2006 Annual Report for National Program 215
Rangeland, Pasture, and Forage Systems

Importance of Pasture, Forage, Turf and Range Lands

Our Nation's grass and shrub lands including range, pastures, and hay and turf lands provide forages, open spaces and ecological services that contribute significantly to our agricultural, environmental, economic, and social well-being. Rangeland, pasture, and forages together comprise about 55% of the total land surface of the United States, about a billion acres. The Nation’s 30 million acres of turf lands are found around 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 an estimated $40 billion a year to the economy.

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

The functions of these lands are of increasing importance as watersheds and as habitat for a set of biologically diverse plants and animals. Maintaining adequate supplies of clean water for urban areas, irrigated agriculture, and environmental needs is a critical function of rangeland, pasture, and forage-producing ecosystems. Rangelands and pastures also provide forage and habitat for numerous wildlife species, including 20 million deer, 500,000 pronghorn antelope, 400,000 elk, and 55,000 feral horses and burros. Associated with these functions is an array of additional demands placed on these natural resources, including camping, hiking, fishing, hunting, and other recreational activities.

Purpose of the annul report

Meeting the multitudes of demands on the pasture, forage, turf and range lands requires that producers and land managers have access to management practices that are effective, economically viable, socially acceptable and environmentally friendly. While substantial progress has been made in applying scientific principles to the management of these lands, there are still many gaps in understanding the interrelationships between basic ecological processes and alternative management practices.

The overall goal of this national program is to provide the knowledge and technologies needed to close these gaps and improve the use and conservation of the natural resource values on these lands. This annual report describes the progress being made in addressing problems outlined in national program 215’s action plan that can be found at http://www.ars.usda.gov/research/programs/programs.htm?np_code=205&docid=14664.

This report is organized around the same format of components and problem areas used in the action plan.

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 rangeland ecosystems.

Drought Risk Management**.** Drought is common in the northern Great Plains and is an important risk for livestock producers and rangeland managers. Traditionally, following a spring drought, mangers delay making decisions such as reducing livestock numbers in the hope that summer rains will compensate for production lost in the spring. ARS scientists at Miles City, Montana found that summer rains can increase forage productions but these increases were seldom large enough to compensate for the 50% reductions causes by spring droughts. For example, the probability of getting 6 inches of rainfall in July and August which would have a significant impact on forage production is less than 1%. This information can aid livestock producers and land managers in making timely and realistic risk-management decisions on when livestock numbers should be reduced because of drought.

Impact of grazing on carbon storage along an environmental gradient. There are many gaps in our knowledge of how alternative managing practices such as grazing impact on carbon sequestration on the nation's vast rangeland areas. ARS researchers collaborating with Texas A&M scientists collected plant, root and soil carbon samples from Colorado to eastern Kansas along an environmental gradient that included short-, mid- and tall-grass site that had long-term histories of being grazed or not grazed. They found that grazed shortgrass ecosystems stored more carbon than non-grazed, but for wetter mid- and tall-grass ecosystems, the opposite was true with the non-grazed storing more carbon. The higher carbon storage in the grazed shortgrass sites was thought to be due to shifts in plant composition. On grazed sites there was a shift from cool-season to warm-season grasses and this appears to favor greater carbon storage. This information will aid policy makers and land managers seeking to increase carbon storage on rangelands to mitigate carbon dioxide levels in the atmosphere.

Reducing costs in monitoring rangelands. Low-cost rangeland monitoring strategies using remote sensing in the past has been limited by insufficient resolution needed to track changes in soils and vegetation. ARS scientists at Las Cruces have evaluated using a combination of sensors to provide adequate resolution. Five-centimeter resolution aerial photographs from Unmanned Aerial Vehicles (UAV) provided measurements of gap and patch sizes as will as percent bare soil and vegetation ground cover over much of a 150,000 acre experimental range site. Simultaneously, data were collected at one-meter resolution to assess patterns of ecological states while 15-30 meter resolution data were used to delineate larger uniform landscape units. Using this combination of images taken at different resolutions provides lower-cost and timely information needed to help managers identify rangeland areas at risk of degradation and degraded areas with good potential for restoration.

Impact of flood irrigation on forage production and water temperature. In the Northwest, many streams are considered too warm to meet water temperature standards and water diversion for flood irrigation has generated controversy because of concerns about increasing water temperatures even more. ARS scientists at Burns, Oregon, studied the impact of flood irrigation of meadows on temperatures of headwater streams. Flood irrigation of meadows is essential to producing sufficient forages for grazing and haying needed to support the local livestock industry. The scientists found that flood irrigation in the early summer helped buffer water temperatures in a positive way. This information will help managers integrate land uses in a way that meets multiple objectives with the least potential for conflict.

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.

Controlling Broom snakeweed to protect rangeland ecosystems and animal performance. Broom snakeweed is a native invasive plant that cokes out more desirable vegetation, degrades wildlife habitat, and may cause abortions in cows, sheep and goats. Scientists at Logan, Utah studied how grazing affected the invasion of snakeweed in sagebrush plant communities. Many years of spring grazing resulted in dense Wyoming big sagebrush stands with sandberg bluegrass understory and some snakeweed. Fall grazing every other year maintained the plant community in a healthy mix of perennial bunchgrass and intermittent big sagebrush that crowded out snakeweed over the four years of the study. Fire on the spring-grazing site knocked out the sagebrush allowing snakeweed to dominate the site. However, fire did not impact significantly on the fall grazing site. This information provides ranchers and public land managers with grazing management tools to improve rangeland health while reducing livestock abortions caused by toxic weeds.

Maintaining cattle condition reduces losses from pine needle consumption. Consumption of ponderosa pine needles by pregnant cows causes premature births and calf death losses across the western U.S. ARS researchers at Logan, Utah have determined that body condition and nutrient status of cattle affects pine needle consumption. They found that thin cattle eat more pine needles than cows in high body condition. Furthermore, low protein diets can reduce the amount of pine needles eaten by cattle in poor body condition, whereas such diets have had no effect on needle consumption by fat cattle.

More effective animal tracking systems for managing livestock-ecosystem interactions. Tracking wildlife and livestock movements and habitat use patterns accurately and affordably is essential to effective ecosystem management. ARS scientists at Boise, Idaho have published manufacturing details of the *Clark ATS*, a GPS-telemetry animal tracking system that solves many of the problems associated with GPS technology in the past. Previous systems were very expensive, had relatively small data storage capacity, and were often difficult to use in the field. The ARS scientists have transferred the new technology to the Idaho Department of Fish & Game, USDA/APHIS/WS, USFS, and

USDI/FWS and are working collaboratively to use the data being collected to evaluate habitat use and activity patterns of livestock and wildlife in response to prescribed fire treatments and programs to reintroduce predators.

Problem Area C: There is a 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:

Improving revegetation success on degraded rangelands. Wildfires, droughts, and other causes of degradation strip the land of vegetation essential for protecting watersheds, providing wildlife habitat, feeding livestock and enhancing recreational activities. Following degradation, managers need affordable seeds of native vegetation that has a high probability of successful establishment and will conserve biodiversity. ARS scientists at Logan, Utah have released a new variety of slender wheatgrass, an important species for restoration, called FirstStrike. In field trials in Idaho, Utah and Wyoming, FirstStrike performed equal to or superior to other commercial varieties in seedling establishment, number of seedlings per unit area, initial stand and persistence, and dry matter yield. FirstStrike has been adapted by 42 Department of Defense facilities encompassing 1.3 million acres of land regularly reseeded following training exercises.

Stopping cheatgrass invasion of rangelands: One of the most damaging invasive weeds is cheatgrass which has spread across millions of acres of western rangelands. In just one year, in Nevada, over $80 million dollars was spent fighting wildfires and restoring critical areas. Looses due to degraded soil and water resources, burned forages unavailable to wildlife and livestock and reduced ecological health were even more damaging. It has long been thought that cheatgrass was only self-pollinating and this would limit a population's ability to adapt to changing conditions such as changes in management practices. ARS scientists at Reno, Nevada applied molecular genetics techniques to characterize cheatgrass populations and for the first time documented that cheatgrass does out-cross to some extent. This cross-pollination between plants results in increased genetic diversity that allows cheatgrass to adapt to new environments more quickly. This discovery may complicate future attempts at controlling cheatgrass but the out-crossing between plants may also open up new lines of controls based on genomic manipulation. This information will help scientists and land managers face the challenges of controlling cheatgrass more effectively by targeting limited funds to the most promising avenues of control.

Selecting the right seeds for rangeland restoration. ARS scientists at Logan, Utah found that Indian ricegrass populations often exhibit two or three different seed genetic variants (morphs) found in separate plants. These morphs frequently give individual plants in the population very different levels of seed dormancy and thereby increase the population's genetic diversity in terms of environmental adaptation. Indian ricegrass morphs occurring at the same rangeland site suggests that the genetic variants originated in different geographical locations and then migrated independently to the common rangeland site where they are now found. This information suggests that introducing a genetically diverse mix of Indian ricegrass seeds would be genetically and ecologically appropriate action for rangeland restoration managers.

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.

<u>Extending the grazing season with the release of new Italian ryegrass, Floregon</u>. Extending the length of the grazing season significantly increases the profitability of the livestock industry because it reduces the need to feed hay and other harvested forages. A key factor in determining the length of the grazing season is when the forage plants shift from vegetative growth to seed production when both the quality and quantity of forages drops. ARS scientists at Corvallis, Oregon working with the University of Florida have released a new cultivar of Italian ryegrass called Floregon, an important winter pasture grass in the Southeast. Floregon has improved resistance to crown rust, seed yields in Oregon similar to or higher than other cultivars, and as good as forage yield and quality. However, when grown in the Southeast, 20% of the plants do not flower and continue to grow vegetatively and extend the grazing season. So the new cultivar meets the needs of the seed industry in Oregon with good seed production and the needs of Southeastern livestock producers who want a longer grazing season. To meet anticipated demand, an estimated 2 million pounds of seed will be available for market at the end of the 2007 growing season.

<u>Developing a new seed production methods for bioenergy and forage crops</u>. Eastern gamagrass is a highly productive and digestive native grass with great potential in livestock and bioenergy production. However, seed availability could limit a rapid expansion in taking advantage of this grass' potential. ARS scientists at Woodward, Oklahoma applied high-throughput molecular genetics techniques to speed the selection of seed production traits. They found a mutant form of gamagrass that produces entirely female flowers as contrasted to the predominately male type found in the wild. By identifying the mutant form is caused by recessive genes and being able to identify which plants to cross, it will be possible to develop gamagrass varieties that will greatly increase seed production and provide another option for improving livestock and bioenergy production.

<u>Developing new grass varieties by applying molecular genetics to improve forage digestibility</u>. Lignin and ferulic acid are both thought to be important components of the cell wall that limit the utilization of plants by ruminant livestock. ARS scientists at Madison, Wisconsin found that both lignin and ferulic cross-linking act independently to limit cell-wall digestion in three important species of forage grasses (smooth bromegrass, orchardgrass and reed canarygrass). This information is now being used to identify the specific genes controlling lignin and ferulic acid so they can be manipulated to create new forage varieties that will improve the efficiency of livestock production.

Problem Area E: Need for Profitable and Environmentally Sustainable Pasture-Livestock Systems for the Mid-South

Reducing input costs in livestock production. Reducing the need for hay by extending the grazing season and increasing forage quality will increase the profitability of forage-based livestock systems. ARS researchers in Beaver, West Virginia found that forage grown under moderate tree canopies had higher protein than similar forages grown in open pastures. The forages growing in woodlots also tended to grow later in the fall because the canopy moderated climatic change. Grazing livestock in woodlots can provide a low-cost source of protein while extending the grazing season thereby reducing the need for supplemental feed. However, the understory forage is lower in energy than pasture forages so managers need to ensure there are adequate sources of energy available to utilize the protein. Taking an agroforestry approach to woodlot management to supply both forages and wood products can turn land that is often considered as marginal into viable part of the farm enterprise.

Reducing the prevalence of E. coli and Salmonella in beef cattle. Reducing the shedding of Escherichia coli 0157:H7 and Salmonella in beef cattle feces reduces risks to human health and the producer. ARS scientists at Booneville, Arkansas, working with ARS scientists at College Station, Texas, evaluated management practices to reduce pathogen shedding. They found that feeding hay to grazing cattle reduced E. coli shedding and feeding the dewormer, fenbendazole, reduced Salmonella shedding. The Booneville scientists working with ARS scientists from Lexington and Kentucky, and University of Arkansas scientists, found that reducing the presence of muddy conditions around cattle watering tanks decreased the prevalence of E. coli. These results show that management practices can reduce fecal shedding of pathogens and lead to safer meat products.

Problem Area F: Need for Profitable and Environmentally Sustainable Pasture-Livestock Systems in the Great Plains

Improving profitability of stocker enterprises with perennial cool-season grasses. Millions of cattle graze winter wheat or warm season grasses in the southern Great Plains to achieve low-cost weight gains en route to feedlots. This two-forage system does have seasonal gaps in forage availability and quality that limits the flexibility and profitability of the stocker enterprise. ARS scientists at El Reno, Oklahoma continue to seek ways to fill the seasonal gaps. They found that replacing a portion of the winter wheat fields with endophyte-free tall fescue could significantly increase animal gains. With minimal management, the addition of the tall fescue extended the grazing season by 30 days and produced comparable gains as using winter wheat alone but at lower cost. By increasing management and doing intensive grazing (2 or 3 times normal stocking rates) for 35 days in the fall and spring when winter wheat and warm-season grasses were not available, an additional 145 pounds of gain per head were obtained. Using this information, producers can increase cost-effective gains and have greater flexibility in marketing livestock.

Managing pastures to control fluxes in greenhouse gases. ARS scientists at Mandan, North Dakota, evaluated the effects of long-term grazing on soil carbon properties and nitrous oxide emissions on fertilized crested wheatgrass pasture and unfertilized native mixed grass pasture. Soil organic matter was greater in the fertilized pasture than the native pasture both near the surface (0-2 inches) and at greater depths (12-24 inches). However, the fertilization caused greater soil acidity and the annual nitrous oxide emissions were over three-fold higher than on the native pasture. Results of this study will help managers balance the trade-off between livestock production, carbon sequestration and nitrous oxide emissions in achieving economic and environmental sustainability.

Problem Area G: Need for Profitable and Environmentally Sustainable Pasture-Livestock Systems in the Northeast and North Central States

Managing seed banks to control invasive weeds. Buried seeds in pasture soils serve as a seed bank for both desirable forage species and weeds. ARS scientists at University Park, Pennsylvania, over three years, evaluated management practices to reduce the quantities of weeds in the soil seed bank by evaluating the relationship between four different above-ground-plant mixtures and below-ground seeds. They found no relationship between composition of the above-ground plant mixtures and the number of germinable seeds in the soil, and little relationship between the seed-bank species composition and the species in the above-ground plant mixtures. However they did find that annual weed species were less abundant in the seed banks containing a greater variety of forage plant species than the pastures containing a two forage-species combination. Therefore, pasture managers may be able to reduce the presence of annual weeds by planting more complex mixtures of forage species than the more traditional two-species systems, e.g., a grass and a clover.

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.

Improving alfalfa breeding by whole genome transcript analysis. ARS researchers at St. Paul, Minnesota, used the Medicago GeneChip to identify gene transcripts specific to alfalfa leaves and roots. The GeneChip was developed primarily from gene sequences from barrel medic. Although barrel medic is a close relative of alfalfa, scientists did not know whether the chip has utility for measuring gene expression in alfalfa. They found the chip's utility was very high because it allows analysis of all genes in both alfalfa and barrel medic. The two species share a high proportion of genes expressed in leaves and roots although species-specific genes were identified. Using the GeneChip will accelerate alfalfa improvement by speeding up the discovery of genes for improving disease resistance, environmental stress tolerance, animal nutrition, and bioenergy potential.

Increasing alfalfa resistance to verticillium wilt. Verticillium wilt can reduce alfalfa yields up to 50% in northern regions of the U.S. so increasing resistance to this wilt is a goal of all the companies breeding improved alfalfa varieties. Although wilt is a major problem, there has been a lack of knowledge of how resistance is inherited in alfalfa. ARS researchers at Prosser, Washington studied two alfalfa populations over time that were repeatedly exposed to wilt and determined that resistance is highly heritable and controlled by additive gene action. With this new knowledge, breeders can more effectively develop new resistant varieties.

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.

Potential Impact of bioenergy crops on greenhouse gas emissions. Bioenergy cropping systems have the potential to offset a portion of greenhouse emissions but quantifying the offsets is difficult because so many factors are involved. ARS scientists at University Park, Pennsylvania and Ft. Collins, Colorado working with Colorado State University conducted life cycle analysis of net greenhouse gas emissions for several bioenergy cropping systems. The findings were compared with the life cycle emissions of gasoline and diesel from production through utilization. The life cycle analysis for bioenergy crops went from establishing and growing the crop through harvesting and conversion to utilization of the biofuel. When compared to fossil fuels, ethanol and biodiesel from corn rotations reduced gas emissions by 35-40%; reed canarygrass reduced emissions by 85%; and switchgrass and hybrid poplar reduced emissions by more than 115%. These findings can help policy makers select between alternative bioenergy production systems to help achieve national objectives including reducing gas emissions while increasing domestic energy supplies.

Economic feasibility of growing switchgrass for bioenergy. On-farm trials are required to determine the economic feasibility of producing switchgrass as bioenergy crop in the eastern Great Plains so the nation can accurately assess the feasibility of this energy option. ARS scientists at Lincoln, Nebraska in cooperation with the University of Nebraska managed and assessed switchgrass production for five years on 10 farms spread across Nebraska and the Dakotas. Average yield was 3.4 tons/acre with average production cost of $33/ton plus $17/ton for land rent. Pro-rating the establishment costs over 9 years would reduce costs by $6/ton. Two farmers experienced in switchgrass production were able to produce the biomass for less than $40/ton including land costs. At this cost, the farm-gate feedstock cost per gallon of ethanol produced would be about $0.50 per gallon. Therefore, biomass production costs can be feasible so overall economic viability depends primarily on conversion costs.

Component IV. Turf Plant Materials

Problem Area K: There is a 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.

<u>Selecting best turfgrass varieties for different climates</u>. The National Turfgrass Evaluation Program (NTEP) housed in ARS facilities at Beltsville, Maryland, conducts a national program that evaluated the performance of 20 turfgrass species in trials conducted in forty states. While this is an evaluation project conducted mainly by university personnel it provides valuable information to those scientists seeking opportunities to improve plant varieties and the management of turf systems. In 2005/2006, extreme cold temperatures in the Midwest allowed evaluators to collect data on the winter tolerance of different varieties of perennial ryegrass and bent grass. Very warm summer temperatures in 2005 in the Northeast and Mid-Atlantic states provided data on the heat tolerance of the same species. In the near term, this information will help turf managers select the best cultivars for their climatic situation. In the longer term, scientists can evaluate the most cold and heat tolerant cultivars to identify the processes producing this behavior and the genes that may be controlling these processes. If genes controlling such processes are identified, plant breeders maybe able to develop more tolerant cultivars.