FY 2007 Annual Report for National Program 215, Rangeland, Pasture, and Forage Systems

Public and private range, pasture, forage and turf lands contribute significantly to the Nation's agricultural, environmental, economic, and social well-being by providing a rich variety of goods and services. Range, pasture, forage, and turf lands are found in all 50 states and comprise about 55% of the total land area of the United States. Reliance on the production, maintenance and use of perennial grasses, legumes and other herbaceous vegetation within sustainable ecosystems is the common foundation of these land types. These lands are used by more than 60 million cattle and 8 million sheep and support a livestock industry contributing over $80 billion in farm sales annually. The estimated value of hay production alone is around $13 billion, making hay the third most valuable crop in U.S. agriculture. Another 30 million acres is in turf that directly affects the citizenry through home and commercial landscaping, school grounds, right-of-ways, parks and other recreational facilities. The Nation's highly diverse grass, forage and shrub lands also provide an important habitat for many wildlife species, including 20 million deer, 500,000 pronghorn antelope, 400,000 elk, and 55,000 feral horses and burros. Other important environmental services include water resources, open space, and recreational opportunities. The benefits derived from these lands will increase dramatically as grasses and forage legumes become significant bioenergy feedstocks.

Although vast in area and rich in resources, these lands are being stressed in order to meet the rapidly expanding demands of a growing population and world economy. Research must provide land owners with new science-based management systems and practices that identify, quantify and balance the trade-offs between resource uses in ways that are economically viable, environmentally sustainable and socially acceptable. These needs will be met through research that results in scientific and technological advances that are integrated within an ecosystem framework based on the principles of ecology, agronomy, economics and the earth sciences.

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

Problem Area A: *Need for economically viable and environmentally sustainable rangeland management practices, germplasm, technologies and strategies to conserve rangelands ecosystems.*

Determining if an endangered species candidate is genetically distinct from another species. Listing a plant species as endangered has a significant impact on land management that may seriously affect the viability of other land uses such as livestock grazing. Ranchers in southern Idaho were concerned with proposals to list slickspot peppergrass as endangered, in part because this plant was previously considered a variety

of mountain peppergrass, rather than a fully distinct species as asserted by other taxonomists. ARS scientists at Logan, UT determined that the genetic relationships between slickspot and mountain peppergrass had not been adequately investigated. In cooperation with the BLM and Idaho Office of Endangered Species, ARS scientists gathered specimens of the two plant types from over 50 sites across the region and their extensive DNA testing indicated that slickspot peppergrass was a subgroup of mountain peppergrass and detected evidence of gene flow between groups. With this information, and useful data from other sources, the U.S. Fish and Wildlife Service decided not to list slickspot peppergrass as an endangered species. This decision prevented significant regulatory costs and disruptions in livestock production, military activities and other land use activities.

Fire-grazing interactions on the sagebrush steppe. The lack of information on the impacts of grazing on post-fire environments in the sagebrush steppe has limited the development of post-fire management strategies. ARS researchers at Burns, OR evaluated plant community recovery after prescribed fire and the application of spring and summer grazing. They found that moderate grazing after fire did not limit recovery and productivity of herbaceous plants when compared to ungrazed treatments. This information will enhance the ability of land managers to prescribe post-fire grazing practices and reduce the loss of income for livestock producers who depend on rangeland grazing.

Rainfall variation and soil carbon sequestration in rangelands. Shifts in precipitation patterns accompanying global climate change are predicted to affect rangeland ecosystems significantly. Most research has focused on how vegetative communities will change but little work has been done on soil processes. At Burns, OR, ARS scientists observed that shifts in precipitation timing from winter to spring in cold desert ecosystems resulted in lower carbon inputs into the soil by plants while increased microbial activity led to increased decomposition. This resulted in as high as a 14% increase in carbon loss from the soil. This information will help scientists develop regional and global models of the carbon cycle and aid policy makers in developing standards for carbon trading.

Assessing the impact of prescribed fire on erosion on steep rangelands. Given budgetary limitations, identifying the most effective conservation practices has become an important national priority. Erosion models such as WEPP (Water Erosion Prediction Project) are potentially valuable tools in assessing how a management practice will impact selected environmental services. ARS scientists at Boise, ID assessed the impact of fire on soil erosion on steep slopes (35-50%) to provide experimental data for improving WEPP. They focused on rill erosion since this is the most dominant erosion process in these conditions. Measurements of runoff, soil erosion, and rill hydraulics were made and compared to WEPP model estimates. They found that the model's equations related to rill erosion need improvement, including modifying regression equations and including interactions involving rill width and surface roughness on soil shear stress estimates. Improving the model will help producers and land management

agencies more effectively estimate the benefits of conservation practices and select those with the greatest potential.

Controlling grasshoppers with fire. Grasshoppers in rangeland systems play important ecological roles in nutrient cycling and as a source of prey for other animals. However when their numbers get too high, they become serious pests, consuming more than 20% of the forage needed by wildlife and livestock. ARS scientists at Miles City and Sidney, MT studied the interrelationship between fires and the population of *A. deorum*, a grasshopper that lays its eggs just below the soil's surface. They found that when there was a prescribed burn with 4,500 kg/ha of plant biomass to serve as fuel, none of the eggs of *A. deorum* hatched in 86% of the trials. In contrast, the eggs of *M. sanguinipes*, a grasshopper that lays its eggs deeper in the soil, were not affected by the heat. Other grasshopper species that lay their eggs at intermediate depths have moderate rates of mortality. These data show a clear relationship between the depth of the egg in the soil and mortality during fires. Land managers can still use fire to help control species that lay their eggs at greater depths by timing the fire to coincide with the eggs hatching and the wingless nymphs emerging on the surface.

Problem Area B: *Need for improved livestock production systems for rangelands that provide and use forages in ways that are economically viable and environmentally sustainable.*

Managing horses and locoweed poisoning. Many individuals moving into the Western States own horses for work and recreation. Many horse owners are concerned about the risk to horses from grazing locoweed. ARS scientists at Logan, UT determined that horses are more sensitive than other domesticated large animals to locoweed poisoning. Sheep and cattle require 0.30mg of swainsonine (the toxin in locoweed) per kg of animal weight per day over a period of 21 days before clinical poisoning symptoms occur. In contrast, horses develop clinical symptoms in 14 days with a daily dose of only 0.25mg/kg. Locoweed poisoning affects the reproductive process of mares with clearly identifiable symptoms. These symptoms are reversible if further exposure is avoided. While the recovered mares can be used for breeding, they should not be used for work or riding. This information will help veterinarians in advising clients on avoiding locoweed poisoning, and in diagnosing and treating poisoning. Knowing that poisoned mares can still be used for breeding results in significant economic savings.

Effects of prairie dogs on livestock. ARS scientists at Cheyenne, WY working with scientists at Colorado State University as part of the Shortgrass Steppe Long-term Ecological Research project studied the impact of blacktailed prairie dogs on livestock gains. They found that livestock gains during the grazing season decreased with an increasing percentage of the pasture colonized by prairie dogs. Economic reductions were $14.95 per steer and $5.51 per acre with 20% of the pasture colonized. When colonization increased to 60%, reductions in earnings increased to $37.92 per steer and $13.79 per acre. Gains per steer can be increased by reducing the number of grazing animals per acre but this practice results in reduced gains per acre. Wildlife that depended on the forages of the shortgrass steppe would also be affected by large

concentrations of prairie dogs. This information will help develop better land-management strategies for balancing competing forces on the shortgrass prairie.

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

Using alternative mixtures of plants to control invasive weeds on rangelands. Millions of acres of western rangeland have been degraded by invasive weeds that reduce biodiversity and contribute to wildfires. A major problem facing land managers is which plants to seed into degraded areas to restore ecosystem function. In the past, large and expensive plant reseeding projects have failed to control the weeds. There is evidence that invasive weeds, e.g. cheatgrass and dyer's woad, outcompete the native plants for nutrients, particularly nitrogen, that are released when rangelands are seriously disturbed. ARS scientists at Logan, UT examined alternative mixtures of plants in a five-year experiment to identify combinations that can effectively compete for nutrients and resist invasive weeds. They evaluated planting mixtures of native and introduced grasses, forbs and shrubs to determine whether they could get better utilization of nutrients across the growing season and thereby reduce nutrient availability to the invasive weeds. Crested wheatgrass, sagebrush and western yarrow were found to outcompete the invasive weeds, but in all cases, mixtures of grasses, shrubs and forbs did better than planting any one of these competitive plants. These findings can help private and public land managers select the right seed mixtures to increase the chances of success in restoring rangelands in a cost-effective manner.

Managing plant density for optimum forage production. In restoring degraded cropland and pastures in the southern Great Plains, land managers need information on the optimum density of plants to seek during seeding operations. At Woodward, OK, ARS researchers evaluated the effects of plant density on two native bluestem grasses (Andropogon species). They found that the optimum plant density for forage production was between 6.0 and 8.0 plants per square meter. However, the optimum density for plant crude protein was at low density (1.2) and at a much higher density (10.8). They also found that the greatest leaf area occurred at 10.8 plants per square meters. Therefore the most palatable and highest quality forage could be obtained with only a small decrease in total dry matter when there averaged 10.8 plants/square meter. This is equivalent to 43,560 plants per acre. Assuming good germination, this density can be achieved by planting around 4 lbs of pure live seed per acre for sand bluestem and slightly less for big bluestem because its seed is smaller.

Component II. Pasture Management Systems to Improve Economic Viability and Enhance the Environment

Problem Area D: *Need for appropriate plant materials to improve the economic viability and environmental sustainability of pasture and livestock grazing systems.*

Identifying plants that adapt to high temperatures. With global climate change, varieties of wheat and other grasses are needed that are better adapted to high soil and air temperatures, and use water more efficiently. ARS scientists at Corvallis, OR studied grasses that are adapted to geothermal areas in Yellowstone Park. Microscopic analysis of these plants revealed that they had many more of a structure called trichomes that helps maintain water in the plant in hot environments. The trichomes of the adapted plants were also thicker in structure. This information will help plant breeders develop more heat-tolerant wheat varieties and grasses for animal and human consumption.

Problem Area E: *Need for profitable and environmentally sustainable pasture-livestock systems for the Mid-South*

Alternative methods for controlling parasites in goats. *Haemonchus contortus*, an abomasal species of nematode, is a major problem for sheep and goats in warm, humid climates worldwide. It causes anemia and death in growing animals and has become increasingly resistant to available chemical dewormers. Copper oxide wire particles (COWP) have been used as an alternative to chemicals in sheep but little research has been done on goats. ARS scientists at Booneville, AR working with Fort Valley State University, GA and Louisiana State University determined that *H. contortus* could be controlled in young goats with COWP alone and in older goats when COWP is combined with the goats grazing *Sericea lespedeza*. The COWP was much more effective in kids than in adult goats. COWP proved less effective in controlling intestinal parasites. COWP costs less than 10 cents per head to administer compared to 70 cents for the more commonly used chemical dewormers which are often ineffective. Because of resistance, producers are being encouraged to use more than one chemical dewormer and this practice can cost more than a dollar per head. COWP offers an effective and affordable alternative to help in controlling parasites in both goats and sheep.

Problem Area F: *Need for profitable and environmentally sustainable pasture-livestock systems in the Great Plains.*

Managing grazing of winter wheat that has potentially high nitrate toxicity. Winter wheat is the primary cool season forage of the southern Great Plains but, like other cool season grasses, winter wheat can accumulate high levels of nitrate that are a threat to ruminant health. Bulk forage sampling and testing of winter wheat for nitrate involves collecting samples of the above-ground biomass of winter wheat and combining them for analyses. In the fall, bulk forage samples often indicate that nitrate levels are very high and turning livestock out for grazing would be risky. ARS researchers at El Reno, OK found that nitrates do not collect evenly throughout the above-ground biomass of the winter wheat plant. Nitrate concentration in the leaves is substantially lower and thus the leaves are safe, particularly when compared to the stem-like tissue of the juvenile wheat plants that are very high in nitrates. This information will help producers select appropriate grazing systems that allow using the winter wheat resource safely. For example, more extensive grazing systems with light stocking rates are much safer than rotational grazing with intensive stocking rates that force the livestock to graze much of the plant biomass.

Problem Area G: *Need for profitable and environmentally sustainable pasture-livestock systems in the Northeast and North Central States*

Managing the risks to pasture productivity and farm profitability during droughts. An important avenue for new farmers to enter agriculture is through pasture-based dairy because it requires a lower initial investment. With global climate change, weather variability is becoming more common and pasture-based dairy producers in the Northeastern U.S. need new strategies for managing the risk of drought. ARS scientists at University Park, PA evaluated the use of more complex mixtures of forage plants in pastures instead of the traditional grass monoculture or mixture of just two species (a grass and a clover). They found that combinations of six species produced the most forage in good years and increased economic returns per cow by more than $100 per year during dry years. They also found that alternate six-species combinations of different forage species responded differently to local variations in climate, soils and other conditions. This information provides producers with opportunities for using alternative forage combinations that are better adapted to the local environment and can help maintain farm profitability by improving risk management.

Choice of vegetation sampling methods depends on patchiness of pastures. Accurate affordable vegetation sampling methods for pasture lands are vital to researchers, producers, and those providing technical assistance. Sampling results are used to evaluate pasture condition, set livestock stocking rates, and assess the impacts of alternative management practices. Environmental variations and grazing affects can result in patchy patterns in pasture vegetation that need to be taken into account in sampling pastures. At University Park, PA, ARS scientists evaluated four vegetation sampling methods (random, transect and two multi-scale methods) to determine how variations in patchiness affected accuracy in estimating species frequency and cover. They found that the most used methods (random and transect) were not the most accurate with the transect method being very inaccurate in pastures with considerable patchiness. Inaccurate data can result in the incorrect stocking rates and lead to economic losses and environmental degradation. These results are being used by ARS scientists to develop new more accurate sampling methods that are still affordable for researchers, producers, and technical advisors.

Pasture finishing sheep and goats for niche markets. The rapid growth in ethnic markets for small ruminants is creating an economic opportunity for small producers who can supply animals of appropriate quality with low input costs. At Beaver, WV, ARS scientists have been evaluating productions systems that rely heavily on forages to reduce the need for more expensive supplementation. They placed three breeds of hair sheep (Barbados Blackbelly, Katahdin and St. Croix) on alfalfa hay diets and evaluated forage intake and utilization. They found that growth without energy supplementation was moderate and did not allow the Katahdin, an improved breed, to express its higher growth potential when compared to the St. Croix. The scientists also compared weight gain and carcass quality when traditional lambs (Suffolk), hair sheep lambs (Katahdin) and Boer x Kiko meat goats were finished on mixed pasture of orchardgrass, red clover, and white clover with and without whole cottonseed supplementation. In all cases, daily gains,

body weights and desirable carcass qualities were greater for the supplemented animals. However, all the small ruminants finished on grazed pasture and hay diets were of sufficient quality to be acceptable in the Halal ethnic market.

Increasing profitability of sheep production on small Appalachian farms. The rapid growth of the market for sheep on the East coast creates an opportunity for greater profits if the limited-resource producers have reliable, affordable options for finishing lambs without using high-cost supplements. Traditionally, farmers have relied on grass pastures to finish their lamb crop, but in the late summer and early fall, as the production and nutritive quality of the grasses declined. As a result, costly supplements are often used. ARS researchers at Beaver, WV found that using a mixture of prairiegrass, a highly productive and nutritious perennial grass, and forage turnips in pastures provided high quality forage throughout the grazing season and greatly reduced or eliminated the need for supplements. They found that lambs finished on the prairiegrass-turnip pastures nearly double their rate of gain over lambs finished on the traditional grass-clover mixture.

Component III. Sustainable Harvested Forage Systems for Livestock, Bioenergy and Bioproducts

Problem Area H: *Need for improved plant materials to improve the profitability and environmental sustainability of using harvested grasses and forage legumes for livestock, bioenergy and byproducts production.*

Modifying smooth bromegrass to alter the correlation between forage yield and fiber concentration. Profitability of livestock production is increased when forages have high yield per acre and low non-digestible fiber content. Low fiber content increases forage consumption and digestible energy content, resulting in improved animal performance. Unfortunately, some key forage grasses have shown a positive genetic correlation between higher yield and higher fiber concentration, so opportunities to breed higher yielding, lower fiber varieties have appeared to be limited. ARS scientists at Madison, WI, found that breeding work to improve smooth bromegrass, an important harvested forage, resulted in a 1% decrease in non-digestible fiber but was accompanied by a 5% decrease in yield. However, in follow-on research they have been able to partially break this correlation by studying hybrids of smooth bromegrass and identifying a few genes that improve yield but are not linked to fiber content and vice versa. Based on this knowledge, work is proceeding to develop forages with both increased yield and lower fiber to increase livestock performance.

Problem Area J: *Need for economically viable, energy efficient and environmentally sustainable production systems for establishing, growing, maintaining, harvesting, treating, storing and transporting forages for livestock, bioenergy, byproducts and conservation objectives.*

Quantifying the net energy balances of switchgrass grown on farmer fields. An important step in developing the nation's bioenergy potential is determining the economics and net

energy balance for perennial-grass feedstock production systems. Until now, previous estimates have been based on smallplot data or estimates. ARS scientists at Lincoln, NE planted and managed switchgrass as a biomass energy crop for five years on 10 cooperating farms in the northern Great Plains. Biomass yields and farmer inputs were used to determine the net energy balance. Net energy averaged 60 GJ ha^{-1} y^{-1} and switchgrass produced 540% more renewable energy than the nonrenewable energy consumed. Switchgrass managed for high yield had equal or greater net energy than low input restored prairies and can produce twice as much liquid fuel per acre. This large scale study clearly demonstrates that perennial grass energy crops are net energy-positive and improvements in genetics and management will enhance both total and net energy yields and the cost of production. The economics information that was reported last year also indicated that biomass switchgrass production systems were economically viable.

Assessing potential adverse effects of crop residue removal on sustainability. Many have assumed that crop residues such as corn stover are an abundant and inexpensive source of biomass that can be removed from fields to produce bioenergy and this resulted in less research emphasis on perennial biomass energy crops. Increased emphasis on crop residue was based on the assumption that with minimum or no-tillage farming methods, there will be no deleterious production or environmental effects. A long-term field study by ARS scientists from Lincoln, NE compared carbon sequestration of switchgrass managed as a biomass energy crop with non-irrigation, no-till corn production to evaluate the effects of stover harvested for biomass energy. In the first five years of the study, removal of half the stover significantly reduced corn yields. During the same time period, the potential ethanol yield for switchgrass was equal or greater than the potential total ethanol yield of corn grain and harvested stover. As a result of this and other research, DOE and USDA now recognize that sustainability is a major issue in the use of crop residues for biomass energy. New research initiatives on stover removal and sustainability are in progress.

Characterizing fungal pathogens to identify risks to alfalfa production. Accurate tools are needed to detect and identify domestic and foreign fungi strains that can cause disease outbreaks that threaten the nation's $8 billion alfalfa crop. ARS researchers at Beltsville, MD applied recent advances in DNA analyses to foreign and domestic collections of fungi to identify those causing disease, to determine their virulence, and to understand their pathogenicity. They discovered new species, branches in family trees and host associations that revealed strains not found in the U.S. and are potential sources of new diseases. This information will help diagnose new diseases more rapidly and develop appropriate control strategies.

Component IV. Turf Plant Materials

Problem Area K: *Need for improved germplasm that is adapted to biotic and abiotic stresses to reduce economic and increase environmental sustainability while meeting the objectives of turf producers and users.*

Opportunities to improve stress resistance in turf grasses. Enhancing the persistence of turf-types of tall fescue by improving resistance to pests and disease by breeding improved varieties would allow turf managers to use fewer inputs. Using fewer inputs would lead to significant economic and environmental benefits. ARS scientists at Beltsville, MD examined the genetic relationships of 16 commonly used tall fescue cultivars using 10 different Simple Sequence Repeat (SSR) DNA markers. Data was collected from 20 plants of each cultivar and on a bulk DNA sample of the 20 plants. They compared the bulked sample with the individual plant samples and did not find a strong correlation. These results indicate that while collecting and analyzing bulk samples of a cultivar can save time, the results on cultivar relationships should be used with caution. A diversity analysis indicated that the cultivars fell into four groups and the most diverse material was likely to have a different number of chromosomes than the more common cultivated materials. Overall these results indicate that crossing materials with different chromosome numbers may offer opportunities to increase genetic diversity and improve important traits such as disease resistance to improve tall fescue persistence in turf systems.