technologies, and germplasm can be improved to meet production, conservation and restoration objectives under changing climatic conditions.

This Problem Area focuses on providing the fundamental, science-based understanding of soils, plants, animals and their interactions necessary to develop sustainable livestock production strategies (Problem Area A) and strategies to conserve and restore rangeland natural resources (Problem Area B). ARS has made substantial contributions to our understanding of fundamental processes at plot-to-pasture and allotment scales. However, climate variability and changing land use patterns require increased understanding of how interactions among these elements vary across rangeland landscapes in order to support development of innovative management strategies necessary to adapt to changing conditions and management objectives.

<u>Research Needs Addressed</u>

- Better understanding of how soil (including microbial, water and nutrient), climate, plant, and animal processes and interactions affect rangeland status and responses to management
- Better understanding of how patterns and processes operating at site scales vary and interact with those at landscape to regional scales to affect rangeland status
- Better understanding of how changes in climate patterns interact with other ecological processes to cause changes in rangeland status

- Better understand endophytic and soil microbial mechanisms associated with plant salt tolerance, drought resistance, winter injury, seed shattering, herbicide resistance, and forage quality
- Improved plant materials that enhance productivity, conservation and restoration of rangelands

Objective C.1. *Improve understanding of the fundamental relationships among management practices, ecological processes, and climatic variability to improve rangeland production, conservation and restoration.*

Foundational work has been conducted describing various ecological processes. However, progress in rangeland production, conservation and restoration is hindered by limited basic science explaining process interactions and changes over time and space. Additionally, significant gaps exist in the understanding of belowground processes and their effects on aboveground vegetation. Improved understanding of fundamental relationships among management practices, ecological processes, and climate variability will facilitate development of management practices, prediction tools, and risk assessment. The information derived in this objective will be used to develop decision tools in Problem Areas A and B, and will serve as the basis for the next phase of research.

Anticipated Products and Potential Benefits

- C1.a: Ecological site descriptions including state and transition models
- C1.b: Habitat suitability assessments
- C1.c: Forage and livestock management practices
- C1.d: Woody species management practices
- C1.e: Annual and invasive species management practices
- C1.f: Seedling establishment technologies for rangelands
- C1.g: Description of endophyte and soil microbial influences on rangeland structure and function
- C1.h: Improved remotely sensed techniques for rangeland evaluation, monitoring, and prediction
- C1.i: Evaluation of ecohydrological models
- C1.j: Assessments of accelerated erosion

Objective C.2. *Improve understanding of plant material adaptations and develop tools to increase the efficiency of germplasm improvement.*

Increased emphasis on establishing biologically diverse ecosystems of native and introduced plant materials on disturbed rangelands requires improved native grasses and legumes that can compete with invasive weeds and are adapted to local, but changing environments. Current wild land collected natives species often are not able to establish and compete in severely disturbed or changed environments. However, little effort has focused on the breeding, selection, and improvement of native grasses and native, nitrogen-fixing legumes to address these challenges. Native plant materials need to be developed that are easy to establish, competitive, and persistent in local

environments experiencing increased wildfires, drought, and heat associated with climate change.

Anticipated Products and Potential Benefits

- C2.a: Improved native grasses and legumes that can compete with invasive weeds and are adapted to changing environments
- C2.b: Native plant materials that are competitive, easy to establish, and persistent in environments experiencing increased drought, heat associated with climate change, and wildfires
- C2.c: Improved introduced plant materials with increased seedling vigor and persistence, and high drought and defoliation tolerance to revegetate and stabilize severely disturbed rangelands
- C2.d: Genetic libraries providing opportunities to characterize genetic and physiological pathways as a means to more efficiently improve plant materials

Component 1 Resources

Research objectives of 11 ARS NP215 projects to address the research needs of Component 1. ARS lead scientists for these projects are:

- Boise: Fred Pierson
- Burns: Anthony Svejcar
- Cheyenne: Justin Derner
- Dubois: Gregory Lewis
- Las Cruces: Kris Havstad, Debra Peters
- Logan (Forage and Range): Jack Staub, Kevin Jensen
- Logan (Poisonous Plants): Kip Panter
- Mandan: Matt Sanderson
- Miles City: Mark Peterson, Lance Vermeire
- Reno: Mark Weltz
- Woodward: Stacy Gunter

Component 2: Develop Improved Pasture Technologies and Management Systems

Production concerns of primary interest for producers managing pastures include generating an optimum supply of forage with acceptable nutritive value in sustainable production systems that maximize profitability. Production of livestock is heavily dependent on pasture systems for economic viability in a growing global market for food animal products. Pastures are an economical means of producing high quality, nutrient dense food for human consumption as well as other recognized services such as soil conservation, water quality protection, wildlife habitat, carbon sequestration, and improved air quality – typically on land that is not suitable for grain or vegetable production. Often there is little or no direct economic return to the livestock producer for these latter services, yet society is rapidly recognizing the intrinsic need and value of these ecosystem benefits. Predicting animal performance in response to grazing pastures is limited due to poor understanding of plant nutrient interactions with the genetic/phenotypic expression of grazing animals under various environmental conditions and plant communities. Further, our limited understanding of the effects of plant nutraceuticals or factors that limit nutrient uptake and utilization limit improvements to management protocols for efficient forage production.

Agriculture is responsible for about 6% of total U.S. greenhouse gas (CO_2, CH_4 and N_2O) emissions. Proper management of pasture systems can reduce direct emissions and offset emissions from other entities by sequestering C in the soil. Improved pasture management could increase the quantity of C sequestered in U.S. soils by 10 to 34 Tg per year. The potential to sequester C can be influenced by practices such as grazing frequency, stocking rates, plant community composition, and soil fertility, but additional information is needed to quantify the effects of specific management practices. Climate variability is also expected to increase with increasing atmospheric greenhouse gases, increasing the need for additional information on management practices that improve pasture resilience to temperature and precipitation extremes.

Mismanagement of pasture and hayland can reduce sustainability of production and harm the environment. There is an estimated 30 million ha of pasture and hayland in the United States that could benefit from conservation practices that result in greater environmental benefits, such as prescribed grazing, pasture/hayland planting, and nutrient management. The Conservation Effects Assessment Project (CEAP) is a multiagency effort to quantify and improve the environmental outcomes of conservation practices used by private landowners. New technologies should improve predictions of nutrient losses, runoff, and erosion from the Nation's 180 million acres of pasture and hayland that will enable more accurate comparisons of emerging conservation technologies and alternative management practices.

Problem Statement D: Need for pasture-based livestock production systems that meet producer, environmental, and food security objectives and are adaptable to changing environmental and climatic conditions.

This problem area focuses specifically on developing pasture management strategies and practices for increasing food production through flexible livestock grazing systems that are economically viable, environmentally sound, and adaptable to changing conditions.

Research Needs Addressed:

- D1.a: Management practices to extend the effective grazing season.
- D1.b: Optimal legume/grass mixtures in pastures to reduce fertilizer use and improve nitrogen efficiency.
- D1.c: Endophyte control in pasture management systems.
- D1.d: Animal phenotypes that do well on low-input forage systems.
- D1.e: Best management practices for multi-animal species grazing systems either simultaneously or sequentially.
- D1.f: Small ruminant pasture systems to control parasites.
- D1.g: Improved methods to identify nutrient management and animal supplementation practices that enhance nutrient use efficiency and reduce negative environmental impacts.
- D1.h: Decision support tools to assist land-use with placement of pastures and bioenergy crops in the farming landscape.

Objective D.1. *Develop pasture-based livestock production systems that are economically viable, conserve natural resources, and are adaptable to changing environmental and climatic conditions*.

There is a need to increase the efficiency of forage-based livestock production to meet the challenges associated with rising costs from supplemental feed grains, fertilizer and energy combined with competing land uses and uncertainty in environmental conditions. Extending the grazing season and improving plant materials that maintain forage yield and nutritional quality are important opportunities to meet these challenges. ARS has made valuable contributions to the development of plant materials for restoration uses and increased production. However, additional research is needed to understand how stockpiled forage maintains forage yield and nutritional quality in the dormant season. Additionally, identification of animals that are more efficient at using nutrients from forage-based diets, and strategies that improve forage utilization and resultant livestock production efficiency through improved forage use efficiency and strategic supplementation would increase the economic viability and environmental sustainability of livestock production systems.

Anticipated Products and Potential Benefits

- D1.a: Management practices to reduce the need for small ruminant supplements and/or hay, extend the grazing season, and optimize livestock production systems.
- D1.b: Management practices and decision support tools to reduce fertilizer use and improve nitrogen efficiency on pasture legume productivity and persistence, and maximize pasture productivity and nutritional quality.
- D1.c: Development of best management practices for production and/or control of endophyte-infected forage in pasture systems.
- D1.d: Identification and selection of animal phenotypes that are productive and thrive on low-input pasture systems to minimize management inputs.
- D1.e: Best management practices for multi-animal species grazing to increase pasture utilization and efficiency.

- D1.f: Management practices to control parasites and increase production and sustainability in small ruminant pasture systems.
- D1.g: Management strategies that enhance nutrient and animal supplementation for increased production, improved nutrient utilization efficiency, and adaptability to environmental and climatic changes.
- D1.h: Establishment of guidelines for placement of pastures and bioenergy crops on landscapes derived from assessment of simulated land-use scenarios.

Problem Statement E: *Need for management strategies and practices that enhance and conserve pasture agro-ecosystems to provide multiple ecosystem services under changing environmental and climatic conditions*.

This Problem Area focuses on maintaining and enhancing pasture ecosystem structure and function under changing conditions that can simultaneously provide forages suitable for livestock grazing along with a broad spectrum of other ecosystem services. These services are essential to environmental health as well as to the vitality of rural communities including water resources, soil conservation, wildlife habitat, biodiversity, recreational opportunities, and heritage values.

Research Needs Addressed*:*

- Better utilization of nutrients or fertilizer to increase pasture productivity.
- Integrated NRCS conservation practices in systems approaches.
- Pasture-based livestock management practices that improve resilience to climate change.
- Pasture-based livestock management systems that enhance C sequestration and minimize greenhouse gas emissions.
- Assess environmental outcomes of pasture-based conservation practices.
- Pasture-based livestock management systems that conserve soil and water resources.

Objective E.1. *Develop strategies and practices for conserving and improving pasture agro-ecosystems to meet a variety of ecosystem services objectives under changing environmental conditions*.

Challenges associated with pasture land management involve both conservation practices to avoid degradation as well as remedial strategies where agro-ecosystems services have been degraded. ARS has made valuable contributions to linking a science-based knowledge of agroecosystem dynamics with strategies and practices for establishing and maintaining vegetation production and sustainability while preserving the integrity of ecosystem services. However, the dynamic nature of markets, management technologies and environmental conditions underscores the importance of on-going research to modify existing strategies and practices to maintain effectiveness while exploring new approaches for addressing emerging problems.

Anticipated Products and Potential Benefits

- E1.a: Management practices that reduce manure, sediment and nutrient movement off-farm, retain pasture productivity under variable environmental conditions, and provide tools to evaluate effectiveness of conservation practices.

- E1.b: Establishment of integrated NRCS conservation practices in production systems approaches.
- E1.c: Best management practices to increase carbon sequestration, reduce greenhouse gas emissions from pastures and biofuel feedstock systems, and provide supplementation strategies to reduce methane emissions in dairy cows.
- E1.d: Bioclimatic models of forage species distributions under climate variability, and grassland management guidelines to optimize environmental benefits in forage production systems.

Objective E.2. *Develop decision support tools usable at multiple scales including landscape levels for inventorying and assessing pastures; and, for selecting, implementing, and monitoring conservation and restoration practices*.

Pastures are complex, heterogeneous lands that are distinctly classified by their soils, vegetation, and climates and that respond differently to management actions and natural disturbances. The agroecosystem processes determined by these characteristics result in distinctive sites varying across temporal and spatial scales. This complexity requires support tools to inventory, assess, and implement utilization and conservation practices. In many cases, pasture lands may not be functioning at their full potential, suggesting the need to develop conservation and restoration practices specifically tailored to the site that reflects underlying ecological and agronomic conditions, management objectives and historical land-use. Understanding how abiotic and biotic thresholds dictate and limit the application of utilization and conservation practices is a critical step towards developing tools to increase the effectiveness of pasture management.

Anticipated Products and Potential Benefits:

- E2.a: Ecologically-based pasture assessment, concepts and monitoring tools for forage suitability groups, and for regional scale assessment of forage and pastures.
- E2.b: Indicators for recovery of degraded pasture.
- E2.c: Tests for rapid assessment of soil Carbon and Nitrogen.

Problem Statement F: *Need for science-based understanding of how soils, plants, animals, climate and human activities interact to affect pasture ecosystem structure and function at multiple scales over time to improve the effectiveness of land management under changing environmental conditions*.

This Problem Area focuses on providing the fundamental, science-based understanding of soils, plants, animals and their interactions necessary to develop sustainable livestock production strategies (Problem Area D) and strategies to conserve and restore rangeland natural resources (Problem Area E). ARS has made substantial contributions to our understanding of fundamental processes at plot to pasture scales. However, climate variability and changing land use patterns require increased understanding of how interactions among these elements vary across pasture, crop, woodlands and rangeland landscapes in order to support development of innovative management strategies necessary to adapt to changing conditions and management objectives.

Research Needs Addressed:

- Optimal legume/grass mixture in pastures to improve nitrogen efficiency.

- Genomic, proteomic and metabolomic tools for common grass and legume species to support cultivar development.
- Genetic markers/QTLs and maps for trait based selection in forage grasses and legumes.
- New grass germplasm and cultivars with later flowering time (longer vegetative phase), higher digestibility, and broader adaptation to fluctuating and extreme climatic conditions.
- Novel endophytes that provide biotic and abiotic stress resistance without detrimental effects to livestock.
- New legume germplasm and cultivars with improved persistence under management intensive grazing, improved seed production, and broader adaptation to fluctuating and extreme climatic conditions.
- Genetic stocks, mapping and genomic information for orchard grass.

Objective F.1. *Improve understanding of the relationships between management practices and biological, geological and climatic processes to provide a scientific basis for improving the effectiveness of pasture production and conservation management*.

Foundational work has been conducted describing various agronomic and ecological processes important to sustainable pasture management. However, progress in production, conservation and restoration continues to be hindered by limited basic science explaining process interactions and changes over time and across landscapes. Additionally, significant gaps exist in the understanding of belowground processes and their effects on aboveground vegetation. Improved understanding of fundamental relationships among grazing and other management practices, agronomic and ecological processes, and climate variability will facilitate development of management practices, evaluation tools, and risk assessment. The information derived in this objective will be used to develop decision tools in *Problem Areas D* and *E*, and will serve as the foundation for the next phase of research.

Anticipated Products and Potential Benefits:

- F.1.a: Improved fundamental knowledge of optimal legume/grass mixtures to enhance nitrogen use efficiency in pastures.
- F.2.b: Improved establishment via increased seed germination and persistence in low moisture soils of native warm-season grasses, and in low moisture soils of native cool-season grasses.
- F.2.d New legume germplasm and cultivars with improved persistence under management intensive grazing, improved seed production, and broader adaptation to fluctuating and extreme climatic conditions.

Objective F.2. *Provide improved plant materials that will enhance the productivity and conservation of pastures by collecting and evaluating germplasm; identifying desirable traits and their modes of action; and, developing tools to enhance the efficiency of germplasm improvement*.

Increased emphasis on establishing and maintaining diverse combinations of native and introduced plant materials on pasture lands to provide sustainable livestock grazing and other agro-ecosystems services requires improved forage grasses and

legumes that can compete with invasive weeds and are adapted to changing environments.

Anticipated Products and Potential Benefits:

- F.2.a. Discovery and application of endophyte biology to enhance plant biotic and abiotic stress resistance without detrimental effects to livestock.
- F.2.b New genomic, proteomic, and metabolomic tools to support cultivar development of forage grasses and legumes, and to determine implications for plant production, fitness, and forage utilization under differing environmental conditions.
- F.2.c. Genetic markers/QTLs and maps for trait-based selection in forage grasses and legumes.
- F.2.d. New grass germplasm and cultivars with later flowering time (longer vegetative phase), greater digestibility, and broader adaptation to fluctuating and extreme climatic conditions.
- F.2.e Improved genetic stocks, mapping populations, and genomic information for studying orchard grasses with varying flowering time, winter hardiness, and digestibility.

Component 2 Resources

Research objectives of 13 ARS NP215 projects address the research needs of Component 2. ARS leaders for these projects are:

- Booneville: David Burner
- Corvallis: Gary Banowetz
- El Reno: Sam Coleman, Paul Bartholomew
- Lexington: James Strickland
- Lincoln: Kenneth Vogel
- Logan (Forages and Range): Jack Staub, Kevin Jensen
- Madison: Michael Casler
- Tifton: Bill Anderson
- University Park: Howard Skinner

Component 3: Improved Harvested Forage Systems for Livestock, Bioenergy and Bioproducts

Harvested forage is an essential cornerstone in agricultural production systems throughout the United States. Forages provide a critical component of the feed for livestock, and are particularly important in dairy, sheep and beef cattle production systems. Additionally, harvested forage species for use as bioenergy feedstock will play an increasingly important role in production of renewable energy. The U.S. Department of Agriculture and the U.S. Department of Energy have set a goal of replacing 30% of the Nation's petroleum consumption with biofuels by 2030. To meet this goal, approximately 1 billion tons of dry biomass per year will be needed. A large proportion of this total will come from harvested biomass. Perennial forages and biomass crops also provide immensely important public benefits by improving and protecting the quality of our soil, water, and atmosphere, facilitating management of limited resources, and providing wildlife habitat. Benefits of perennial crops are important now, and will become more important as demand for food products increases with world population growth, and as agriculture adapts to increasing weather variability.

Alfalfa, the predominant harvested forage in the U.S., is the fourth most widely grown crop in the country, and is grown in all 50 states. It has a direct annual value of over $8 billion and is essential for U.S. milk production, annually a $35 billion industry. Cultivation of alfalfa promotes soil conservation and enhances water quality. Alfalfa also has attributes that make it well suited as a bioenergy and bioproduct crop. Harvested alfalfa can be separated into an energy-rich stem fraction for biofuel production and a protein-rich leaf fraction for animal feed or other bioproducts. Importantly, alfalfa can provide all of the nitrogen needed for subsequent corn, small grains, or other crops, including those dedicated to bioenergy production, thereby significantly reducing fertilizer costs and improving net energy yield.

Perennial grasses are expected to be an important pillar of the national biomass feedstock production system that supports our future energy infrastructure. Economic and modeling studies have shown that current yield may be sufficient to generate economically viable feedstock at the farm-gate with good management and a favorable price structure. Improved farming systems (growing, harvesting, processing, and storage) are needed to capture the maximum value of current perennial forages. New improved germplasm needs to be developed as well.

Problem Statement G: *Need for improved plant materials for harvested forage and biomass production systems based on forage legumes and grasses that will increase the efficiency of livestock and bioenergy production systems while enhancing the environment*.

This problem area will utilize DNA marker and other technologies that represent opportunities to enhance the efficiency of plant selection by reducing the time required to evaluate large numbers of progeny. Basic knowledge of the genes, enzymes, and metabolic processes involved in cell wall development that is needed to improve conversion efficiency will be developed, Genetic stocks and improved germplasm and cultivars will be developed for livestock and biofuel production.

<u>Research Needs Addressed</u>:

- Methods for identifying, evaluating, and incorporating desired bioenergy and forage traits into improved germplasm.

- Knowledge of the metabolic and physiological capacity of forage and biomass legumes and grasses.
- Improved understanding of cell wall structure and function.
- Identification of the genetic basis of biotic and abiotic stress tolerance in forages for improving yield of feedstocks.
- Improved methods for identifying pathogens of forage and biomass legumes and grasses.
- Identification of new endophytic organisms for improving biotic and abiotic stress tolerance in forages.
- Forage and biomass legumes and grasses with increased resistance to biotic and abiotic stresses.
- Forage and biomass legumes and grasses with improved performance.

Objective G1: *Provide the scientific knowledge and technologies needed to develop plant materials that can be produced economically and efficiently converted to high-value products*.

DNA markers, which would accelerate selection of germplasm with desired traits, have not been developed for use in breeding perennial forages. Identification of genetic stocks with resistance to biotic and abiotic stresses is needed. Much of the energy in forage cell walls is not captured efficiently by ruminants or in biofuel production, and we lack much of the basic knowledge of the genes, enzymes, and metabolic processes involved in cell wall development that is needed to improve conversion efficiency

Anticipated Products:

- G1.a: Genetic tools and plant breeding methods for improving performance and conversion efficiency of forage grasses.
- G1.b: Improved analytical tools for rapidly determining cell wall composition, physiology and development as they affect conversion efficiency.
- G1.c: Identification of genetic, metabolic, and physiological factors affecting performance of alfalfa as a forage and biomass feedstock.
- G1.d: DNA markers for identifying genetic stocks of alfalfa associated with biotic (diseases, nematode pests) and abiotic stress tolerance (drought, salt).
- G1.e: Diagnostic tools, assays, and phylogenies to aid in the identification, classification, and control of pathogens affecting forage cropping systems, biomass legumes and grasses.
- G1.f: Identification of endophytes and genetic approaches to enhance disease resistance in forage legumes and grasses and increasing seed yield in forage grasses.

Objective G2: *Develop improved grass and legume germplasm and varieties that can be produced in diverse environments and efficiently utilized by livestock or production of bioenergy and bioproducts*.

Increasing biomass yields from perennial forages is needed to improve profitability for producers and to achieve national biomass energy goals. This will require both improved germplasm and improved management practices. Breeding for improved

yield needs to include breeding for stress-tolerance traits and disease and insect resistance or tolerance. Furthermore, increases in biomass quality could lead to significant reductions in both time and inputs to biochemical conversion processes, increasing the value of perennial feedstocks, paving the way for development of profitable and sustainable bioenergy feedstock production systems.

Anticipated Products:

- G2.a: Alfalfa germplasm with improved establishment, stress tolerance, persistence, and quality for semiarid dryland, grazingland, and cropland.
- G2.b: Alfalfa germplasm with improved energy availability for feed and biofuel use, and with altered nitrogen uptake capacity for remediation and cultivation with grass.
- G2.c: New switchgrass and big bluestem cultivars with increased biomass yield and adaptation to a wide range of environmental conditions in the northern US.
- G2.d: Napiergrass with improved energy production for the southeastern US.
- G2.e: Seeded forage Bermuda grass with improved yield and adaptability.
- G2.f: New warm-season perennial grass cultivars for biomass production in the Midwest and the central and northern Great Plains.
- G2.g: Native legume germplasm for breeding legumes used in grass-legume polycultures for bioenergy.
- G2.h: Genetic stocks of domestic and exotic warm season grass species and accessions with stubble cold-tolerance and an expanded range for increased biofuel production.
- G2.i: Sorghum-based, perennial, interspecific and wide hybrids with high-sugar content for biofuel production on the Southern Plains.

Problem Statement H: *Need for improved harvested forage and biomass production systems that increase economic and energy efficiency while enhancing the environment to meet national energy and food security goals.*

Research in this problem area will develop sustainable harvested forage and biomass production systems on agricultural lands that will increase the yield and quality of harvested perennial vegetation used for livestock and bioenergy production. Because of climatic and ecological variation, improved production systems are needed for each the major agro-ecosystems in the U.S. Biomass research will be a component of the larger research strategy of the regional USDA Biomass Research Centers. These improved production systems will be flexible to adapt to changing climatic, environmental and market conditions.

Research Needs Addressed:

- Forage and biomass feedstock production systems that mitigate greenhouse gases.
- Biomass feedstock production systems that reduce energy and nutrient inputs.
- Biomass production systems for marginally productive lands.

- Multipurpose forage systems that integrate trees, forage, and grazing livestock to maximize bioenergy and livestock production potential, reduce risk, and protect the environment.
- Biomass harvest and storage systems that enhance the value of the feedstock for animal, bioenergy, or bioproduct production.

Objective H1: *Provide improved management practices that enhance the environment and increase the economic viability of growing, harvesting and storing forage grasses and legumes for livestock, bioenergy and byproduct systems.*

To meet national and producer objectives, the sustainability of production systems for grasses, legumes and woody vegetation grown for livestock feed and bioenergy feedstock on agricultural lands needs to be increased. Flexible production practices, technologies, strategies and systems are needed that can adapt quickly to changing environmental and market conditions. Knowledge of mechanisms for organic carbon sequestration need to be better understood so appropriate practices can be developed to improve carbon sequestration in the topsoil and subsoil by forages. Improved practices and systems for managing the factors regulating net greenhouse gas emissions for mechanically harvested crops are needed. There is also a need for more reliable predictive models for estimating the amount of carbon sequestered and greenhouse gas emissions produced under varying environmental conditions and management practices.

Anticipated Products:

- H1.a: Evaluation and characterization of components in perennial and annual forage production systems based on carbon sequestration, nutrient removal, and greenhouse gas emissions.
- H1.b: Recommendations for plant production and management practices that reduce the need for nitrogen inputs.
- H1.c: Best management practices, energy yield, and feedstock quality data for candidate feedstocks on marginally productive land.
- H1.d: Production systems, crop and soil responses, and biomass yields for integrated agroforestry systems that include forages.
- H1.e: Economic guidelines for harvesting and storing feedstocks with available and alternative technologies.
- H1.f: Guidelines and management options for livestock use of bioenergy and forage crops.
- H1.f: Improved management strategies that increase preservation of dry matter and increase the energy density of harvested forages for dairy cattle.

Component 3 Resources

Research objectives of 11 ARS NP215 projects address the research needs of Component 3. ARS locations and lead scientists for these projects are:

- Beltsville: Andrea Skantar, Lev Nemchinov
- Booneville: David Burner
- Corvallis: Gary Banowetz

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- Lincoln: Kenneth Vogel, Robert Mitchell, Gautam Sarath
- Logan: Jack Staub
- Madison: Michael Casler, Ron Hatfield
- Prosser: Alva Ashok
- St. Paul: Deborah Samac
- Tifton: Bill Anderson

Component 4: Turf Improvement

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 J: *Need for improved germplasm and management practices that are adapted to biotic and abiotic stresses and meet the objectives of turf producers and users under changing climatic and environmental conditions***.**

Turfgrass is a component of many urban and rural landscapes. The turf acreage in the U.S. is comparable to that of wheat acreage. However, turfgrass often requires greater inputs of irrigation, fertilization, and pesticides than other crops. As a result, turfgrass is often targeted for removal from landscapes despites its important environmental impacts including cooling, runoff water filtration, aesthetics, and use on recreational areas. The genetic development of turf grasses that require limited to no supplemental irrigation and that utilize fertilizers more efficiently will result in substantial savings for urban water supplies and more environmentally sustainable production as less fertilizer is used. Increased drought and salinity tolerance will help adapt turfgrass to changing environmental conditions arising from climate change.

Research Needs Addressed:

- Need to determine genetic and physiological mechanisms of salt tolerance, water-use and nitrogen-use efficiency in turfgrasses.
- Need to identify genetic stocks of turfgrasses tolerant of salt and water deficit.

Objective J.1. *Identify, characterize, and develop germplasm for turf uses with improved water-use efficiency, drought tolerance, and salt tolerance using conventional and molecular methods to improve the germplasm enhancement process*.

Regions of the U.S. are experiencing rapid population growth, and demand for water is increasing for human consumption, recreational uses, landscaping, and industrial purposes. Consequently, less water will be available for watering lawns, parks, and golf courses. As a result, a critical need exists to identify and characterize turfgrass germplasm that can provide high quality turf under sub-optimum water levels. The use of recycled effluent water for irrigation is either being used or considered in many areas of the U.S. The use of recycled effluent water would conserve primary water sources for other drinking and culinary uses rather than use on landscapes. However, effluent water is often high in salinity and most landscape plants including turfgrass lack adequate salinity tolerance for production in this setting. In recent decades, turfgrasses have been selected for high visual quality and disease resistance under ideal conditions. Selecting turf to maintain green color under less water, lower quality (saline) water, or with less nitrogen is a more recent endeavor. How to best improve the turfgrasses for these traits, however, remains unclear. Variation for the traits can lead to insights into the plant physiology and the genes expressed under these stressed conditions, and elucidation of mechanisms will aid in the efficient improvement of turfgrasses. Additionally, the turfgrass germplasm *per se*, that is tolerant of these stresses and efficient in water and nitrogen use, will be identified and characterized.

Anticipated Products and Potential Benefits

- J1.a: Kentucky bluegrass germplasm with increased salinity tolerance.
- J1.b: Identification of turfgrasses germplasm tolerant to salt, and water deficits.

- J1.c: Identification of genetic and physiological mechanisms of salt tolerance in turfgrasses that will enhance the ability of turf companies to evaluate their plant material.
- J1.d: Identify physiological mechanisms associated with variation in water use efficiency and nitrogen use efficiency in turfgrasses adapted to the semi-arid western USA.
- J1.e: Improved seed germination and enhanced turf quality for *Danthonia spicata* germplasm.
- J1.f: Protocols for enhanced biotic and abiotic stress tolerance through interspecific hybridization of *Agrostis* germplasm.
- J1.g: Molecular markers for identifying genomic regions that are involved in salt tolerance in Seashore paspalum.
- J1.h: Identification of salt tolerance mechanisms in Seashore paspalum (exclusion, tolerance, osmotic tolerance).
- J1.i: Mapping and marker tools for selecting grass germplasm with resistance to rust diseases.
- Logan (Forages and Range): Jack Staub, Kevin Jensen
- Madison: Michael Casler
- Tifton: Bill Anderson