FY2024 Annual Report
National Program 215—Grass, Forages, and Rangelands Agroecosystems

The USDA-ARS National Program for Grass, Forages, and Rangelands Agroecosystems (NP215) is comprised of 100 scientists conducting 25 congressionally appropriated (base program funding of $63M) research projects at 21 locations across the U.S. Those scientists had a productive year in 2024 with scientific output, technology transfer, and collaborations with partners and stakeholders across the U.S. and the world. Scientists in NP215 continue to have significant 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: Forage, fiber, and turfgrass enterprises and production systems that have state-of-the-art, science-based tools needed to use an agroecological approach to optimize productivity, resilience, economic viability, and environmental enhancement.

NP215 Mission: Through comprehensive, stakeholder-informed, basic and applied research, develop and promote use of improved plant germplasm, novel crops and production approaches, decision support tools, and ecological land management practices in enterprises and production systems that use turfgrass and forages.

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Introduction
Across the U.S., rangeland, pasture, and forage-based and turf landscapes serve many critical functions. Farms and ranches produce high quality, nutritious, abundant, and safe food products, as well as fiber and wool products that are the basis of income for producers and their rural communities. Rural landscapes 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, 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 US and across the globe meet the food security demands of a projected 9+ billion people by 2050. In FY2024, the importance of these global applications was demonstrated by collaborations with researchers in Argentina, Australia, Brazil, Canada, Chile, China, Colombia, Dominican Republic, Estonia, Ethiopia, France, Germany, Guatemala, Italy, Kazakhstan, Kenya, Mexico, Netherlands, Peru, Russia, Switzerland, and the United Kingdom.

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 ecosystem services such as erosion prevention, nutrient cycling, and aquifer replenishment. Turfgrass industries also 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, erratic weather conditions, 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 66 new agreements among agency partners such as the U.S. Forest Service, BLM, USGS, NRCS, NIFA, FSA, and NASA, and stakeholders such as the U.S. 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 evaluating 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.

The quality and impact of NP215 research was further evidenced in 2024 by the following:

- 180 refereed journal articles and two books/chapters published;
- 36 new incoming cooperative agreements;
- 2 new invention disclosures; and
- 146 students and postdoctoral research associates working and training in ARS laboratories.

NP 215 Accomplishments for FY2024

This section summarizes significant and high impact research results that address the specific components of the FY2023-2027 action plan for NP215. Each section summarizes accomplishments of individual research projects in NP215. Of note are the high-impact accomplishments that address key problems facing management of the Nation's grazing lands. Units in NP215 have been 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 FY2024 include significant collaborations with both private industry and public institutions. These collaborations provide ARS extraordinary opportunities to leverage funding and scientific expertise, rapidly disseminate technology, and enhance the impact of research.

Component: Provide basic and applied research at the plant and soil scale to improve utility of crops for turfgrass; harvested forage, fiber, and bioenergy; pasture; and rangeland systems.

Artificial intelligence accelerates alfalfa and turfgrass breeding. Traditional plant breeding is often a slow, laborious process that includes many steps of manual phenotypic assessment. Artificial intelligence (AI) holds great promise to replace these manual steps and accelerate plant assessments in breeding programs. ARS scientists in St. Paul, Minnesota, analyzed 15,000 root systems of alfalfa plants using digital images as input into an AI model to test its ability to predict root types. Initial model results were 64 percent accurate at predicting root type, and the model was improved an additional 11 to 13 percent by applying machine learning. This method can be used by non-specialists, requires only a phone camera, and reduces the time for identifying root types from 22 to 2 weeks while reducing human errors during sampling and plant selection. The AI method has accelerated the breeding process and the accuracy of selecting for developing plants with diverse traits such as more fibrous roots with more nitrogen-fixing root nodules, a deep tap root for drought tolerance, and highly branched roots for wet soil tolerance. Similarly, ARS researchers in Beltsville, Maryland, developed a cost- and labor-efficient RGB imaging system to monitor drought progression and recovery in 1,000 turfgrass germplasm accessions growing in a greenhouse. This system automatically captured 345,600 images at hourly intervals during the course of a month. Researchers created an AI processing pipeline with advanced algorithms for image processing, annotation, and quantification of stress symptoms as well as a neural network to filter out false positives. This method achieved a prediction accuracy of 93 percent. This innovative approach allows for precise and efficient assessment of genetic variation in drought responses and recovery patterns, enabling identification of key traits within the mapping population. Compared to expensive robotic gantry systems, this imaging and AI pipeline delivers the same analysis at a significantly lower cost in 30 minutes compared to months of manual observations. These AI systems are proving to be of tremendous value for plant breeders for increasing the efficiency and cost effectiveness of their programs.

Discovering genetic regions controlling seed dormancy speeds development of new hairy vetch varieties for cover crops. Hairy vetch is a legume crop with the potential for diverse uses in most regions of the United States as a source of nitrogen to soils, a cover crop for erosion control, and animal feed. Despite this potential, many farmers fear hairy vetch because its dormant seed can grow after harvest and create weed problems in subsequent grain crops or surrounding natural areas. ARS researchers in Madison, Wisconsin, collaborated with NRCS plant material centers, other ARS sites in Corvallis, Oregon, and Beltsville, Maryland, and the Cover Crop Breeding Network, to identify a genomic region in hairy vetch that largely eliminates dormant seed. This discovery has allowed hairy vetch breeders to develop non-dormant hairy vetch varieties in 2 years, rather than a projected 7 years without the genomic marker. Non-dormant hairy vetch varieties can help farmers adopt and succeed with hairy vetch cover crops, which can reduce soil erosion and the need for nitrogen fertilizers and improve farm profitability.

Basic research explores beneficial uses of hemp-based cannabidiol. There is increasing U.S. interest in producing hemp for a variety of agricultural and industrial uses, but much basic research is needed to establish the viability of proposed uses. ARS researchers in Lexington, Kentucky, investigated potential uses for hemp-based cannabidiol (CBD) for three objectives: as an antimicrobial for controlling detrimental clostridia bacteria in animal production and forage preservation settings, controlling hyper ammonia-producing bacteria (HAB) in bovine rumens that negatively impact the ability of beef cattle to gain weight, and mitigating gastrointestinal inflammation in cattle that can result in lower weight gain or reduced milk production. They found all five agriculturally relevant Clostridia types were inhibited by CBD at some concentrations and that some concentrations of CBD were effective in treating existing inflammation and in preventing or delaying the onset of inflammation in rumen cells. These results support the idea that CBD could be used to help mitigate or prevent the negative effects of gut inflammation that could improve animal productivity, although CBD was not found to be a viable candidate for controlling HAB in beef cattle. This work will be of interest to researchers interested in cannabinoids as natural products in animal feed and suggests options for creating a value-added product out of spent hemp biomass.

New ‘Basin’ Utah sweetvetch improves seed and forage production. Legumes are important for rangeland restoration because they fix atmospheric nitrogen as nitrogen source to soils, enhance forage resources for grazing livestock, and provide food for wildlife herbivores and pollinators. Utah sweetvetch, a native drought-tolerant perennial legume, has received particular interest by land managers, but reliable seed sources are limited and very expensive. ARS researchers in Logan, Utah, and Utah Department of Wildlife Resources collaborators developed and released ‘Basin’ Utah sweetvetch, which has double the seed yield and 90 percent greater forage mass than ‘Timp’, the only previous cultivar of this species. Basin sweetvetch will benefit seed producers, help increase seed inventories, and provide a valuable resource to land managers by facilitating rangeland restoration success.

Component: Develop systems-based approaches for rangeland management to enhance forage and livestock productivity, land restoration, and ecological services.

New remote sensing approach reduces wildlife-livestock conflicts. Environmental conservation and economic sustainability can collide when wildlife and livestock compete for forage in working lands, creating challenges for private and public land managers. One example is competition between the black-tailed prairie dog, a keystone wildlife species, and livestock in the western U.S. Great Plains. ARS researchers in Fort Collins, Colorado, collaborated with the Thunder Basin Grasslands Prairie Ecosystem Association and the U.S. Forest Service on using high spatial resolution remote sensing imagery and a deep learning approach to detect prairie dog burrows across vast areas of remote rangeland. Researchers were able to accurately map prairie dog colonies and vegetation use intensity, giving managers new tools to understand prairie dog population changes and their associated impact on livestock forage availability. In a related long-term experiment, the ARS researchers discovered that prairie dogs often have little impact on forage availability and grazing cattle weight gain, but during drought years on some soil types can negatively impact cattle and reduce rancher revenue by 27 percent. This research is helping public and private land managers understand where and when livestock production operations are impacted by prairie dogs and develop site-specific management strategies that can more successfully mitigate wildlife-livestock conflict compared to one-size-fits-all recommendations. For example, if prairie dog conservation is focused on soil types where impacts to livestock production are low, producers may be able to reduce control costs and enhance coexistence of wildlife and livestock on U.S. rangelands.

Machine learning and artificial intelligence creates rangeland fuels maps for fire planning. Western juniper/pinyon pine woodlands occupy more than 22.8 million hectares of North America and are invading sagebrush steppe rangeland at a rate of 4,600 square kilometers per year. Sagebrush steppe is a critical landscape for livestock forage and wildlife habitat for the greater sage grouse. Developing safe and effective juniper control strategies using prescribed fire is often challenged by a lack of spatial information on pre-fire vegetation fuel conditions. ARS researchers in Boise, Idaho, used commercial, high-resolution satellite imagery and machine learning (ML)-artificial intelligence (AI) analysis methods to create pre-fire maps of vegetation fuel types to inform prescribed fire planners about spatially relevant rangeland fuel conditions. Seven separate fuel types were mapped to very high resolution (50-cm) with an accuracy of 83 percent using random forest ML methods. The scientists made these maps publicly available via the Ag Data Commons repository, where they received 710 downloads the first 2 months they were available. These fuels maps will improve efforts in U.S. wildland fire prevention, suppression, and restoration, which cost $1.5 billion, and help protect human lives, property, and natural and cultural resources across extensive areas of the U.S. West.

Forage leaves—not stems—are critical for livestock production across the Great Plains. Vegetative forage production on U.S. Great Plains rangelands generally increases as annual precipitation increases, but it is not known if more vegetation leads to increased livestock production as well. ARS researchers in Fort Collins, Colorado, and Mandan, North Dakota, and university collaborators analyzed long-term (20-30 years) livestock production data from six North American rangelands that received from 13-33 inches of annual precipitation. They determined that livestock production declined at sites with more precipitation, because plants had more stem than leaf material that reduced forage quality and reduced livestock performance. These results provide land managers with critical knowledge for developing rangeland vegetation and grazing management practices that increase plant leaf relative to stem growth in relatively wetter sites to increase livestock production, efficiency, and profitability.

Prescribed fire enhances forage nutritive value and mineral content and increases cattle weight gains. Rangeland management often prioritizes either conservation or livestock production, but sustainable grazing management that includes ecological processes such as prescribed fire could optimize both. These disturbances interact to shape plant communities and outcomes for rangeland biodiversity and livestock production. However, it is commonly assumed that deferring grazing for up to two growing seasons after a fire is necessary to ensure plant community recovery, which puts livestock producers at risk due to lost grazing resources. Additionally, the impact of grazing deferment on plant biodiversity is not well understood. ARS scientists in Miles City, Montana, and university collaborators conducted a ranch-scale experiment in the U.S. Northern Plains to compare forage nutritive value and livestock performance from patch-burned pastures and rotationally and continuously grazed pastures without fire. Fire increased forage crude protein, fiber digestibility, and energy, and reduced the fiber and lignin components of forage nutritive value relative to unburned patches and grazing systems without fire. Recently burned patches had the best forage nutritive value throughout the grazing season, and often had more mineral content than areas with longer postfire interludes. It is likely that cows spent more time grazing in recently burned patches because they could better meet their nutritional requirements. Because of these benefits, cows from patch-burned pastures performed better over the course of the grazing season. In similar work, ARS scientists in Dubois, Idaho; Miles City, Montana; and Woodward, Oklahoma, determined that prescribed fire seasonality and grazing deferment in big sagebrush plant communities had important economic but relatively moderate ecological implications in this system. Together, this research is establishing the value of prescribed fire as a viable option for ranchers and providing land managers with information about returning livestock to graze after fire in ways that ensure post-fire recovery of vegetation production and diversity.

Integrated weed control and perennial grass seeding strategies can improve rangeland restoration success for sustainable grazing resources. Great Basin rangelands have experienced a nearly 10-fold increase in area dominated by the exotic and invasive annual cheatgrass. Cheatgrass represents a significant vegetative fuel that can contribute to larger and more frequent wildfires that damage grazing and wildlife resources and threaten life and property. ARS researchers in Reno, Nevada, tested the efficacy of pre-emergent herbicides to control cheatgrass and increase the success of seeding efforts to restore native perennial vegetation. Integrated weed control practices, including pre-emergent herbicides and seeding perennial grasses, significantly increased perennial grass density and diversity, successfully reducing cheatgrass fuel loads from 1,241 pounds per acre down to 85 pounds per acre—a 93 percent reduction. At the same time, the successful restoration of native and introduced perennial grasses significantly increased grazing resources for livestock and wildlife. In related research, ARS scientists in Miles City, Montana, tested how plant densities change as more species and varieties are added to restoration seed mixes. They found that chances of low plant densities and plant establishment failures decline as fixed seed rates are divided more evenly among more species and varieties, and that the odds for establishment are greater if plant survival probabilities vary widely among seeded species. To determine how much survival probabilities vary, the scientists studied grasses commonly seeded in U.S. West Great Plains, Great Basin, and Mediterranean grasslands. Survival probabilities varied extensively, so plant establishment increased markedly with increasing species numbers. Seeding multiple varieties of individual species often increased the odds of establishment for individual species from 50 percent to 100 percent. Together, this research is increasing information land managers need to successfully control invasive grasses and restore desirable rangeland vegetation.

Targeted livestock grazing promotes wildfire protection and recovery of fire-damaged resources. Rangeland megafires that are becoming more frequent in the western United States are often due to invasive and highly flammable annual grass species like cheatgrass, which alone now dominates a total area as large as the state of Idaho. Management tools are critically needed to combat cheatgrass, reduce the wildfire threat posed to human lives and property at the wildland-urban interface, and promote recovery of fire-damaged ecosystems. ARS researchers at Boise, Idaho, determined that targeted cattle grazing in spring can create and maintain fuel breaks between cheatgrass-invaded rangeland and critical resources upslope and downwind, and that prescribed cattle grazing in spring and fall can suppress cheatgrass and promote increases in native or desirable plant species. ARS researchers in Burns, Oregon, tested the effectiveness of virtual fencing for spatially targeting cattle grazing within the bounds of a pasture-scale fuel break in the sagebrush steppe and found that virtual fencing was highly effective in containing dry cows but less effective for cows with calves. This research is developing the information needed for land managers to use targeted grazing in combination with virtual fencing to manage annual grass fuel abundance within fuel breaks and potentially larger rangeland landscapes for both wildfire mitigation and other grazing resource needs.