FY2019 Annual Report
National Program 215—Grass, Forage, and Rangeland Agroecosystems

The USDA-ARS National Program for Grass, Forage, and Rangeland Agroecosystems (NP215) is comprised of 92 scientists conducting 25 congressionally appropriated research projects at 21 locations across the U.S. Program funding in 2019 was $43M. The scientists had a productive year in 2019 with scientific output, technology transfer, and a number of collaborations with partners and stakeholders across the U.S. and the world. Scientists in NP215 continue to have important impact in numerous areas of research that improve management of the Nation's natural resources, including the more than 1 billion acres of range and pasture lands.

NP215 Vision
Healthy, productive rangelands, pastures, forage cropping systems, and green spaces that support rural prosperity, food security, and environmental sustainability.

Mission
The mission of the NP215 is to provide research results that can be used to improve management decision making and enhance the utility, function, and performance of rangelands, pastures, forage, and turf agroecosystems while sustaining environmental and ecosystem services.

Introduction
Across the U.S., range, pasture, and herbage-based forage and turf landscapes serve many critical functions. Farms and ranches produce high quality, nutritious, abundant, and safe food products, as well as fiber and wood products that are the basis of income for producers and their rural communities. Rural areas provide significant ecosystems services such as clean air, water, and wildlife habitat, and are a long-term repository for biodiversity. These systems comprise about half of the land surface of the United States and represent a large and diverse mix of ecologies, such as annual grasslands of California, tundra rangelands of Alaska, hot arid deserts of the Southwest, temperate deserts of the Pacific Northwest, semiarid cold deserts of the Great Basin, prairies of the Great Plains, humid native grasslands of the South and East, and pastures and hay fields within all 50 states from Hawaii to Maine and Alaska to Florida. Turf covered urban and suburban areas and roadsides also contribute to ecosystem services in regions where they dominate.

The United Nations estimates that two-thirds of the world's agricultural land is pasture, forage and rangelands that can sustainably produce high quality animal products but are unsuitable for sustaining the more intensive production of grains or vegetables for human consumption. Knowledge gained through research about the sustainable management of pasture, forage, and rangelands will help producers in the U.S. and across the globe meet the food security demands of a projected 9+ billion people by 2050. In FY2019, the importance of these global applications was demonstrated by collaborations at 14 locations with researchers in Argentina, Australia, Brazil, Canada, China, Czech Republic, Denmark, Ethiopia, France, Germany, Greece, India, Ireland, Kazakhstan, Kenya, New Zealand, Pakistan, Portugal, Russia, South Africa, and Uruguay.

The Nation's 30-40 million acres of turf lands are found around our homes, schools, municipal and commercial buildings, parks, greenbelts and recreational areas, roadsides, airports, and rights-of-way. These lands contribute to our well-being in many ways, including beautifying our towns and cities; enhancing property values; and providing vital environmental services such as erosion prevention, nutrient cycling, carbon sequestration and aquifer replenishment. These industries contribute an estimated $40 billion a year to the U.S. economy.

Pastures, forages and rangelands are the primary forage base for U.S. livestock grazing industries and are used by more than 60 million cattle and more than 8 million sheep and goats. Forage livestock systems contribute more than $100 billion in farm sales annually to the U.S. economy. The estimated value of alfalfa and other hay production is $15 billion, and alfalfa is the third most valuable crop to U.S. agriculture, behind only corn and soybeans. The publicly owned rangelands in the western U.S. are also critically important, providing forage on 260 million acres for three million beef cattle and sheep raised on over 30,000 primarily family-owned and operated ranches. Nearly 70% of dietary protein and 40% of dietary calories for the U.S. population are of animal origin, and forage resources are crucial for sustained efficient production of food animal products. The ecosystem services provided by these lands are also critical. Watersheds in upland range and pasture regions are essential sources of clean water for urban areas, irrigated agriculture, and recreation. These lands provide forage and habitat for numerous wildlife species, including 20 million deer, one-half-million pronghorn antelope, 400,000 elk, 55,000 feral horses and burros, and hundreds of additional animal and bird species. An array of additional demands is also placed on these natural resources, including mining, oil and natural gas production, camping, hiking, fishing, hunting, and other recreational activities. For example, on the 246 million acres of Bureau of Land Management rangelands, primarily in the western U.S., total direct spending for hunting, fishing, and wildlife viewing totaled more than $2 billion in 2016. These public lands also supported 26,500 jobs, generated more than $1 billion in salaries and wages, and produced more than $421 million in federal, state, and local tax revenue. Meeting these many demands requires an ever-improving understanding of how basic ecological processes are affected by grazing livestock production, drought, climate change, forage management and harvest, and other conservation practices.

Of particular significance is the extent of collaboration between NP215 scientists, other federal and state agencies, and private stakeholders. There were 172 agreements among agency partners such as the US Forest Service, BLM, USGS, NRCS, NIFA, FSA, and NASA, and stakeholders such as the US Golf Association, Bayer Cropscience, Nature Conservancy, and The National Alfalfa and Forage Alliance. ARS continues a close working relationship between NP215 scientists and technical staff with the Natural Resource Conservation Service. The NRCS provides technical support to the management of ~1 billion acres of private grazing lands. ARS scientific support in the development of conservation practices deployed by the NRCS, and the quantitative techniques employed in evaluation their effects, is critically important to the management of these natural resources.

Harvested and conserved forages provide a dietary resource for continuity of livestock production that is especially important during periods of cold or drought when nutrient rich plants are not available. Harvested and conserved forages also provide an important source of roughage and nutrients for dairy cattle in confined animal feeding operations. To meet this demand, nearly 200 million tons of forage

crops are harvested each year from 73 million acres in the U.S., which is 24% of the cropland - providing about half the forage requirements of dairy cattle. The remainder, along with rangeland and pasture, supplies the forage needs of beef cattle, sheep, goats, horses, and other livestock. Increased forage and food animal production efficiencies are needed to ensure the competitiveness and sustainability of food animal producers and to improve domestic and international food security.

Personnel news in FY2019

New additions to the NP215 team in 2019 were:

- **Dr. Travis Witt** joined the Grazinglands Research Laboratory, El Reno OK, as a Research Agronomist. Dr. Witt came to ARS after being an assistant professor of agricultural sciences at Eastern New Mexico University in Portales, NM. He is working on green manures in conjunction with summer annual crops. He is also exploring the possibility of using novel legumes for forage and their adaptability to the Southern Great Plains.
- **Dr. Stella Copeland** is a new research scientist the Range and Meadow Forage Management Research Unit in Burns, OR. Dr. Copeland came from Northern Arizona University, where she was working as a post-doc in the restoration ecology program. Her focus at the Burns location will be on improving establishment of desired perennial vegetation on sagebrush steppe rangeland.
- **Dr. Edward (EJ) Raynor** joined the Rangeland Resources and Systems Research Unit, Fort Collins CO, as a postdoctoral research associate. Dr. Raynor came from the University of Nebraska-Lincoln after receiving his PhD from Kansas State. His research addresses livestock foraging behavior in contrasting plant communities and with different origins of cattle. He is also analyzing long-term livestock gain data (back to 1939) regarding influences of short- and long-term climatic influences.
- The Rangeland Resources and Systems Research Unit, Fort Collins CO, hosted visiting scientist **Dr. Quanxiao Fang** from China. His work assessed livestock gains from the shortgrass steppe with different models (IFARM, GPFARM, APEX) to determine which modules can be used with foraging behavior to simulate grazing patterns on landscapes.
- The Cell Wall Biology Research Unit hosted **Viviane Gritti**, a PhD student from University of Sao Paulo, Brazil to work on silage microbiology, as well as **Emma Hanisko**, a Wallace-Carver Fellow from the University of Wisconsin to work on the isolation and purification of condensed tannins from heirloom varieties of cranberry, and on forage preservation of tannin-containing birdsfoot trefoil.
- The Plant Science Research Unit in St. Paul MN hosted visiting scientist **Dr. Dalibor Zivanov**, a plant pathologist from the Serbian Institute of Field and Vegetable Crops, Novi Sada, for 5 months to identify alfalfa pathogens and learn molecular techniques for pathogen identification and characterization.

The following scientists retired from the ranks of NP215:

- **Dr. James A. Pfister** retired from the Poisonous Plant Research Unit, Logan UT. Dr. Pfister's research focused on effects of toxic plant consumption on animal behavior, nutritional status of grazing animals and effects on consumption of poisonous plants, and grazing management of livestock to reduce risk of losses to poisonous plants.

- **Dr. James E. Dombrowski** retired from the Forage Seed and Cereal Research Unit, Corvallis OR. Jim was a research geneticist whose research focused on endophytes of cool season grasses and expression profiling of *Lolium* exposed to stress conditions.
- **Dr. Robert Graybosch**, Research Leader and Geneticist, retired from the Wheat, Sorghum and Forage Research Unit, Lincoln, NE. Bob's research focused in identifying and developing wheat germplasm having novel quality traits, including modified starch composition, enhanced gluten strength, reduced levels of grain polyphenol oxidase, and enhanced mineral element concentration.

The following scientists in NP 215 received prominent awards in 2019:

- **Dr. Mark Weltz,** of the Great Basin Rangelands Research Unit, Reno NV, along with colleagues, was awarded the 2019 American Society of Agricultural and Biological Engineers Superior paper award, for the paper: S.K. Nouwakpo, M.A. Weltz, A. Arslan, C.H. Green, O.Z. Al-Hamdan. 2019. Process-Based Modeling of Infiltration, Soil Loss, and Dissolved Solids on Saline and Sodic Soils. Transactions of the ASABE. Vol. 61(3): 1033-1048.
- **Dr. Corey Moffet**, of the Rangeland and Pasture Research Unit, Woodward OK, and colleagues on the Great Plains Grazing project received the 2019 Research, Education and Economics Under Secretary's Award for noteworthy accomplishments that significantly contributed to the advancement of USDA strategic goals. The team also received a 2019 Partnership Award for Multistate Efforts from the USDA-NIFA, which cited the group's "outstanding efforts to strengthen the stewardship of private lands through technology and research." The project's goals are to project how climate change will affect the beef grazing industry and how to manage that industry more successfully through future drought conditions.
- **Dr. Hailey Wilmer**, Fellow for the USDA Northern Plains Climate Hub in Fort Collins CO, received the 2019 Outstanding Young Range Professional Award at the Society for Range Management's (SRM) 72nd Annual Meeting. The award recognized Dr. Wilmer's research and outreach program that embodies the true integration of social and ecological science to address interdisciplinary challenges in rangeland social-ecological systems.
- **Dr. Matt Rinella** and **Dr. Sue Bellows**, of the Livestock and Range Research Laboratory, Miles City MT, were awarded the Outstanding Paper in Invasive Plant Science and Management by the Weed Science Society of America for their paper on "Timing Aminopyralid to Prevent Seed Production Controls Medusahead (Taeniatherum caput-medusae) and Increases Forage Grasses."
- **Dr. Kevin Panke-Buisse**, of the Cell Wall Biology Research Unit, Madison WI, was awarded an ARS OTT Innovation Fund award for his work to develop a simple, on-farm assay for Milk Urea Nitrogen (MUN) that can be used as a feed management tool to optimize protein nutrition on dairy farms.

The quality and impact of NP215 research was further evidenced in 2019 by the following:

- 169 refereed journal articles and 4 book chapters published;
- 4 new patent applications filed and 1 new patent issued;
- 2 new cooperative research and development agreements, and 6 new material transfer agreement with stakeholders.

NP 215 Accomplishments for FY2019

This section summarizes significant and high impact research results that address the specific components of the FY2019-2023 action plan for NP215. Each section summarizes accomplishments of individual research projects in NP215. Of particular note are the many high impact accomplishments that address key problems facing management of the Nation's grazing lands. Units in NP215 have been nimble in directing research to develop conservation practices and pasture/forage management systems that solve critical problems, including controlling wildfire and erosion, enhancing habitat values for critical species including sage grouse, controlling invasive species such as cheatgrass, and developing ecologically based techniques for quantitatively assessing and monitoring land. Many of the programs summarized for FY2019 include significant domestic and international collaborations with both industry and academia. These collaborations provide extraordinary opportunities to leverage funding and scientific expertise for ARS research by rapidly disseminating technology, which enhances the impact of ARS research programs.

Component 1: Provide fundamental knowledge and understanding of interacting ecological components of grass, forage, and rangeland agroecosystems.

Carbon sequestration by a perennial sorghum. Carbon sequestration by plants in the soil can be a major factor in capturing organic carbon and reducing contributions to atmospheric carbon dioxide. In a collaborative study with Texas A&M University, ARS scientists at College Station, Texas, used ground penetrating radar (GPR) to determine that a perennial forage sorghum (Columbusgrass) annually accumulated 25 tons per hectare of below ground biomass (roots and rhizomes) compared to 12 tons per hectare (about 2.5 acres) of above ground biomass. Subsequent total carbon analyses revealed that these roots and rhizomes sequestered 12 tons of carbon per hectare (44 tons of CO2-equivalent per hectare) annually which is 4 to 10 times greater than the amount accumulated by non-rhizomatous crops with only fibrous roots. Field trials have confirmed this perennial, rhizomatous, forage hybrid can increase soil organic carbon by 1% in five years on perennial grasslands, which is significantly more than either conservation tillage practices or growing perennial species with only fibrous root systems.

Condensed tannins play an important role in alfalfa resistance to root lesion nematode. Condensed tannins are flavonoid oligomers that contribute to many agronomically important plant traits, including disease resistance. Tannins may provide a way to beneficially manipulate protein digestion and prevent pasture bloat in ruminants. Leaves of alfalfa, a major forage crop, contain no detectable tannins that could protect ruminant animals from potentially lethal pasture bloat. Researchers in Beltsville, Maryland have been working for years to produce tannins in the leaves and stems of the alfalfa plant to prevent pasture bloat in dairy and beef cattle and to suppress internal parasites. They demonstrated that levels of condensed tannins significantly increased in alfalfa roots upon infection with root lesion nematode. The same mechanisms that contribute to the tannin gain in alfalfa roots during nematode infection can be used to increase tannin concentrations in alfalfa leaves and develop tannin-rich alfalfa cultivars.

Planting alfalfa in corn grown for silage protects soil and water resources. Using new management techniques, alfalfa can be planted and grown in corn to more quickly bring it into profitable, full forage

production the following growing season. Using a rainfall simulator, ARS researchers in Madison, Wisconsin, found alfalfa planted in corn reduced the loss of soil and nutrients from cropland by 40 to 80% compared to a conventional system where alfalfa was planted in the spring, seven months after corn harvest. Soil sampled at different depths also revealed that alfalfa planted in corn was much more effective than alfalfa planted after corn for rapidly reducing the risk of nitrate leaching to groundwater. Overall, planting alfalfa in corn holds promise for improving farm profitability and for protecting cropland and water resources.

Alfalfa cyst nematode found in North America identified and characterized. Plant-parasitic nematodes cause nearly $10 billion in crop losses annually in the United States. ARS scientists from Beltsville, Maryland, along with researchers from Nebraska, Idaho, and Kansas, determined that features of juvenile and adult nematodes collected from alfalfa fields in Kansas and Montana were consistent with the alfalfa cyst nematode. Collectively evidence suggests that this represents the first record of alfalfa cyst nematode in North America and may represent an emerging threat to productivity of the alfalfa industry. This information will be used by plant pest management specialists and regulatory officials to manage and potentially contain this nematode to prevent inadvertent movement to additional areas.

Evaluation of noninvasive specimens to determine livestock ingestion of toxic plants. Poisoning of livestock by plants often goes undiagnosed because there is a lack of appropriate or available specimens for analysis, especially in dead animals. ARS scientists in Logan, Utah, detected Lupine alkaloids in the earwax, hair, oral fluid, and nasal mucus in cattle that were administered a single dose of *Lupinus leucophyllus*. In addition, alkaloids from lupine were detected in the earwax of cattle that grazed lupine-infested rangelands. Larkspur alkaloids were detected in the earwax, hair, oral fluid, and nasal mucus in cattle that were administered single doses of *Delphinium barbeyi and Delphinium ramosum*. The advantage of using earwax, hair, oral fluid, and nasal mucus for chemical analysis is that these biological specimens are noninvasive and are simple to collect. Special equipment is not required, and untrained personnel can easily collect the samples for analysis.

Alternative fungicide for protection of alfalfa seeds identified. Seed rot and damping off of alfalfa is a soilborne disease caused by multiple pathogens that results in thin initial stands of alfalfa plants, decreases forage yields, and reduces survival of plants over the winter. Almost all alfalfa seed is treated with mefenoxam, but this fungicide is not active against the pathogen causing Aphanomyces root rot, a lethal widespread disease of alfalfa, nor against fungal seed rot pathogens. ARS researchers at St. Paul, Minnesota, tested eight alternative fungicides for activity against alfalfa pathogens. A commercial fungicide containing a mixture of metalaxyl, prothioconazole, and penflufen reduced growth of all alfalfa seed rot and damping off pathogens at a low concentration, including the pathogens not controlled by mefanoxam. Seeds treated with mefanoxam or the fungicide mixture that were planted in soil infested with damping off pathogens were protected from disease. This research provides alfalfa growers with a new tool to reduce damage from Aphanomyces root rot and damping off pathogens of alfalfa.

Component 2: Improve the physiology and genetics of plant materials to enhance health, vitality, and utility of pasture, biomass for feed and fuel, rangeland, and turf systems.

New cool-season grass cultivars for the Southern Great Plains. The hot, dry climate of the Southern Great Plains present a challenge to producers using introduced perennial cool-season grasses. These problems require new plant materials that tolerate the region's summer weather. An ARS researcher at El Reno, Oklahoma, and collaborators, developed two improved grasses, "Artillery" Smooth Bromegrass and "Ammo" orchardgrass. Artillery was registered for sale in Canada, and registration of this cultivar in Europe and Russia are pending. ARS has applied for Plant Variety Protection (PVP) for Ammo. These new plants were selected and developed to function under hot, dry growing conditions, and on lower amounts of fertilizer than existing bromegrass and orchardgrass available in North America or Europe. These plants will allow producers in a range of hot and/or dry climates worldwide to grow pastures of high-quality grass where these plants would not grow in the past.

Gene discovery for grain production in a dual-purpose perennial grain and forage crop. Perennial plants enhance ecosystem services by reducing soil erosion and nutrient runoff/leaching, and improving wildlife habitat. Perennialism would be a valuable option for grain production, but attempts to capture this complex trait from wheat-perennial wheatgrass hybrids has not been commercially successful. In contrast, efforts to breed intermediate wheatgrass (IWG) itself as a dual-purpose forage and grain crop have demonstrated useful progress and commercial applications, such as Kernza® grain, but its grain yields are significantly less than wheat. ARS scientists at Logan, Utah cooperated with researchers from The Land Institute, Kansas State University, University of Minnesota, and the U.S. Department of Energy to identify chromosome regions and candidate genes associated with 17 grain production traits in intermediate wheatgrass, such as seed size, shattering, and threshing. The researchers identified 42 potential domestication genes that could augment the domestication of IWG and other wild relatives of wheat. These findings will help further develop IWG as a perennial grain, thereby resulting in increased environmental and economic sustainability of grain production on semi-arid and/or erodible croplands.

DNA markers are associated with drought resistance and salt tolerance in alfalfa. Drought resistance and salt resistance is an important breeding target for enhancing alfalfa productivity in arid and semi-arid regions. An ARS scientist in Prosser, Washington phenotyped and genotyped a diversity panel of alfalfa accessions comprised of 198 cultivars and landraces. Marker-trait association identified 19 and 15 loci associated with drought resistance index (DRI) and relative leaf water content (RWC), respectively. DNA markers associated with salt tolerance were also identified in a breeding population. Eight drought tolerant/salt resistant alfalfa lines resulting from this project have been transferred to Alforex Seed Company under an ARS material transfer agreement (MTA) as breeding materials for developing alfalfa cultivars with improved drought resistance/salt tolerance and water use efficiency.

Component 3: Develop integrated science-based tools to foster improved management of grass, forage, and rangeland agroecosystems.

Weather-centric contingency planning for rangeland restoration. Recent changes in federal rangeland-restoration planning and management policy provide opportunities to better incorporate weather and climate information into multi-year revegetation management efforts in the intermountain west. Researchers at Boise, Idaho, in collaboration with colleagues from Burns, Oregon; Woodward, Oklahoma; Moscow, Idaho; Stillwater, Oklahoma; Logan, Utah; and Reno, Nevada, developed new tools for characterizing the historic variability in seedbed microclimates for plant establishment, and new strategies for multiple-year contingency planning of rangeland restoration management. These retrospective analysis tools have been made available on a website (greatbasinweatherapplications.org) and contribute to the annual training program currently given by the U.S. Bureau of Land Management for rangeland restoration planners and managers. Weather-centric, contingency-based rangeland restoration planning could significantly improve rangeland restoration outcomes over millions of acres of disturbed rangeland in the western U.S.

Low-cost, precision technology helps with peak rangeland production. Rangeland producers need timely, reliable, and easy-to-understand information about the condition of their land to make management decisions. Critical information needed for managing grazing cattle productivity is pasture plant variability, including timing of establishment, growth, peak production, and reproduction. Producers traditionally collect this information during field visits, which are expensive and time intensive. Through extensive field work in dominant ecosystems of the Great Basin and Chihuahuan Desert, ARS scientists at Reno, Nevada, and Las Cruces, New Mexico, determined that inexpensive, land-based, plant phenology cameras can quantify changes in mixed shrub-grasslands and meadow ecosystems. These plant “phenocams” offer producers a powerful technology to improve precision management decision-making for applications such as timing of peak greenness for grazing, best time for herbicide application, and opportunities to reduce fuel loads that increase risk of wildfires.

Component 4: Generate strategies to manage grass, forage, and rangeland agroecosystems that simultaneously contribute to environmental conservation and are beneficial to human and animal use.

Active stakeholder participation in research leads to community-focused, adaptive rangeland management. Agricultural producers and industry personnel have diverse perspectives on production systems and environmental issues. Fully engaging them as co-developers and co-participants in agricultural research, from discovery to application to outreach, holds great promise for advancing sustainable agricultural intensification. ARS scientists from Fort Collins, Colorado, and Cheyenne, Wyoming—in collaboration with scientists from the University of Wyoming, Colorado State University, and Texas A&M University, and an 11-member stakeholder group representing a diverse membership of ranchers, state and federal land managers, and non-government conservation organizations—initiated a novel, participatory research project in 2011 to evaluate adaptive management for sustaining livestock production, wildlife habitat, and economics of ranches and rural communities in the western Great Plains. The project generated practical and impactful improvements in management of complex agroecosystems, increased engagement of ranchers with conservation and environmental groups and researchers and provided a model for co-production of trans-disciplinary research to address contemporary societal issues. Lessons learned have been implemental locally by ranchers and the U.S. Forest Service, and extended regionally by outreach engagement through the USDA Northern Plains Climate Hub, the USDA Long-Term Agroecosystem Research (LTAR) network, and the University of Nebraska, and even internationally. With its emphasis on human dimensions and social-ecological systems, this project has been showcased by the Group of Twenty (G-20) Agroecosystem Living Laboratories effort as the primary U.S. example of stakeholder engagement in participatory research.

Changing when finishing cattle stop fall grazing increases profits and range sustainability. To maximize economic return, ranchers in semiarid environments must decide each year when to move cattle off rangeland and on to feedlots for finishing, traditionally in October. The decision is based on expected cattle weight gain given rangeland conditions and market prices, but this forecasting is increasingly challenged by changing climate and highly variable precipitation within and across-years. ARS scientists in Cheyenne, Wyoming, and Fort Collins, Colorado, in collaboration with scientists from Argentina and the University of Wyoming, used livestock gain and economic market data from 2003-2017, which represented a range of weather conditions including drought, to quantify differences in net revenue based on the date cattle were delivered for finishing. There was wide revenue variability, which highlights the economic challenges for individual operations and rural economies in the region. However, because livestock gains were negligible from early September to the end of the grazing season, removing cattle from pastures in early September can increase net revenue. Early removal also provides ecological advantages of more plant residue for soil cover and a longer rest period for healthier vegetation. This information will help regional cattle producers improve their economic and ecological sustainability.

Establishment and persistence needed to restore cheatgrass-infested rangelands. In the Great Basin, invasive annual cheatgrass is estimated to have displaced approximately 25 million acres of native perennial vegetation, leading to catastrophic and costly wildfire cycles. Land management agencies spend millions in re-seeding efforts, but restoring rangelands to a diverse, healthy, perennial-

dominated ecosystem can be difficult with native grasses, and most studies don't look at the long-term effect of re-seeding efforts. ARS scientists at Logan, Utah, studied seedling establishment and plant persistence over five years for native grasses compared with typically used crested and Siberian wheatgrasses at four locations in Idaho, Wyoming, and Utah, ranging in mean annual precipitation from 11 to 16 inches. Native grass seedling establishment of bottlebrush squirreltail, bluebunch, slender, and Snake River wheatgrasses were similar to Siberian wheatgrass; however, by year five, western, Snake River, and thickspike wheatgrasses were the only native grasses to have plant densities similar to Siberian and crested wheatgrasses. In these cheatgrass-infested regions, many native grasses can establish, but may not persist, leading to continued cheatgrass and wildfire. Seed mixes that include combinations of species that establish quickly, persist, and compete against invasive annual grasses is necessary for rangeland restoration. The research provides important information for land managers making decisions concerning what species to plant on rangeland revegetation projects.

New transplanting and seeding methods help restore native rangelands. Degradation of rangelands from wildfires has led to millions of acres of native rangelands being dominated by the invasive and exotic annual grass, cheatgrass, causing significant loss of critical browse communities for wildlife and livestock. Scientists at Reno, Nevada, initiated and tested new transplanting and seeding methods to reestablish the critical browse plant, antelope bitterbrush, following an extensive wildfire in northern Nevada. Transplanting resulted in an initial establishment of over 100 new antelope bitterbrush/acre while seeding had initial establishment of over 15,000 antelope bitterbrush seedlings/acre. The research was successful in demonstrating cost-effective techniques that significantly increased the establishment and recruitment of this critical species, improved nutritional forage for numerous wildlife species as well as domestic livestock, and prevented conversion of the area to cheatgrass dominance.

Mineral supplementation increases productivity and profitability of cattle grazing wheat. Supplemental feeding of grazing cattle is a powerful tool for producers to increase net returns to the livestock enterprise. Wheat pasture is a unique resource in the Southern Great Plains because it provides income from both the grain crop and body weight gain by grazing cattle. Because potential profit is exceptional, many producers do not supplement to improve cattle performance. However, mineral analysis has shown that wheat herbage is deficient in calcium for cattle requirements, so supplementing with free-choice mineral mixtures high in calcium can increase cattle performance. ARS scientists in Woodward, Oklahoma, examined the practice of providing high-calcium mineral mixtures and trace minerals to cattle grazing winter-wheat pasture to compensate for the high potassium in wheat herbage. Cattle offered minerals had up to a 43% faster average daily body weight gain than cattle not offered minerals, and at the end of the grazing period supplemented cattle weighed as much as 6% more than non-supplemented cattle. Mineral intakes averaged 4.4 ounces per day, resulting in a cost of supplement per pound of weight gain of $0.09 (assuming a mineral cost of $0.025/ounce). Producers can use this information to improve cattle weight gain and increases the net-return to their stocker cattle enterprises.