FY 2011 Annual Report for National Program 215

Pasture, Forage, and Rangeland Systems

The goal of National Program 215 is to improve food and energy security from range and 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, 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 product 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.

New decision tool targets rangeland erosion to save money and conserve soil. Soil erosion from agricultural lands and deposits of sediment into rivers and lakes is a persistent environmental challenge that costs the United States over $6 billion every year. In collaboration with ARS scientists in Boise, Idaho, and Tucson, Arizona, scientists at the Great Basin Rangelands Research Unit in Reno, Nevada developed a new soil prediction tool for rangelands that helps land managers to predict long-term soil loss after individual storms. This new tool provides a way for land managers to predict where erosion will occur, and provides a way to assess the possible effectiveness of different conservation practices before soil degradation

occurs. The tool has been adopted by the Natural Resources Conservation Service and is being used to evaluate existing conservation programs and how they can be enhanced and improved deliver of conservation in a more cost-effective manner by targeting areas of concern. This research contributes to the USDA Conservation Effects Assessment Project for western rangelands.

Inexpensive grazing solution developed to reduce overgrazing on partially forested range. Livestock often concentrate grazing in one part of a range, while avoiding other regions. Keeping livestock dispersed from heavily grazed regions is a challenge for grazing management. ARS at Miles City, Montana and U.S. Forest Service researchers evaluated several factors that drive livestock aggregation patterns in partially forested range in eastern Oregon. It was found that the point where cattle initially entered a pasture was the primary driver of subsequent grazing distributions. Results indicate that by instituting simple, inexpensive changes in where livestock enter pastures, managers could prevent overgrazing and increase profitability. Altering pasture entry into large pastures and allotments can be considerably less expensive and more easily implemented than herding, water development, fencing, and reduce the need for purchased supplements and their movement to different grazing locations.

Annual steer mortality from selenium toxicity documented. Although selenium is an essential mineral, livestock that eat selenium-accumulating plants can be poisoned and die. ARS researchers in Logan, Utah investigating acute selenium toxicity determined that 3% of yearling steers died after grazing rangelands infested with western aster, a selenium-accumulating plant. Death resulted from severe damage to heart muscle tissue. Because high levels of selenium are slowly eliminated from the animal's systems, relatively long periods of time are required for selenium to be cleared by the animal. Some poisoned steers also developed congestive heart failure weeks after the toxic exposure. Documentation of slow selenium elimination rates serves as a useful warning to animal producers to be vigilant when knowing their livestock are grazing forages growing on areas with high selenium concentrations in the soil.

Clear invasive eastern red cedar to produce jet fuel. Eastern red cedar trees are native but have invaded formerly productive eastern Great Plains rangeland over the past 100 years due to fire exclusion and other human activities. ARS scientists at El Reno, Oklahoma have developed a remote sensing technique to accurately estimate the amount of red cedar biomass in Oklahoma that can be harvested. Working with NRCS, the team estimates that the 12 million tons of red cedar growing in the 17 highest impacted counties is enough to produce 800 million gallons of biofuel or 9-million megawatt hours of electricity. Clearing the red cedar will also restore the rangeland productivity for native wildlife habitat and cattle grazing. Commercial business developers are proposing to use this feedstock resource and are pursuing capital to build a first-of-a-kind jet fuel biorefinery in Oklahoma. The accomplishment is also a contribution to the western and northwestern regional USDA Biomass Research Centers.

Accurate costs and risks estimates for fencing rangeland pastures. One of the most common management practices used on rangelands is subdividing pastures by adding additional fences to provide flexibility for increasing grazing intensity to uniformly use pastures. ARS scientists in Cheyenne, Wyoming and Fort Collins, Colorado, in cooperation with the Environmental Defense Fund, determined how fencing materials and installation costs, longer-term maintenance costs, and the influence of Farm Bill financial incentives affect financial risk to the land manager. Researchers estimated livestock stocking rates would need to be increased 9-16% over twenty years to maintain break-even conditions. These increased stocking rates could reduce the health

of rangelands and decrease animal and plant productivity. This kind of integrated science and policy analysis is necessary to determine the most economic options for achieving realistic conservation outcomes based on the actual grazing capacity of the rangeland.

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 that are done in ways that are protective of natural resources, economically viable, and adaptable to changing climate and market conditions.

New bioassay improves livestock de-worming screening. Traditional bioassays use expensive culture testing methods to identify plant materials with potential to control digestive track worms in sheep and goats. ARS researchers at Beaver, West Virginia developed a modified bioassay method using *Caenorhabditis elegans*, a free-living roundworm, instead of gastrointestinal roundworms to screen for effective plant materials. Free-living roundworms are easier to culture and maintain than gastrointestinal worm species, and give reliable results when screening medicinal and tannin-containing plants for potential de-worming activity. This method has potential to reduce the expense and time required to identify plants that contain gastrointestinal-worm-control compounds with potential for use with sheep and goats.

Monitoring and classification of grazing lands. Frequent reliable measurements of pasture quality are required for profitable farm management, while accurate mapping of grazing lands is needed for regional planning. ARS scientists at University Park, Pennsylvania have released software to automate corrections for atmospheric and landscape topography variability that are necessary before Landsat and other satellite imagery can be used to measure forage production and quality. Landsat-derived National Land Cover Data estimates were compared with the more accurate but non-spatial NASS National Agricultural Census data to determine whether county-level areas were correctly identified in the twelve Northeastern states. Total agricultural areas were similar for the two data sources, but the National Land Cover Data poorly distinguished between row crops and pasture or hay-producing lands. By employing accurate satellite tools for mapping and monitoring eastern pasturelands to develop more effective management plans, the resulting improvements from watershed planning can increase profitability of pasture-based agriculture of $95 million.

Two new native legume germplasm released for rangeland restoration. Effective restoration programs are needed to combat weed invasions and restore the diversity of plant species in western rangelands. Currently, there is a lack of commercially available native legume species such as western prairie clover, a perennial legume that provides its own nitrogen through biological fixation. ARS researchers at Logan, Utah released ‘Spectrum’ and ‘Majestic’ western prairie clover germplasm to the commercial seed trade. Spectrum was selected to represent plant materials from the eastern Columbia Plateau, Blue Mountains, Northern Great Basin and Range, and Snake River Plain regions. Majestic was selected to represent plant materials from the western Columbia Plateau and western Blue Mountains regions. Range restoration with these clover germplasm releases will enhance biodiversity, provide forage for wildlife and livestock, and enhance habitat for native pollinators. The seed industry is now increasing foundation seed for sale to the Bureau of Land Management, U.S. Forest Service, and private producers. The

potential impact is considered to be dramatic since these are the only such germplasm developed for the arid western rangelands.

SUSTAINABLE HARVESTED FORAGE AND BIOMASS PRODUCTION SYSTEMS

Harvested forage is an essential in livestock production systems throughout the United States. Forages provide a critical component of feed in dairy, sheep and beef cattle production systems. Additionally, harvested forage species will 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, while reducing the environmental footprint of these systems. Harvested forage production in the U.S. has a value of about $13 billion, making hay the third most valuable crop after corn and soybean.

New gene inserted in alfalfa could save dairy producers $100 million annually. More efficient food production will be required to meet increasing demands by a growing population. Reducing protein nitrogen losses in dairy operations is one strategy to improve production efficiency. ARS researchers in Madison, Wisconsin identified a novel red clover enzyme and transferred the gene that encodes this enzyme to alfalfa. If red clover phaselic acid protection can be reconstituted in alfalfa, it is estimated that improved protein and nitrogen utilization would save farmers more than $100 million annually by reducing the need for purchased supplemental feed proteins. Improved efficiency could also substantially reduce nitrogen waste from cattle on dairies would end up in surface and ground waters. Plants with higher levels of phaselic acid may also be more resistant to ultraviolet light and ozone pollution stresses, as well as stresses from insect pests and plant pathogens.

First alfalfa gene index assembled. ARS scientists at St. Paul, Minnesota conducted an in-depth analysis of the genes active during cell wall development and assembled the first alfalfa gene index that identifies a majority of alfalfa genes. Two major components of alfalfa stems are cellulose that is a sugar molecule that is easily converted to ethanol, and lignin, which is a cross-linking molecule that interferes with conversion of cellulose to ethanol. Several genes associated with the regulation of lignin and cellulose biosynthesis were identified that along with the new gene index can provide ways for plant breeders to increase cellulose and decreasing lignin expressed in cell walls to increase the value of alfalfa as a bioenergy crop. As a result of assembling this first alfalfa gene index, there has been a10-fold increase in the number of known alfalfa gene sequences. The potential usefulness in animal production is that a 1% increase in cell wall digestibility can lead to a 3.2% increase in daily live-weight gain in beef cattle, and a 5% increase in digestibility can increase dairy net returns by 2%.

Switching from CRP grassland to corn does not mean more greenhouse gases. Many USDA *Conservation Reserve Program* (CRP) contract acres are scheduled to end soon, and there are concerns what impact conversion from grassland to cropland would have on soil carbon reserves. ARS scientists at Lincoln, Nebraska, and Ft. Collins, Colorado followed changes in the soil under switchgrass and no-till corn over a nine-year period. The team demonstrated that organic carbon was sequestered down to a five-foot depth, and that over 50% of the soil organic carbon was found below the one-foot level– below the depth at which most modeling work has been based. Both switchgrass and corn sequestered 0.9 tons of carbon per year. Nitrogen fertility rates and harvest management affect the net increase in soil carbon. Previous soil carbon modeling work was conducted assuming uniform responses to management and a shallow one-foot soil sampling depth; this research demonstrates that existing work significantly underestimates the

soil carbon storage benefits of switchgrass and no-till corn production. Just like switchgrass, with proper management under the right conditions, no-till corn can also sequester significant amount of CO_2.

TURFGRASS GENETIC DEVELOPMENT

Turfgrass is a natural component of many urban and rural landscapes, but often requires large inputs of irrigation, fertilization, and pesticides. There is need for improved germplasm with reduced input requirements that are adapted to biotic and abiotic stresses and meet turf producer needs**.**

Turf species show differences in salt tolerance. Golf courses requiring irrigation during summer months compete with other water users. The use of low quality water not suitable for other purposes could relieve irrigation water use conflicts. In collaboration with researchers from the National Turf Evaluation Program, ARS Scientists at Beltsville, Maryland evaluated the tolerance of turf species and cultivars to low quality/saline irrigation water. The use of recycled, low quality and/or saline irrigation water on golf courses, athletic fields, and parks is now required in some regions of the U.S., and is being considered for use in many other areas as the amount of potable water available for turf irrigation is becoming limited. A multiple-year study demonstrated differences among cultivars of Kentucky bluegrass, tall fescue, bermudagrass, and zoysiagrass for their responses to different water quality levels. This research shows that under controlled field conditions it can take 3-5 years to adequately test for differences in salt tolerance in turf species.