FY 2008 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 grazed 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.*

Accomplishments

Grazing exclusion can increase the fire risk to sagebrush communities. Considerable controversy exists over the role of livestock grazing and prescribed fire to manage sagebrush steppe rangeland to stop the spread of cheatgrass and reduce the severity of wildfires in the Great Basin. ARS scientists at Burns, OR evaluated the impacts of fire on sagebrush rangeland, which had either been grazed up until the year of burning (1993) or had been excluded from grazing since 1937. Vegetation characteristics were measured in the 12th through 14th years after burning. Burning caused a huge increase in cheatgrass (an invasive annual grass) in the ungrazed areas, but not in the grazed areas. This long-term research provides ranchers and land

managers with science-based information in selecting fire and grazing management practices for controlling cheatgrass.

Improving seed harvesting of native grasses. Seed shattering is common in many native grasses and often leads to the practice of premature seed harvesting. This contributes to high-cost seed and seeds of poor quality. ARS scientists at Logan, UT genetically mapped chromosome regions controlling the number of seeds per plant, percent of flowers with seed, seed germination, and percent seed shattering using experimental hybrids of basin wildrye and creeping wildrye. These experiments pin-pointed a major-effect seed retention gene that will reduce seed loss and improve seed development and quality in basin wildrye and other related grasses where seed shattering reduces seed yield significantly. This seed retention gene was also aligned to chromosome regions known to control seed disarticulation in American wildrice. Future research projects to better understand and incorporate the seed retention gene in grasses affected by seed shattering could have a significant impact on seed production in a variety of native grasses and important grain crops.

Aerial surveys reduce small stream monitoring costs on western rangelands. Managing stream-side vegetation effectively is critical to maintaining fish and wildlife habitat. Good management depends on frequent ecological monitoring to identify needs. However, traditional ground monitoring of stream-related habitat is expensive because of manpower and travel costs. Very-large scale aerial (VLSA) surveys (low-altitude, high-resolution, intermittent aerial digital photography) were conducted in a watershed inhabited by the Lahonton Cutthroat trout, a threatened species, to measure late-summer open water width, number and location of late-summer dry channels, widths of riparian areas and willow coverage, and riparian proper functioning condition (PFC; an ecological assessment protocol for streams). PFC assessments from VLSA imagery averaged 4 staff hours per stream compared to 36 staff hours per stream for ground PFC assessments. Reduced labor requirements more than compensate for the higher technology cost of aerial surveys. Demonstrating the effectiveness and labor efficiency of aerial monitoring will allowed samples to be analyzed at about half the costs.

Understanding a biogeochemical relationship to control an invasive plant. Millions of acres of western rangelands have been invaded by cheatgrass. Cheatgrass crowds out plants essential to livestock and wildlife while significantly increasing the frequency of wildfires. Understanding the ecology of cheatgrass is essential to controlling the spread of the weed and reclaiming invaded land. ARS scientists at Reno, NV studied how cheatgrass affects nutrient availability as it competes with other plants. They quantified elemental fluxes and soil nutrient pools at sites representing three classes of land: 1) non-invaded winterfat ecosystems, 2) ecosystems invaded for three years by cheatgrass, and 3) those invaded for 10 years by cheatgrass. Compared to non-invaded sites, 10 years of cheatgrass invasion resulted in significantly greater plant biomass, a significantly greater flux of carbon and a significant decrease in flux of calcium. Plots invaded by cheatgrass for 10 years also had significantly greater nitrogen availability deeper in the soil profile, which suggests that cheatgrass invasion may increase the nitrogen leakiness of the system. This long-term research helps provide the basic understanding of the ecology of a major invasive weed and is essential to developing science-based strategies for effective weed control.

Managing postfire shrub recovery on western rangelands. Mountain big sagebrush is an important plant species for wildlife habitat on many western rangelands, and there is limited information to guide land managers on how these shrubs respond to fire over long time periods at a landscape scale. ARS scientists at Dubois, ID have developed a spectral mixing model to classify shrub cover in mountain big sagebrush communities using Systeme Pour l'Observation de la Terre-5 (SPOT-5) imagery. The results indicate that 1) satellite imagery can be used successfully to estimate shrub cover in mountain big sagebrush communities, and 2) shrub cover in mountain big sagebrush is fully recovered within 27 years after fire. Land managers can use these results to document the response of similar ecological sites to fire and to improve their management decisions.

Managing nitrogen availability to control invasive annual grasses is questionable. Managing soils for low N availability has been suggested as a strategy to reduce the growth advantage of invasive annual grasses and improve establishment of desirable plants. As a result, some rangeland restoration projects have included expensive treatments to reduce soil N. Growth rate, biomass allocation and physiology of annual and perennial grasses were measured, by the ARS scientists at Burns, OR, under a wide range of soil nitrogen levels. No evidence was found that low nitrogen soils favored growth of perennials over annuals. These results suggest the cost of nitrogen reduction efforts is not warranted and will private and public rangeland managers design more cost effective post-fire strategies.

Assessing impact of global change on shortgrass steppe ecosystem. ARS scientists at Cheyenne, WY as part of the collaborative research on the Shortgrass Steppe Long Term Ecological Project (LTER) have focused on the climatic attributes controlling net primary production, including spatial and temporal patterns in net primary production. The purpose was to assess how future global change may influence net primary production in the shortgrass steppe over the next 25 to 50 years. Yearly patterns of plant production were found to be determined largely by seasonal variations of temperature and precipitation with precipitation being the dominate factor on annual net primary production. Landscape effects, soil nitrogen, and atmospheric CO2 also affected temporal primary production but to a lesser degree. Close monitoring of how global change affects precipitation patterns will indicate the shifts in productivity that will affect the future carrying capacity of the land to support wildlife and livestock population.

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.*

Accomplishment

Altering greenhouse gas emissions by modification of cattle diets on mixed-grass prairie. Use of dietary amendments such as condensed quebracho tannin to reduce nitrogen (N) in urine has been suggested as a possible strategy to decrease greenhouse gas (GHG) emissions from livestock. ARS scientists at Mandan, ND compared the effects of tannin-affected cattle urine to normal cattle urine on carbon dioxide, methane, and nitrous oxide flux over a six-week period while the animals were on mixed grass prairie. Though the tannin urine treatment possessed 34% less N than normal cattle urine, overall nitrous oxide emission between the treatments did

not differ, indicating that the nitrogen entered the environment through other pathways. Furthermore, methane uptake from the tannin urine treatment was 40% less than the normal urine treatment. Results from this study suggest that the use of condensed quebracho tannin as a dietary amendment for livestock does not yield GHG mitigation benefits at least in the short-term.

Evaluating different breeds of cattle for arid lands. Increasing costs for fuel, grains, and supplemental feeds are requiring livestock producers to consider new strategies to maintain profitability. ARS scientists at Las Cruces, NM have been evaluating Criollo cattle that evolved in arid environments as an alternative to traditional breeds. They found Criollo cattle traveled farther to use a greater diversity of habitat types, and spent less time near water/riparian areas compared to British breeds. Criollo cattle also mature earlier with a greater probability of reaching puberty at a younger age. These traits suggest that Criollo cattle may be a heritage breed well-suited for beef production systems in arid lands and merit further study.

Comparing the effects of grazing systems on cattle gains and vegetation. Alternative grazing systems can vary greatly in cost so greater benefits are required to justify more expensive systems. ARS scientists at Cheyenne, WY time-controlled rotational grazing and season-long continuous grazing on the shortgrass steppe at the same moderate stocking rate. They measured the effects on animal gains, and foliar and basal cover of functional groups (C4 and C3 perennial grasses, C3 annual grasses, perennial and annual forbs, litter and bare ground) across landscape types from 1995 to 2003. Gains per unit land area (pounds/acre) did not differ between grazing systems in any year. Grazing system did not affect basal or foliar cover of any functional plant group in either upland or lowland topographical positions. The findings from this time period indicate that producers in the shortgrass steppe will not gain significant livestock or vegetative benefits from using more complex rotational grazing systems instead of more traditional continuous, season-long grazing at least at the moderate stocking rates used in this study.

Improved forage legume for western rangelands. ARS scientists at Logan, UT released 'DON' falcata alfalfa to provide the legume component in western pastures and rangelands to increase overall forage productivity and quality. Forage legumes previously available for use on western U.S. often lack long persistence. 'DON' falcata alfalfa was specifically developed to persist under harsh conditions typical of western U.S. rangelands and provides land managers with new option for increasing the legume component.

Reducing abortions by understanding factors affecting consumption of ponderosa pine needles. Consumption of sufficient quantities of ponderosa pine needles by pregnant cattle can induce abortions. ARS scientists at Logan, UT conducted pen and field studies to determine the effects of body condition and dietary nitrogen and energy concentration on cattle consumption of ponderosa pine needles. Cattle in low body condition (LBC) ate more pine needles than did cattle in high body condition (HBC) when fed a balanced ration. The same result was obtained when cattle were fed a low energy/high protein ration. When cattle were fed a high energy/low protein ration, there was a treatment x time interaction, with LBC cows initially eating more pine needles (days 1-3), with no treatment effect during the remainder of the trial (days 4-7). In the following field grazing study, LBC and HBC cows were grazed in winter range in the Black Hills. During mild weather cattle ate few needles, but a combination of cold temperatures and

snow accumulation influenced LBC cows to eat greater amounts of pine needles than did HBC cows. Understanding the conditions that affect consumption of pine needles will aid producers in making decisions concerning grazing practices to avoid pine needle-induced abortions in cattle.

Horses are highly susceptible to locoweed poisoning. ARS researchers at Logan, UT found that mares develop clinical signs of poisoning at doses of 0.25 mg swainsonine/kg bw/day for 14 days. (Swinsonine s the toxic component in locoweed.) This is lower than other livestock as sheep and cattle require doses of 0.30 mg/kg for nearly 21 days to develop clinical signs. High swainsonine doses of 0.75 and 1.5 mg/kg produced similar clinical changes supporting the hypothesis that poisoning progresses in threshold fashion. This information will alert horse owners to exercise care in using locoweed invested land and aid veterinarians in diagnosing animal illnesses.

Drug therapy for intoxicated cattle. In the past, the drug, physostigmine, has been sometimes been given intravenously to treat cattle suffering from potentially fatal larkspur intoxication. ARS scientists at Logan, UT have been searching for more effective and affordable drug therapy to prevent death of cattle suffering from larkspur intoxication. They found that neostigmine injected at 0.04 mg/kg body weight was effective at reversing the physiological response to toxic larkspur in cattle. Neostigmine is a reversible cholinesterase inhibitor does not cross the blood-brain barrier. It is an inexpensive drug that has fewer side effects and is easier to use than physostigmine that must be given intravenously. Livestock producers and veterinarians dealing with persistent larkspur problems may find treating intoxicated animals with neostigmine a practical way to reduce death losses.

Determining variations in toxicity of Astragalus and Oxytropis species. In recent years, scientists found that the locoweed toxin, swainsonine, is produced by a fungal endophyte, Undifilum oxytropis. The presence of the endophyte re determines which Astragalus and Oxytropis species are toxic and should be avoid in livestock management. ARS scientists surveyed the major plant species in 2005 to identify those containing the endophyte and produced swainsonine. Seeds were collected from these plants to determine the level of endophyte transmission to succeeding generations. Seed from each parent plant was germinated and seedlings were tested for the endophyte by real time PCR and swainsonine concentration measured. The endophyte was successfully transmitted in 80% of the progeny from maternal plants that had the endophyte and produced swainsonine. All progeny from percentage of the maternal plants had the endophyte suppressed and did not produce the toxin. Further studies are being done to determine the mechanism of suppression and the potential of using this information for assessing risk from various Astragalus and Oxytropis populations and reducing livestock losses.

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.*

Improved Vavilov Siberian wheatgrass aids effectiveness of weed control and revegetation on rangelands with sandy soils. Vast areas of semiarid rangelands with sandy soils are severely

disturbed, frequently burned, increasingly eroded, and invaded with troublesome weeds such as cheatgrass. In many cases, reseeding disturbed sandy rangelands with genetically improved plant materials that are competitive with weeds is the most effective and economically feasible option. ARS scientists at Logan, UT released more competitive Vavilov Siberian wheatgrass for lands dominated by annual weeds. During the establishment year, Vavilov II had higher numbers of seedlings per unit area than Vavilov I at Yakima, WA (52 vs. 23%); Fillmore, UT (79 vs. 54%); Dugway, UT (79 vs. 52%); and Curlew Valley, ID (70 vs. 40%). Vavilov II was more persistent than Vavilov I at Yakima, WA (68 vs. 44%); Fillmore, UT (84 vs. 62%); Curlew Valley, ID (69 vs. 55%); and Malta, ID (97 vs. 91%). Vavilov II has already been distributed to six Department of Defense facilities. Estimates are that this grass will be a component in seed mixtures for over 40 military facilities encompassing over 1 million acres and capture the Siberian wheatgrass market for use on harsh-dry rangelands to conserve soils and reduce fire cycles.

Improved 'Hycrest II' crested wheatgrass aids effectiveness of weed control and revegetation on rangelands with heavy soils. Measures to control of cheatgrass on disturbed rangelands without replacing it with a desirable perennial frequently results in reestablishment of cheatgrass or other noxious weeds. 'Hycrest II' crested wheatgrass was developed by ARS scientists at Logan, UT for reseeding disturbed rangelands with heavy soils that are dominated by annual weeds associated with severe disturbance, frequent wild fires, and soil erosion. Hycrest II had more seedlings per unit area during the establishment year than did the cultivar Hycrest at Blue Creek, UT (76 vs. 65%); Green Canyon, UT (78 vs. 61%); Mandan, ND (78 vs. 69%); Miles City, MT (85 vs. 72%); Dugway, UT (35 vs. 10%); and Stone, ID (72 vs. 56%). At Dugway, UT, Hycrest II (35%) had significantly more seedlings per unit area than did CD II (13%). Hycrest II is currently under certified seed production with six commercial companies and the Utah Crop Improvement Association anticipates there to be a need for over 5000 lbs of stock seed this year for distribution to seed companies. Based on stock seed demands, it is anticipated that Hycrest II will capture a large portion of the crested wheatgrass market in the future and make a significant contribution in restoring degraded lands and helping to break the fire cycle.

Decision support tool for managing invasive weeds. Producers need estimates of the economic benefits of investing in alternative weed control strategies. ARS scientists at Miles City, MT developed an internet-available model that estimates current spotted knapweed and leafy spurge impacts on forage production. The model at http://199.133.173.229/WeedImpact/ requires weed density data gathered by randomly sampling the site of interest. This data is used by the website model to estimate weed impacts on desired plant species and forage production. The website model then translates reductions in desired plant species into estimates of reductions in livestock carrying capacity. By comparing the costs of treatment options with potential increases in carrying capacity, the producer can select the most economically viable weed control strategy.

Selecting post-fire practices to mitigate runoff and erosion. Many land managers of sagebrush ecosystems assume that fire increases soil water repellency and this greatly reduces infiltration of surface water resulting in increased runoff and erosion rates. Multiple studies, by ARS scientists at Boise, ID, on burned and unburned sagebrush sites showed that soil water

repellency and infiltration capacity were highly variable over time and that unburned sites had greater water repellency and lower infiltration than burned sites. These results are contrary to common belief and could improve selection of less expensive runoff and erosion mitigation practices on post-fire sagebrush dominated landscapes.

Plant symbiotic relationships conserve water. ARS scientists at Las Cruces, NM have been studying the impacts of endophyte colonization on the survivability of desert shrubs to improve plant establishment on degraded sites. Assessing the impact of endophyte colonization has been hampered by an inability to cultivate plants free from endophytes. Taking a different approach, fungicides were used to remove endophytes from the leaves of host plants to determine their role in stomatal function and water loss. Stomata on treated leaves opened completely suggesting a reduction of the shrubs' ability to reduce water loss. Further studies of the symbiotic relationship between endophytes and desert plants may identify opportunities for managing endophyte populations to improve host plants' ability to regulate water loss and improve the establishment and persistence of desirable plants on degraded sites.

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.*

Accomplishments

Improved low-input grass licensed for southern pastures. Bahiagrass is a productive forage grass that requires low inputs and is well-suited for limited-resource and other livestock producers in the southern states. One problem with bahiagrass is that in newly seeded pastures, an establishment period of as much as 5-months is required before the grass can be grazed or cut for hay. ARS researchers at Tifton, GA have released TifQuik bahiagrass that has faster germination, fewer weeds during establishment, and can be cut for hay 4-5 weeks earlier than other varieties. Three licenses have been granted for seed production and sales of the new variety and TifQuik was on the market for 2008 fall seeding.

Improved indiangrass for forage-livestock and bioenergy systems. ARS scientists at Lincoln, NE three new cultivars of indiangrass, (Sorghastrum nutans), a warm-season native grass. Three cultivars, 'Chief', 'Scout', and 'Warrior,' were released for use forage-livestock systems in the Great Plains and the Midwest. 'Chief' is adapted to USDA Plant Hardiness Zone 4 (HZ 4) and the upper half of HZ 5. It produces significantly greater forage yields than the other available HZ 4 cultivars. 'Scout' is adapted to HZ 5 in the Great Plains and Midwest, USA and potentially other regions where it has not been tested to date. It produces significantly greater forage yields than other adapted indiangrass cultivars when grown for hay in the western part of its adaptation region. 'Warrior" is adapted to HZ 5 and the upper part of HZ 6 in the Great Plains and Midwest. It produces forage with high in vitro dry matter digestibility (IVDMD) that results in improved animal gains when utilized by beef cattle in well managed grazing systems in regions where it is adapted. In the regions where they are adapted, these cultivars also could be used in mixtures with other grasses in multi-species mixture produce biomass for bioenergy

Improving the persistence of intermediate wheatgrass. Intermediate wheatgrass is a high quality, high yielding perennial grass that's usefulness is limited by a lack grazing persistence. ARS researchers at Mandan, ND bred and evaluated through grazing trials new and existing intermediate wheatgrass germplasms. This research resulted in the release of 'Manifest' intermediate wheatgrass, a cultivar with exceptional yield and enhanced grazing persistence. When sufficient seed quantities are available, Manifest could have a significant economic impact by increasing yield up to 0.3 tons per acre on the 600,000 acres currently growing lower yielding, less persistent intermediate wheatgrasses.

More effective screening of medicinal plants for active ingredients. Artemisinin, an anti-parasitic chemical found in *Artemisia annua,* has been difficult and expensive to analyze. ARS scientists at Beaver, WV working with Chinese colleagues have developed a simplified method for direct analysis of plant extracts for artemisinin using gas chromatography with electron capture detection. The method is sensitive to less than 9 µg/ml, allowing dry samples as small as 100 mg to be accurately quantified. The method can be used to screen plant populations for high-artemisinin producing specimens and to assess quality of *A. annua* plants and extracts destined for the pharmaceutical and medicinal botanicals markets. This more accurate and affordable test will help farmers to consistently produce higher quality products and improve quality control of artemisinin products on the market here and abroad.

Intermediate wheatgrass confirmed as a host plant for the wheat stem maggot in Oklahoma. ARS scientists Woodward, OK observed damage consistent with that of the wheat stem maggot in a field plot of intermediate wheatgrass. Adult wheat stem maggot flies were reared from aborted reproductive culms of intermediate wheatgrass collected in western Oklahoma. Percentage of aborted inflorescences, determined by randomly sampling ranged from 10 to 28%. Intermediate wheatgrass was confirmed as a new host for this species of stem maggot in Oklahoma. This information will help in developing strategies to manage the pest.

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

Accomplishments

Reducing undesirable environmental impacts when applying dry poultry litter to pastures. Poultry litter provides a rich source of nutrients for perennial forages, but the current practice of spreading litter on the surface of pastures allows significant nutrient losses that decrease nutrient-use efficiency and often lead to serious odor and air- and water-quality problems. ARS scientists at Booneville, AR found that placing poultry litter applications below the pasture surface can decrease these environmental problems by more than 90%. The ARS research team developed a prototype machine, the ARS Poultry Litter Subsurfer, in cooperation with the National Soil Dynamics Laboratory to make this technology a practical management option for producers. A patent application entitled System for Distributing Poultry Litter below the Soil Surface was submitted for this technology by USDA-ARS in July 2008. This technology has the potential to improve pasture productivity and help solve both air-quality and water-quality problems on

millions of acres of land associated with critical watersheds associated with municipal water supplies and wild and scenic rivers.

Impact of grazing novel endophyte-infected tall fescue on beef heifers. Ruminants grazing toxic tall fescue have reduced feed intake, average daily gain and poor conception rates, costing livestock producers $600 million annually. Fescue cultivars have been developed that contain a novel endophyte that does not produce the toxic ergot alkaloids that cause fescue toxicosis, but comparisons of breed types of growing heifers grazing different fescue cultivars are limited. ARS scientists from Booneville, AR, with cooperation from the University of Arkansas, conducted a study to evaluate the effects of toxic and novel endophyte-infected tall fescue on growth and grazing behavior of pregnant Brangus and Gelbvieh x Angus heifers. Average daily gain was not different between breed types; however, heifers grazing novel endophyte fescue were heavier than heifers grazing toxic fescue. Fewer heifers grazing toxic fescue were observed grazing during the hot time of the day than heifers grazing novel endophyte fescue. Incorporation of novel endophyte-infected tall fescue into a grazing program can increase the performance of pregnant beef heifers compared with heifers consuming toxic endophyte-infected tall fescue partially due to more time spent grazing and less time in the shade.

Tall fescue/endophyte effects on nutrient cycling in pastures. Research from Georgia found that endophyte-infected tall fescue pastures supported larger soil nutrient pools suggesting that this plant-fungal endophyte symbiosis plays a significant role in carbon sequestration and promoting soil fertility. ARS scientists at Lexington, KY investigated whether this finding was limited to Georgia or was common across the South. They identified and sampled 13 tall fescue pastures, with paired, adjacent endophyte-infected and endophyte-free plots located across the southeastern United States. Surface soils were analyzed for organic carbon and total nitrogen and microbial community composition and biomass. They found that the Georgia findings applied across the South. The endophyte-infection appears to enhance the ability of tall fescue pastures to store carbon and enhance soil fertility although effects on the microbial communities are less pronounced. These results highlight that the tall fescue–endophyte symbiosis can have significant environmental impacts in addition to well known animal health issues. More research is needed to better understand the mechanisms producing these environmental results so management strategies can be found to maintain the environmental benefits while reducing the adverse animal health risks.

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

Accomplishments

Benefits of no-till seeding into dormant warm-season pastures. A sequence of warm- and cool-season pasture will increase year-round forage yield and reduce the need for expensive supplementation. However producers do not always have sufficient land for both warm-season and cool-season pastures. ARS scientists at El Reno, OK found that no-till seeding of cool-season grasses into dormant warm-season pasture can increase cool-season forage availability without adversely affecting the productivity of the existing warm-season pasture. The research

also showed that broadcast-seeding was less effective than drill-sowing in stand establishment, but there was no difference in harvested yield in the spring between sowing methods. The reduced cost of broadcast- seeding rather than drill-seeding. The limited equipment required for broadcast seeding makes this an attractive option to limited resource small farmers seeking to extend their grazing season and increase profitability.

Managing forage nitrate levels in winter-wheat grazing systems. Wheat is excellent forage capable of producing stocker weight gains of greater than 3 lb/day, but wheat can accumulate high levels of nitrate that could pose a health risk to the animals. ARS researchers at El Reno, OK over a four-year period compared the levels of crude protein and nitrate in fall forages clipped from winter wheat pasture and perennial cool-season grass pastures of tall wheatgrass, smooth bromegrass, and intermediate wheatgrass. In two out of four years, winter wheat forage contained nitrate concentrations that could pose a risk to cattle. In contrast, the level of nitrate in the perennial cool-season forages measured each of the four years did not pose a risk to cattle. Levels of crude protein in the perennial cool-season forages were as much as 37% less than that of wheat but were still sufficient for growth of stocker calves. The nitrate risks that sometimes occurred with wheat may make perennial cool-season grasses a viable choice for winter pasture for producers seeking to reduce the risks of livestock loss.

Greenhouse Gas Emissions from Normal and Altered Cattle Urine in Mixed-Grass Prairie. Use of dietary amendments to reduce nitrogen (N) in excreta, such as condensed quebracho tannin, represent a possible strategy to decrease greenhouse gas (GHG) emissions from livestock. ARS scientists at Mandan, ND quantified the effects of tannin-affected cattle urine and normal cattle urine on carbon dioxide, methane, and nitrous oxide flux over a six-week grazing period in a mixed grass prairie. Although the tannin urine treatment possessed 34% less N than normal cattle urine, cumulative nitrous oxide emission between the treatments did not differ. Furthermore, methane uptake from the tannin urine treatment was 40% less than the normal urine treatment. Results from this study suggest the use of condensed quebracho tannin as a dietary amendment for livestock does not yield GHG mitigation benefits at least in the short-term.

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

Accomplishments

Increasing consumption of forages without harming forage production. Neutral detergent fiber (NDF) is typically considered the single best laboratory measure of intake potential for forages or feeds—the amount of a forage or feed that an animal can consume before becoming full. However, all attempts to breed grasses for reduced NDF have resulted in significant decreases in forage yield (productivity). ARS researchers at Madison, WI studying smooth bromegrass have identified an alternative method of predicting intake by using a particle-size-reduction index (PSRI) to select plants that are more rapidly broken down into smaller particles. Completed selection and evaluation experiments demonstrated that PSRI has a much smaller or negligible effect on forage yield. These results provide a basis to develop more effective

breeding strategies for forage grasses, allowing increases in forage intake potential without decreasing forage yield.

Measuring the movement of fecal bacteria on pastures. The movement of fecal pathogens from land to surface and ground water are of potential great threat to the public health. Pasture landscape and forage canopy characteristics affect transport of fecal bacteria during rain. The transport of fecal bacteria by rainsplash was studied by ARS scientists at Beaver, WV in white clover, orchard grass, and perennial rye grass grown on slopes ranging from horizontal to 45 degrees. More bacteria were transported by rainsplash in the white clover than either of the grasses. Managing white clover with a short canopy height resulted in the most rainsplash transport of fecal bacteria compared to moderate or tall canopy management, especially in the down slope direction at the steeper slopes. The results of these studies will guide the design and implementation of forage management practices that significantly benefit human and livestock health as well as the environment by considering the new knowledge about farm level transmission of fecal bacteria.

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.*

Accomplishments

Identifying cross-linking structures in corn stover that limit digestibility. Corn stover in silage is a major feed resource for dairy and beef cattle, but digestibility of its fiber is limited. Effective use of biotechnology to increase the availability of carbohydrates in corn silage for milk production by dairy cattle requires accurate information on how and when the limits to fiber digestion develop during plant maturation. ARS scientists at St. Paul, MN studied the development of the cross-linking chemical structures in fiber that limit digestion in maturing grass stems during a 2-year study. They found that these cross-linking structures are deposited throughout development of corn stems, and in both early and late stages of corn fiber development. This finding is contrary to a previously proposed concept that cross-linking occurred mainly at certain times in the plant growth cycle. This knowledge guides biotechnologists to target genetic manipulation of cross-linking to all stages of grass fiber development rather than a limited interval of development. Improved digestibility improve corn and other grass crops potential for livestock and bioenergy production.

Bt Corn Silage Does Not Contain More Lignin. New corn hybrids that contain the Bt gene for insect resistance reduce pesticide use and increase grain yield, but there have been claims stover from Bt corn contained more lignin than other corn hybrids. Because increased lignin concentration in corn silage is associated with reduced fiber digestibility by dairy and beef cattle,

a finding of more lignin in Bt corn hybrids suggests that this GMO (genetically modified organism) crop should be of lower feeding value for livestock. Six Bt and their genetic control hybrid pairs were compared by ARS scientists at St. Paul, MN in cooperation with the University of Minnesota in replicated field trials at four locations. Lignin concentration, using three methods, and other feed quality characteristics, including fiber digestibility, were measured. The data clearly showed that Bt corn stover contained the same amount of lignin and was of similar fiber digestibility as non-Bt corn plants. These results give farmers confidence that Bt corn hybrids are of similar quality for livestock feeding as conventional corn hybrids.

Impact of stem length on fiber digestibility in alfalfa. Particle size of forages fed to dairy cows impacts feed intake, rumen health, milk fat content, and digestible energy available for milk production. However, little is known about how forage cell wall lignification interacts with plant tissue anatomy in large particles to impact forage fiber digestibility. To test if internode length could predict degradation of stem tissues, ARS scientists at St. Paul, MN selected alfalfa genotypes for rate of fiber digestibility and examined them for internode length. The rapidly digested genotypes were found to have shorter internodes whereas those genotypes with slower fiber digestion had longer internodes. These results suggest that plant breeders could select alfalfa plants that are more rapidly digestible by simply determining average length of stem internodes rather than using costly laboratory methods.

High throughput characterization of alfalfa populations. Molecular marker techniques combined with bulked DNA from multiple plants provides perhaps the best combination of accuracy and high throughput for characterization and differentiation of alfalfa populations. Using 20-plant bulked DNA templates ARS scientists at Prosser, WA assessed how molecular markers would estimate genetic similarity among 29 non-dormant and semi-dormant alfalfa populations representing diverse genetic backgrounds and the nine historically recognized US alfalfa germplasm sources. Cluster analysis based on estimates of genetic similarity showed separation of populations in fall dormancy classes 6-8 (semi-dormant) from fall dormancy classes 9-11 (non-dormant) and in many examples, DNA bulks of the same population clustered together. A single DNA marker was identified that was present only in bulks of fall dormancy classes 6 and 7, and another marker was identified that was detected only in bulks of fall dormancy class 8. This research demonstrates that the amplification of molecular markers from DNA extracted from bulked plant samples is an efficient method for estimating genetic similarity both within and between a large numbers of populations. The markers may also be useful for indirectly classifying relative fall dormancies of uncharacterized populations.

Seed transmission of Pea enation mosaic virus (PEMV). PEMV has never been definitively demonstrated not to be seed transmitted, and as such, has been an issue in movement of pea seed from the U.S. to other countries such as Australia and New Zealand. ARS scientists at Prosser, WA studied whether the virus actually is seed-borne and seed transmitted. A highly sensitive assay called real-time PCR (qRT-PCR) was used to detect PEMV on seeds collected from infected plants and to assess the relative concentrations of viral RNA responsible for the disease. Results from qRT-PCR showed that PEMV was present in very small amounts on seed coats but was not able to infect plants emerging from the seed. The lack of evidence for seed transmission is provided in support of relaxing restrictions on international movement of pulse seed which will be a major benefit to the U.S seed industry with sales to New Zealand and Australia.

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.*

Accomplishment

Natural variation in alfalfa lignin content does not impact syngas yield. It is generally assumed that gasification of lignin-rich biomass will produce a more BTU-rich syngas product. ARS scientists at St. Paul, MN assessed the impact of the natural range of lignin content in alfalfa stems (8–20%) on syngas quantity and quality. Although the propane content in syngas correlates with lignin content, the propane levels were low that neither the overall yield nor BTU content of syngas was affected by lignin content. However, this result is in stark contrast to the very strong negative impact of lignin on biological fermentation. Development of alfalfa varieties and management practices may need to differ to reflect the feedstock conversion system being used.

Soil carbon sequestration in switchgrass fields producing biomass energy crops. Nearly all measurements of soil organic carbon (SOC) change under switchgrass have been based on small plot research. While these assessments are useful, small plot research does not take into account spatial variability within or across farmer-managed fields. The fiscal and net energy economics of switchgrass grown as a biomass energy crop on ten farms in the central and northern Great Plains for a five year period has been reported. The soil carbon sequestration that occurred on the ten farms in these trials was determined in a cooperative study between ARS-Lincoln, NE and ARS-Mandan, ND by taking soil samples at the time the fields were planted and in the spring following the fifth year of production. Across sites, SOC increased significantly at 0-30 cm and 0-120 cm , with accrual rates of 1.1 and 2.9 Mg C ha-1 yr-1, respectively, demonstrating the potential of switchgrass as a carbon-negative bioenergy crop within this agroecoregion. The amount of sequestered soil carbon on the farms in this study exceeded the levels used in previous switchgrass life-cycle assessments (LCAs) for greenhouse gases. Change in SOC across sites varied considerably, however, ranging from -0.6 to 4.3 Mg C ha-1 yr-1 for the 0-30 cm depth; such variation in SOC change must be taken into consideration in LCAs of bioenergy crops such as switchgrass.

Impact of switchgrass varieties on soil carbon sequestration in the northeast. Growing switchgrass as forage or biomass feedstock has been identified as a possible practice for reducing atmospheric carbon dioxide and could help generate carbon trading credits. Scientists at University Park, PA evaluated switchgrass's effect on soil carbon by comparing three switchgrass varieties under clipping and grazing management for seven years at two locations in Pennsylvania. One variety did not persist but for the other two, annual variation in weather and harvest management had larger effects on yield and nutritive value than did genetics of the switchgrass cultivars. Soil carbon levels to a 12-inch depth did not change after five years of growing and grazing switchgrass, but soil carbon in the 0 to 2-inch layer was 33% greater after seven years under clipping management to simulate harvesting for hay or bioenergy feedstocks. This information will help farmers and policy makers developing carbon trading guidelines to

understand the complexity of carbon sequestration under various conditions and help select appropriate management strategies to increase soil carbon storage.

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.*

Accomplishment

Genetic resistance to the stem rust pathogen in perennial ryegrass. Stem rust is the most important disease problem in producing seed of cool-season grasses in the Northwest U.S. No current commercial cultivar of perennial ryegrass has a level of rust resistance sufficient to avoid use of fungicides for disease control. ARS scientists at Corvallis, OR have identified a source of genetic resistance to the stem rust pathogen in perennial ryegrass. By repeated testing under controlled conditions, several individuals from a New Zealand cultivar of perennial ryegrass were found to have high levels of stem rust resistance. Identification of this host resistance source will enable new research to characterize the genetics of resistance which will lead to the development of improved genetic material and strategies to incorporate stem rust resistance into perennial ryegrass.