FY 2012 DRAFT Annual Report
National Program 215- Pasture, Forage, and Rangeland Systems

The goal of National Program 215 is to improve food and energy security from range, pasture, and harvested forage-based systems, while enhancing the natural resources base by developing economically viable and environmentally protective technologies based on applications of fundamental ecological and agronomic processes that are flexible to the uncertainties of changing climate and market conditions.

Public and private range and farmlands comprise about 55% of the total U.S. land area and contribute significantly to a rich variety of goods and services from livestock-centered enterprises. The production and use of perennial grasses, legumes, and other herbaceous vegetation within sustainable production ecosystems is a common foundation of these land types, and has implications for more intensive applications in turf use. These lands are grazed by more than 60 million cattle and 8 million sheep and support a livestock industry that contributes over $80 billion in farm sales annually. In addition, the estimated value of U.S. hay production is around $13 billion, making hay the third most valuable crop. Another 30 million acres in turf in home yards, commercial landscaping, school grounds, right-of-ways, and parks directly affects the citizenry. The Nation's highly diverse grass, herbage, and shrub lands are the source of important environmental services include including clean and abundant water resources, carbon sequestration, open space, and recreational opportunities. These areas also provide important habitat for many wildlife species including 20 million deer, 500,000 pronghorn antelope, 400,000 elk, and 55,000 feral horses and burros.

The demand for space and benefits derived from these lands will increase dramatically as the world population grows to nine billion people by 2050. Also, as the global economy expands, there will be increasing need for agricultural-based animal protein and plant products worldwide, as well as for industrial feedstocks needed to produce biofuels and other bio-based products that will replace petroleum-based ones. Mission-oriented research is needed to meet these challenges through the development of new science-based practices that balance the trade-offs between multiple uses in ways that are productive, profitable, and which demonstrate good stewardship of natural resources and social capital.

RANGELAND MANAGEMENT SYSTEMS

This research area focuses on developing rangeland management strategies and practices for increasing food production through flexible livestock grazing systems that are economically viable and environmentally sound. New rangeland livestock grazing systems will help meet global food security objectives while being adaptable to changing markets and varying climate conditions.

Selected Accomplishments

Online weather-based recommendations for rangeland vegetation restoration. The weather across most western rangelands is highly variable and often has a great impact on the success or failure of rangeland restoration efforts. ARS scientists in Boise, Idaho created a microclimatic index of favorable seedbed conditions and developed a management framework for using historical weather data for planning and managing rangeland restoration projects. This framework includes analysis of site-specific historical weather data, evaluation and ranking of

annual, seasonal and monthly precipitation and temperature patterns, and assessment of seedbed microclimatic conditions relative to the growth stage of seeded plant materials that could be used for rangeland restoration. Available via the web (http://www.ebipm.org/) or as a spreadsheet template, implementation of the weather-based restoration planning framework will improve the success of fire-rehabilitation and other projects across western rangelands, reduce restoration costs, and provide land managers a mechanism to adapt restoration efforts to fit site-specific weather conditions. ARS scientists are currently developing a new report tool with the U.S. Geological Survey.

***Rangeland Hydrology and Erosion Model* tool implemented.** Scientists in the Great Basin Rangelands Research Unit in Reno, Nevada, in collaboration with ARS scientists in Boise, Idaho, and Tucson, Arizona, have developed the *Rangeland Hydrology and Erosion Model* (RHEM). RHEM was used by USDA to estimate runoff and erosion rates on non-federal rangelands in the 17 western states and provided maps of where targeted place-based conservation practices to reduce soil loss would be most cost-effective. The spatially unbiased nature of the rangeland assessment allows rapid determination of regional needs and identification of where conservation programs may be utilized most cost-effectively in arresting land degradation and enhancing ecosystem services. This same concept can be utilized to target specific locations for conservation practices to meet specific goals set by landowners, federal land managers, and policy makers in cost-effective ways. The value of using RHEM was demonstrated by its use to assess the place-based benefits of conservation to reduce soil erosion and restore ecosystem services for a demonstration watershed in Texas. This work is being highlighted in USDA's National Conservation Program report that has been delivered to Congress.

Prescribed burning and grazing can help restore wildlife habitat. Historically, both fire and grazing have influenced vegetation structure and the composition and ecosystem functions of land areas across the Great Plains. Land managers in the 20th century focused on reducing the occurrence of fires and prairie dogs to promote livestock production. Subsequent declines in populations of many grassland birds and concerns over the possibility of being listed as threatened or endangered species have prompted land managers to consider restoring fire and prairie dogs to produce a more suitable habitat for grassland birds. ARS scientists in Cheyenne, Wyoming and Fort Collins, Colorado studied the nesting habitat of the Mountain Plover, such a grassland bird, in relation to prescribed fire and grazing by cattle, and with or without disturbance by burrowing prairie dogs. Prescribed burning and grazing by cattle with prairie dogs were shown to be effective strategies to enhance Mountain Plover habitat conditions. These management practices, however, have tradeoffs in that total beef production is reduced compared with traditional grazing management strategies that exclude fire and prairie dogs. This research provides the basis for helping meet both grazing and wildlife management goals, and quantitative consideration of the tradeoffs necessary to allow livestock use of affected rangelands.

Rodents can enhance restoration efforts in Great Basin environments. Native seed harvesting, consumption, and caching by seed-eating desert rodents have profound negative impacts on the kinds of plants that compose plant communities in arid rangeland regions. ARS scientists at Reno, Nevada have studied the feasibility of utilizing seeds of a "diversionary species" that takes advantage of the natural seed dispersal services of native animals as a passive

strategy to increase the effectiveness of rangeland reseeding efforts. Rodents will naturally cache native seeds, and thus reduce their natural establishment. The effectiveness of desert rodents in dispersing seeds was tested at a 1 ha field scale by broadcasting millet as a diversionary species where rodents typically cache Indian ricegrass seeds, an important native species. Under these circumstances, the rodents cached and preferentially recovered the diversionary seeds before beginning to consume the less-than-desirable-to-them Indian ricegrass seeds. Consequently, 118% more Indian ricegrass seeds were available for emergence as seedlings using this passive restoration scheme, than would have been without the diversionary species. The approach can be used to enhance the establishment of native species that is necessary to help maintain multiple ecosystem services.

Introduced Kochia should not become an invasive species. Introduced plants can provide valuable ecosystem services and enhance the value of rangelands to wildlife and livestock. However, there are concerns that non-native species may become invasive and that their range of adaptation may expand with changing climate. ARS scientists in Reno, Nevada and Logan, Utah have been investigating the risks and benefits of the introduced herbage plant Kochia over the last 25 years and completed an analysis of spread of the plant from original plantings. This long-term research has shown that there is no evidence Kochia is invasive and will spread outside of original planting areas and into other established plant communities. Kochia has excellent winter forage value, especially for livestock and wintering mule deer herds, and can be used as a revegetation tool in disturbed rangelands destroyed by cheatgrass invasion and repeated wildfires. This perennial semi-evergreen shrub averages 1 to 3 feet in height, can grow in habitats that receive 5 to 27 inches of annual precipitations, and survives the extreme temperatures (-25 to 104ºF) found in many arid desert regions. Because of these research analysis and conclusions, concern is reduced about the risks of unintended spread by forage kochia, and its safe use as a part of re-vegetation strategies.

ARS releases new Siberian wheatgrass cultivar for revegetation of dry-harsh disturbed rangelands. As rangeland ecosystems experience changing climate conditions that may result in reduced precipitation, there is need for low-growing grasses that are easily established, and that persist under increased drought, weed completion, and wildfire conditions. 'Stabilizer' Siberian wheatgrass cultivar was developed by ARS scientists in Logan, Utah as a rapid-establishing grass for use on arid and semiarid rangelands, roadsides, and as a grass component in fire strip plantings in the western U.S. Intermountain, Great Basin, and Northern Great Plains regions. Stabilizer has been extensively evaluated at semiarid sites representative of different ecological regions in western U.S. Due to its rapid establishment and persistence, Stabilizer can successfully compete against troublesome weeds such as cheatgrass and medusahead that frequently occupy much of the disturbed rangelands and roadsides in the western U.S. Federal and state land management agencies including the Bureau of Land Management (BLM), USDA Natural Resources Conservation Service, state road departments, ranchers, and the seed industry are primary beneficiaries of this release. Commercial sales of previous improved cultivar releases such as this make up a majority of the seed purchased by BLM for reclamation purposes.

Western juniper tree survey across Oregon informs cattle fertility management. Previous research by ARS researchers in Logan, Utah has demonstrated that leaves of western juniper

trees can induce late-term abortions in cattle, similar to abortion caused by ponderosa pine trees. However, the risk by juniper trees is not well characterized and it is unclear how much variation there is in the abortion-causing compounds (abortifacients). A previous report showed that there is significant variation in ponderosa pine needle abortifacients across regions and over time. The researchers found that samples of bark, needles, and berries from western juniper trees from 35 locations across the state of Oregon should be considered a risk to induce late-term abortions in cattle. This knowledge will allow livestock owners and land managers to better understand the potential abortion risk from western juniper trees.

PASTURE MANAGEMENT SYSTEMS AND TECHNOLOGIES

This research area focuses on developing pasture management strategies and practices for increasing food production through flexible livestock grazing systems. There is need for highly productive pastures to meet the challenges associated with the rising costs of supplemental feed grains used by livestock producers, and done in ways that are protective of natural resources, economically viable, and adaptable to changing climate and market conditions.

Selected Accomplishments

Energy cost savings achieved when displacing fuel oil with switchgrass. Many biomass for bioenergy studies have focused on quantifying the life cycle greenhouse gas (GHG) emissions of biofuel use without considering the economic implications for specific feedstocks used in alternative energy production. Given that biomass is a limited resource, densified switchgrass biomass was evaluated for its potential to displace fuel oil, natural gas, and coal, as well as determine its relative consumer energy costs when used as a bioenergy feedstock. Agricultural Research Service scientists at University Park, Pennsylvania, and cooperators at Drexel University and Pennsylvania State University, found that switchgrass was a cheaper feedstock than fuel oil and that annual savings to Northeastern U.S. consumers could be $2.3 to $3.9 billion. The energy derived from switchgrass can displace more than twice as much fuel oil compared with gasoline, and using switchgrass is a cheaper GHG mitigation strategy when it replaces fuel oil for electricity generation, at an annual potential cost savings of $10 to 11.6 billion. This study highlights the importance of explicitly targeting GHG reductions and petroleum offsets so biomass is not used for more expensive options, such as the electricity generation rather than heat replacement.

Targeting strategies for greatest greenhouse gas reductions for bioenergy feedstock production. State and federal regulations reward innovation for reducing GHG emissions when biomass feedstocks are converted to biofuels by specific technology pathways. However, there is no incentive to reward further GHG emissions reductions from the production practices used for a particular feedstock. ARS, National Renewable Energy Laboratory, Drexel University, and DuPont scientists demonstrated specific feedstock production practices contribute more than 50% of the total GHG emissions as determined by GHG life cycle analysis. Instead of tracking the overwhelming number the components of life cycle GHG emissions in feedstock production, it was found strategies should specifically target the most significant GHG contributing components including nitrogen fertilizer material, nitrous oxide emissions, and tillage impacts on soil carbon. This study provides an inventory of relative practice impacts that can be used to

develop a practical path forward to capture further reductions in life cycle GHG emissions by adopting the most efficient components to develop reduction strategies.

Improved winter-hardy switchgrass with high biomass yields. Lowland type switchgrass cultivars have greater biomass yield than upland switchgrass. However, because lowland switchgrass is of southern U.S. origin and mild climates, when grown in the northern environments, lowland switchgrass varieties often have winter injury or winter-kill problems. ARS researchers at Lincoln, Nebraska have developed a lowland-type switchgrass with improved winter hardiness similar to highland types, but with high biomass yield. The improved lowland-type strain was obtained by crossing upland and lowland plants followed by three generations of selection and breeding, and has excellent winter survival in Nebraska, Wisconsin, and Illinois. In eastern Nebraska, average yields were 2.4 tons per acre greater than the best available released upland cultivar. This research demonstrates the feasibility of improving the winter hardiness of switchgrass by breeding. The lowland experimental strain is in the seed increase phase for potential release as a cultivar and commercialization.

Tall fescue/fungal endophytes affect nutrient cycling in southeastern U.S. pastures. Research from Georgia found that endophyte-infected tall fescue pastures supported larger soil nutrient pools than pastures without endophytes, suggesting that the plant-fungal symbiosis plays a role in carbon sequestration and promoting soil fertility. An experiment was conducted to determine whether this finding applied across a wide geographical range. ARS scientists at Lexington, KY identified and sampled tall fescue pastures throughout the southeastern United States, and analyzed surface soils for organic carbon, total nitrogen, microbial community composition, and biomass productivity. The team found that endophyte-infection appears to enhance the ability of tall fescue pastures to store carbon and enhance soil fertility across the southeastern U.S. These results highlight that the tall fescue–endophyte symbiosis can have significant environmental impacts in addition to well known animal health issues, and suggest that more research is needed to identify the mechanisms that enhance pasture performance, while reducing the negative impacts of endophyte-derived toxins on animal health.

New tall fescue cultivars could make cattle producers millions of dollars. Endophyte-infected tall fescue pastures can significantly reduce grazing livestock performance, particularly during the summer months. ARS scientists at Woodward, Oklahoma have developed new cultivars of tall fescue that contain non-toxic endophytes. These new tall fescue cultivars may increase cattle annual weight gain because the new non-toxic endophytes do not produce toxic alkaloids that deter cattle performance. After two grazing seasons, the benefits of endophyte infections on pastures environmental performance was demonstrated by greater stand counts than the endophyte-free tall fescue. The benefits to livestock performance were shown by greater ending body weight and total weight gain per acre were greater for calves grazing the non-toxic endophyte-infected tall fescues, compared with the tall fescue containing toxic endophyte. The persistence of non-toxic endophyte-infected tall fescues was greater than the endophyte-free variety. These findings demonstrate the value of developing new non-toxic endophyte-infected tall fescue for the cattle industry.

SUSTAINABLE HARVESTED FORAGE AND BIOMASS PRODUCTION SYSTEMS

Harvested forage is essential in livestock production systems throughout the United States. Forages provide a critical component of the feed in dairy, sheep and beef cattle diets. Additionally, harvested forage species play an increasing role as feedstocks for bioenergy production. There is need for genetically improved legumes and grasses with increased production efficiencies when grown in fields and as consumed by livestock. At the same time, there is a need to reduce the environmental footprint of these systems.

Selected Accomplishments

Polyphenol oxidase improves silage protein uptake by livestock. When grasses are ensiled, protein degrades so that when the silage is fed to ruminants, excessive nitrogen that is not utilized by he animal is excreted in feces and urine. Polyphenol oxidase (PPO), a naturally occurring enzyme that causes browning in apple fruit, has been found to decrease protein degradation in forages being ensiled when it combines with other naturally occurring compounds called phenolics. ARS scientists in Madison, Wisconsin found that when orchardgrass that is high in PPO is co-ensiled with tall fescue grass that is high in phenolics, the co-ensiled high-PPO and high-phenolic grass mixture fed to lambs had 10-20% improved total protein utilization, as indicated by decreased nitrogen excretion in urine. On average, at least $100 million is spent annually to purchase feed supplements to offset protein that is otherwise lost during ensiling. Incorporating a PPO/phenolic ensiling system could save dairy farmers $10-20 million annually in reduced costs for protein supplements, and would decrease nitrogen waste that is excreted by livestock to the environment.

Eastern gamagrass use limits excessive weight gain in replacement dairy heifers. Dairy heifer diets that typically contain significant proportions of corn silage or other high-energy forages often cause gain excessive weight that negatively affects their future lactation performance. Consequently, dairy farmers and nutritionists will add straw and other high-fiber feeds to replacement heifer feed rations to limit feed intake and caloric density. ARS researchers at Madison, Wisconsin showed that feeding gamagrass that can be grown on dairy farms may provide an alternative to purchasing and processing $150/ton straw. Gamagrass can easily be ensiled and blended into mixed forage diets. The feed with blended gamagrass also eliminates undesirable feed-sorting behaviors by heifers, potentially neutralizes variations in growth performance among pen mates because less aggressive heifers can access the proper diet whenever they reach the feed bunker, and reduces the total caloric density and dry matter intake of alfalfa/corn silage diets. All of these factors provide heifer producers with an effective alternative management strategy for managing replacement dairy heifer weight gains, especially when facilities are at capacity.

Glyphosate can control rust disease in herbicide-tolerant alfalfa. Foliar diseases can reduce alfalfa yields by 10-50% as well as reduce forage quality. ARS researchers at St. Paul, Minnesota found that glyphosate, a widely used broad-spectrum herbicide, completely controlled alfalfa rust on glyphosate-tolerant plants inoculated with the fungus three days after the herbicide was applied. The level of protection declined with time after application, indicating that control is transitory and that protective treatments inhibit fungal growth. Complete control of rust was obtained when glyphosate was applied up to 10 days after inoculation of alfalfa plants with rust spores, indicating that the herbicide also has curative activity properties. Glyphosate treatment

also increased protection from anthracnose disease, and reduced symptom severity from spring black stem and leaf spot disease as well. These results indicate that as glyphosate herbicide is used to control weeds in herbicide-resistant alfalfa, concurrent reductions in foliar diseases in glyphosate-tolerant alfalfa can be expected to increase herbage yields and forage quality.

Purchased preservatives for alfalfa hay not as economical with large-round bales. Applying propionic acid-based preservatives to alfalfa hay packaged in small (80-lb) rectangular bales has been shown to reduce spontaneous heating that damages forage quality. However, the effectiveness of these products when used within large hay packages has not been documented. ARS researchers at Marshfield, Wisconsin tested this practice on 5-foot diameter, large-round bales of alfalfa hay packaged at 10 to 40% moisture content. Propionic acid-based preservatives only minimally improved storage characteristics within large, round bales, so their application cost was greater than post-storage nutritional improvement. Producers should seek other cost-effective alternatives for preserving large, round bales, such as ensuring adequate field drying prior to baling, or the use of oxygen-exclusion methods, such as wrapping bales in plastic.

TURFGRASS GENETIC DEVELOPMENT

Turfgrass is a component of many urban and rural landscapes, but often requires large inputs of irrigation, fertilization, and pesticides to maintain high-quality conditions. There is need for improved germplasm to reduce purchased input requirements and help adapt species to biotic and abiotic stress conditions to meet turf producer needs**.**

Selected Accomplishments

Resistance to stem rust mapped to three chromosomes in perennial ryegrass. Genetic improvement of ryegrass for stem rust resistance has been hampered by a lack of information about the diversity and location of resistance genes in this grass. ARS researchers in Corvallis, Oregon determined that there is an all-or-none stem rust resistance gene located on perennial ryegrass chromosome 7, and effective partial resistance genes located on chromosomes 1 and 6. These discoveries lay the groundwork for developing the first-ever genetic markers to locate grass stem rust resistance genes. Technology based on these markers will allow plant breeders to produce rust-resistant varieties of ryegrass, saving growers the expense of purchasing fungicides and reducing the environmental impact of fungicide use in grass seed production. Information about the location of rust resistance genes in grasses will also add to the knowledge base for finding rust resistance genes in cereal grasses such as wheat, which is currently threatened with a new strain of stem rust worldwide.

Molecular characterization of root-knot nematodes from turfgrass. Turf grasses, alfalfa, and numerous other crops are host plants that are parasitized by root-knot nematodes (RKN). To find crop genetic resistance to RKN, it is necessary to accurately identify nematode species, but the anatomical features of many root-knot nematode species are very similar which complicates identification based on microscopic examination. ARS scientists at Beltsville, Maryland and colleagues from Arizona, California, and Utah used multiple DNA markers to identify and establish relationships among dozens of RKN populations that were isolated from turfgrass throughout the western United States, and developed a new molecular test to discriminate two

closely related species. This research is significant because new molecular information obtained for these populations facilitates RKN identification of root knot nematodes that would not have been possible before. This method is now aiding researchers and diagnosticians in accurately identifying economically important root-knot nematodes that are difficult to tell apart by comparing anatomical features alone, and may allow plant breeders to find specific sources of genetic resistance to these pests.

New genetic tools for turf grass breeding and genetic contamination identification. The release of 'Tifgreen' bermudagrass in 1956 provided a superior variety that could be mowed at 4.7 mm and spurred golf courses around the southeast to replace their common bermudagrass greens with this vegetatively propagated cultivar. However, soon after its release, areas with noticeable off-type differences in plant morphology appeared on Tifgreen putting surfaces that were the result of remnants from common bermudagrass. Off-type contamination in putting greens has remained a challenge for golf course managers. ARS scientists are Tifton, Georgia have developed simple sequence repeat (SSR) molecular markers to identify the genetic sources of contamination among the three of the most important cultivars used today: 'TifEagle', 'MiniVerde', and 'Tifdwarf'. The team also discovered that 'TifEagle' and 'Tifdwarf' are somatic chimeras and were the first to show that somatic chimeras exist in turfgrass. As a result of the research, the distinguishing genetics markers are used on a weekly basis to help golf courses, sod companies, and landscape companies identify the sources of contamination so remediation actions can be taken to improve the playing surfaces of putting greens. Furthermore, these markers were able to reveal new sources of genetic variation from somatic chimeras where the genotype of the shoot is different than the genotype of the root for a single plant.

Capitalizing on urban biomass for bioenergy production. Utilizing biomass from urban landscapes could significantly contribute to the nation's renewable energy needs. An experiment was conducted by ARS scientists in Oklahoma to evaluate the potential biomass yield from bermudagrass lawns in Woodward. In years of high rainfall, it was possible to harvest from 13.5 to 19.0 megagrams (Mg) of dry biomass per planted hectare from an urban landscape, and 0.8 to 2.3 Mg of dry biomass per planted hectare were possible in years with normal rainfall. It was estimated that the city of Woodward could generate about 3,750 Mg of biomass dry matter (DM) in a normal rainfall year and about 6,100 Mg in a high rainfall year if every homeowner collected their lawn thatch, lawn clippings, tree leaves, and tree limb prunings for bioenergy production. On the basis of a 10 Mg/ha DM yield, there is an estimated 164 million Mg of biomass DM material collected or recycled in the USA from urban areas annually. Biomass from urban landscapes is an untapped resource, and further research is needed to fully understand the potential of this resource.