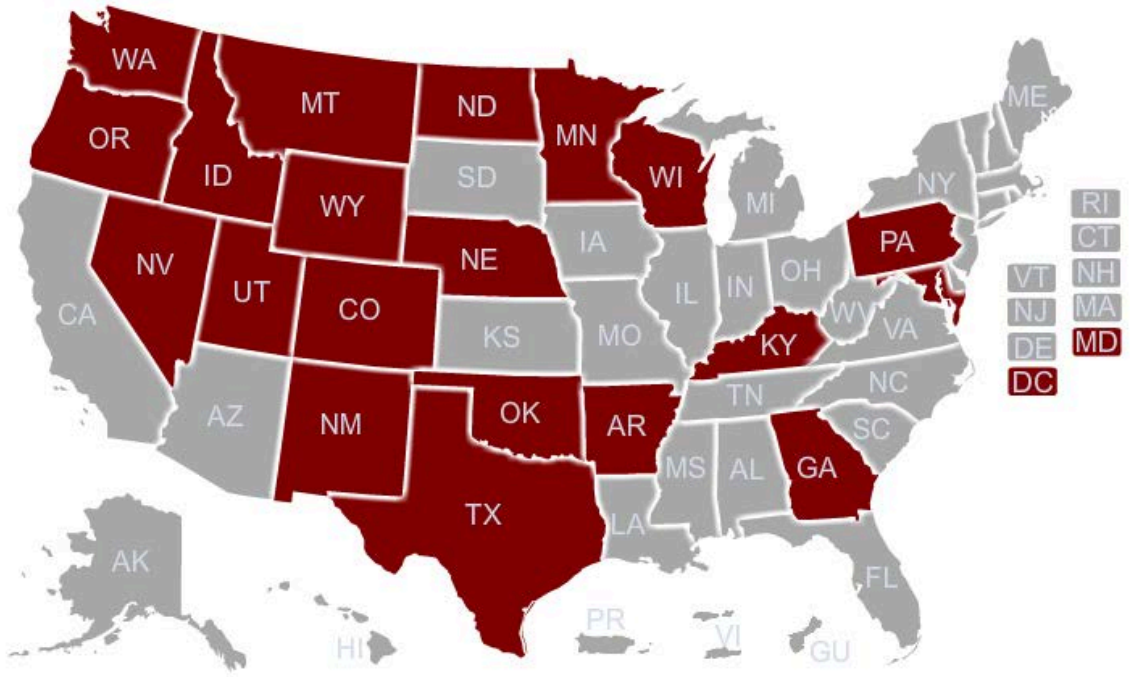
Retrospective Review: ARS National Program 215 – Pasture, Forage, and Rangeland Systems

Based on the NP215 2013-2017 Action Plan

Sept 2017

National Program 215:
Locations of Program Activities (in red)
2013-2018



Sequence of Accomplishments Review

- **Component 1:** Improved Rangeland Management for Enhanced Livestock Production, Conservation, and Ecological Services
  - Problem Statements A, B, and C
- **Component 2:** Develop Improved Pasture Technologies and Management Systems
  - Problem Statements D, E, and F
- **Component 3:** Improved Harvest Forage Systems for Livestock, Bioenergy, and Bioproducts
  - Problem Statements G and H
- **Component 4:** Turf Improvement and Management
  - Problem Statement J

Component 1: Improved Rangeland Management for Enhanced Livestock Production, Conservation, and Ecological Services

- **Problem Statement A:** Developing economic livestock grazing systems for rangelands that meet global food security objectives, while being adaptable to changing climate and varying environmental conditions and preserving natural resources integrity.
- **Problem Statement B:** Need for management strategies and practices that enhance and conserve rangeland ecosystems to provide multiple ecosystem services, including forages for livestock, soil conservation, water quality, control of invasive species, and recreation and wildlife habitat conservation under changing environmental conditions.
- **Problem Statement C:** Need for greater fundamental understanding of ecological processes and interactions so that science-based management practices, technologies, and germplasm can be improved to meet production, conservation, and restoration objectives under changing climatic conditions.

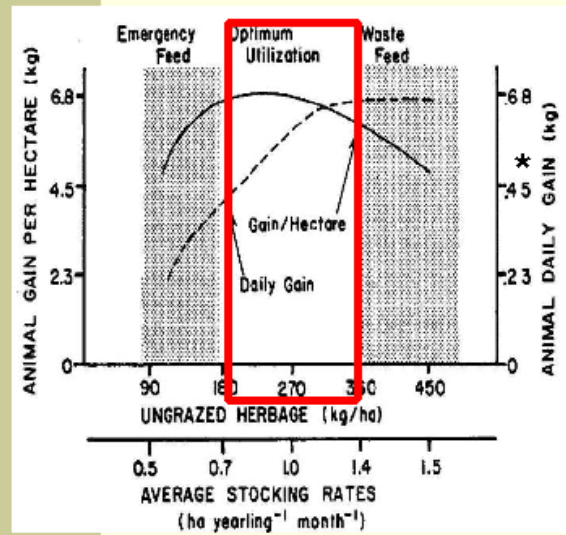
Problem Statement A: Selected Highlights

Economic livestock grazing systems for rangelands that meet global food security objectives, while being adaptable to changing climate and varying environmental conditions and preserving natural resources integrity

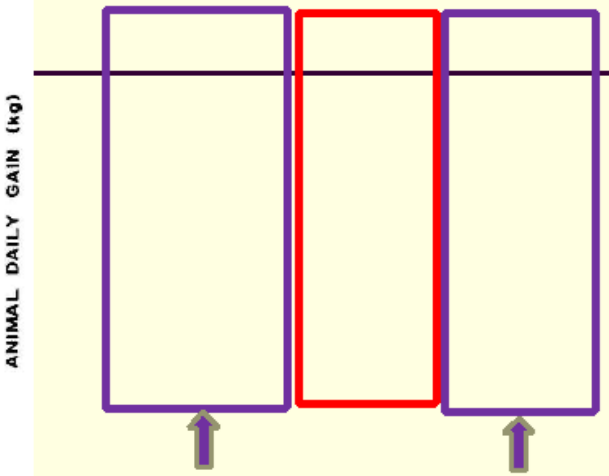
Presenter: Fred Pierson, ARS Boise ID

Livestock Grazing and Conservation – Using Patch Burning

Livestock Production → **Conservation Concerns**



Bement 1969



Underrepresented habitats

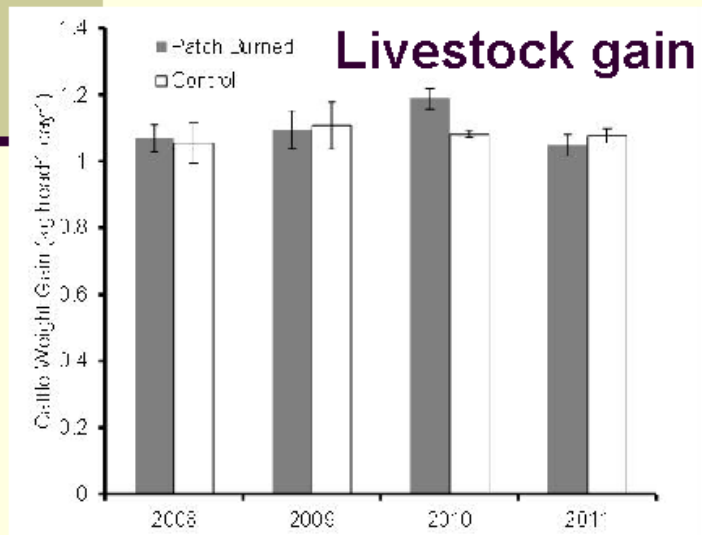
Knopf 1996

Patch burns conducted in fall dormant season to 25% of pasture each year for 4 years, Moderate summer stocking with no deferment

Creates suitable mountain plover habitat

Reduces abundance of cactus

Livestock gain

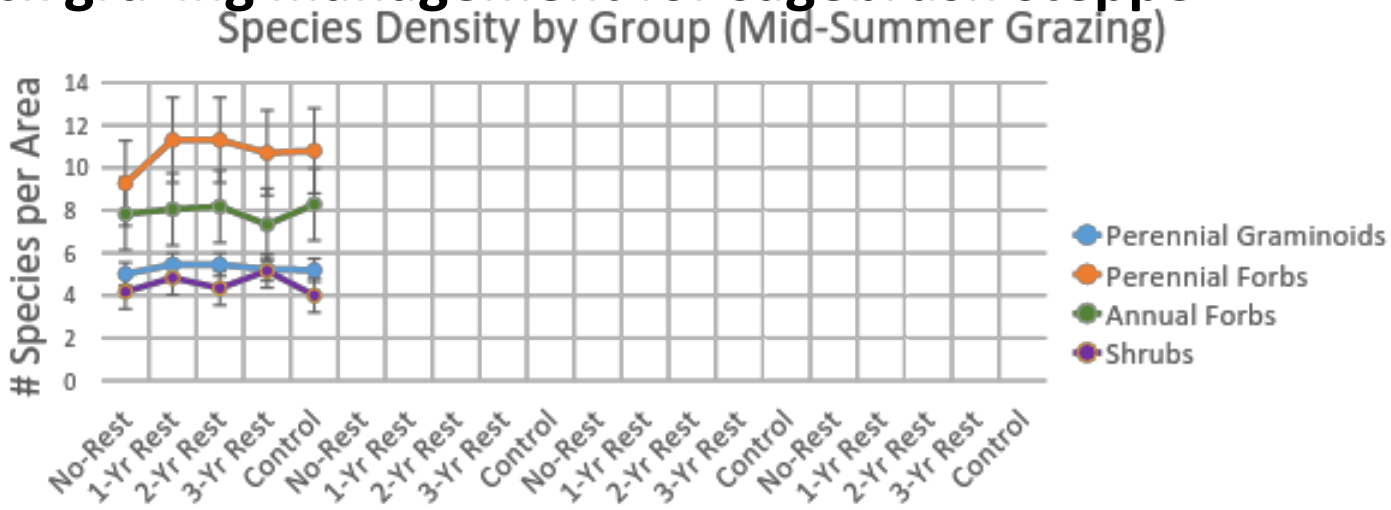


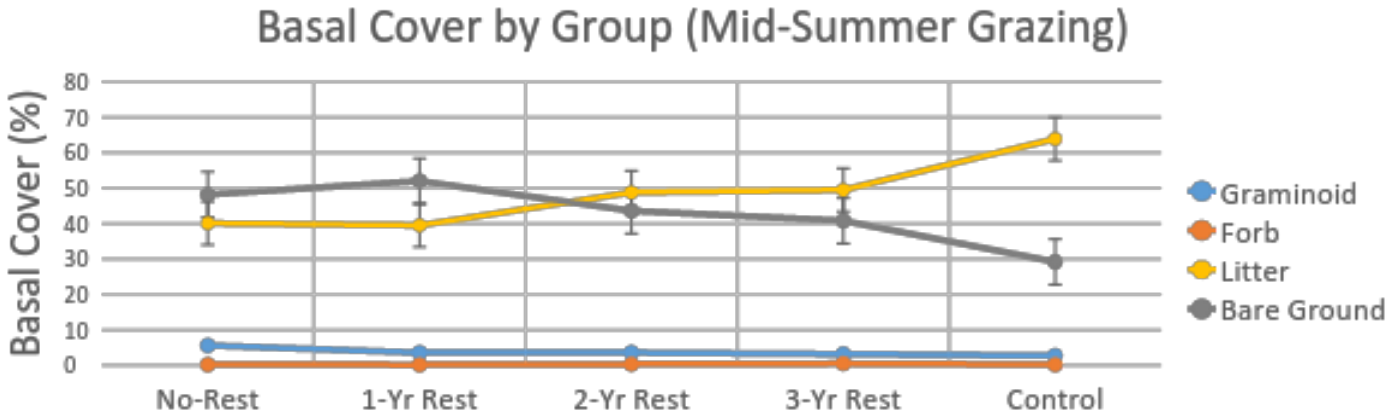
Forage production

Year	Burned Area: Current Year Plant Production (kg/ha)	Unburned Area: Current Year Plant Production (kg/ha)	Burned Area: Old Standing Dead (kg/ha)	Unburned Area: Old Standing Dead (kg/ha)
2008	480 (109)	499 (91)	18 (10)	228 (89)*
2009	1219 (64)	1595 (201)	4 (4)	97 (22)*
2010	1090 (37)	1071 (71)	14 (5)	265 (18)*
2011	717 (136)	696 (54)	13 (3)	251 (50)*

Science-based postfire livestock grazing management for sagebrush steppe

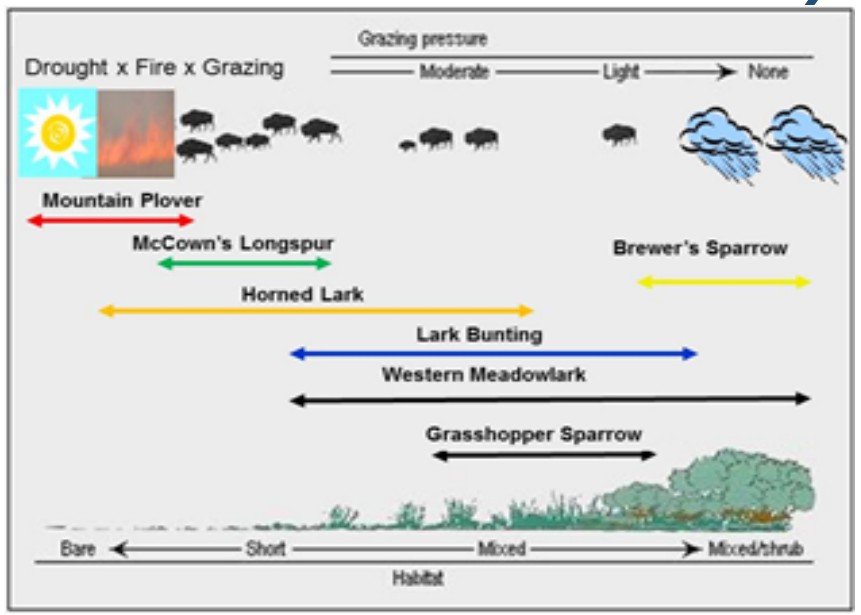
End of Season Fenceline Contrast





- Five levels of postfire rest from cattle grazing were evaluated: No-Rest, 1-Yr, 2-Yr, 3-Yr, and burned/ungrazed Control.
- Grazing had little or no impacts on perennial grass or forb basal cover (measure of vigor) or species density and frequency (measures of diversity).
- Postfire grazing can slow recovery of surface litter cover and thus prolong bare ground exposure to hydrologic events.
- On flat terrain, a No-Rest postfire cattle grazing strategy may be quite acceptable.
- On sloping terrain, managers should balance postfire grazing with potential runoff and erosion risks.

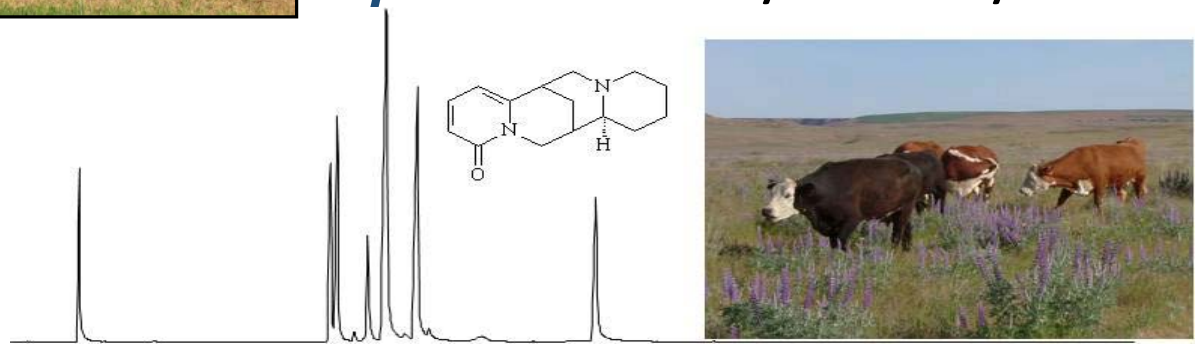
Problem Statement A: Additional Accomplishments



- Incorporating seasonal weather information into management decision-making in the northern Great Plains improves cattle production (Multi-location)
- Patch burning developed as a management strategy resulting in improved production and conservation benefits in semi-arid rangelands(Fort Collins CO and Cheyenne WY)
- Interseeding missing plants into degraded rangelands can improve ecological services (Woodward OK)

Problem Statement A: Additional Accomplishments

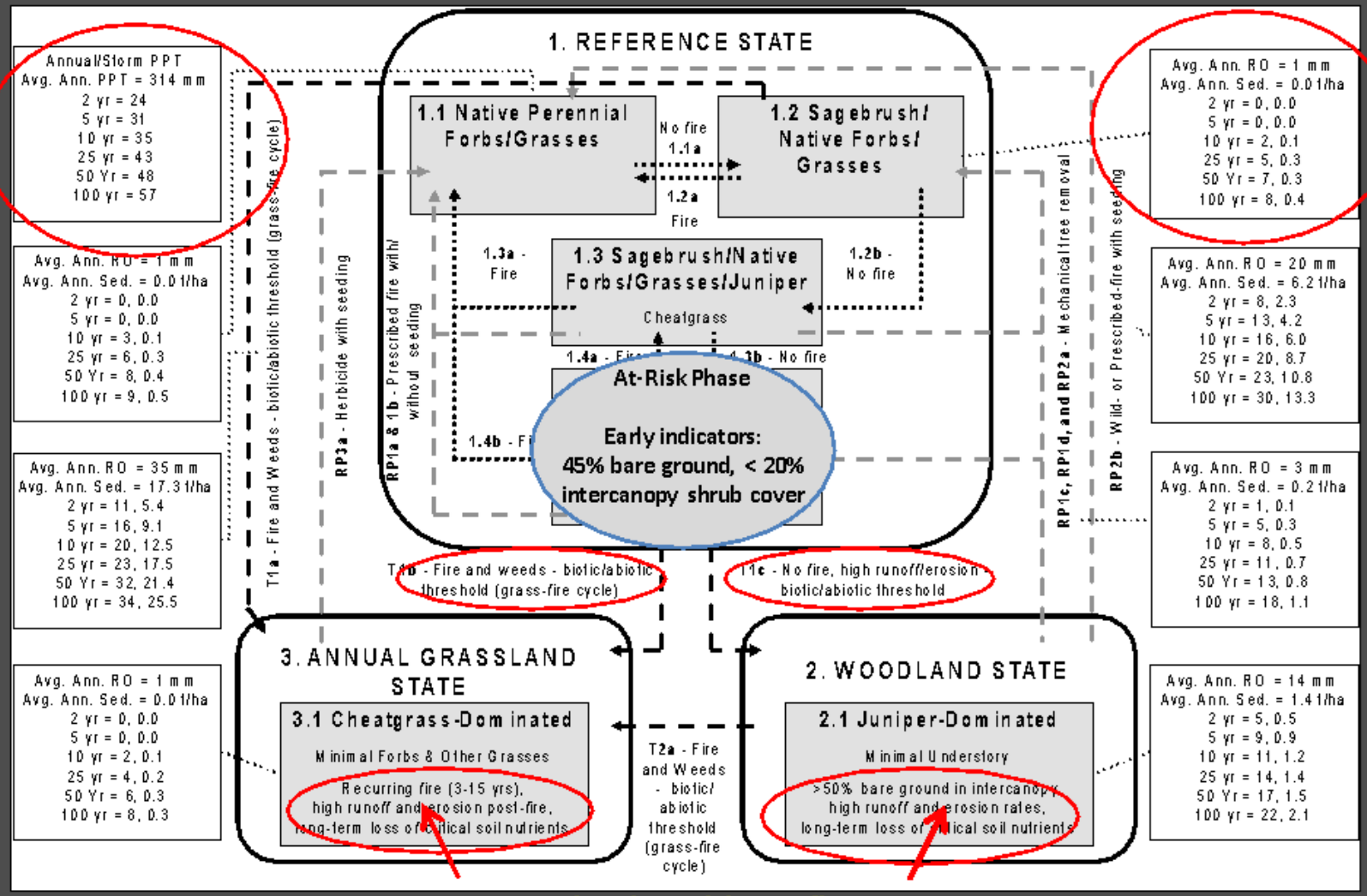
- Semi-arid rangeland plant communities are resilient to post-fire summer grazing (Miles City MT)
- Developed a fall oats management strategy that can improve sustainability of dairy production (Marshfield WI)
- Demonstrated that northern mixed-grass prairie can recover from heavy grazing, but recovery is slow(Fort Collins CO and Cheyenne WY)
- Developed techniques to use biomarkers to successfully identify cattle resistant to plant



Problem Statement B: Selected Highlights

Management strategies and practices that enhance and conserve rangeland ecosystems to provide multiple ecosystem services, including forages for livestock, soil conservation, water quality, control of invasive species, and recreation and wildlife habitat conservation under changing environmental conditions

Ecohydrological Framework for Ecological Site Descriptions (ESD)



ARS - Boise, Idaho

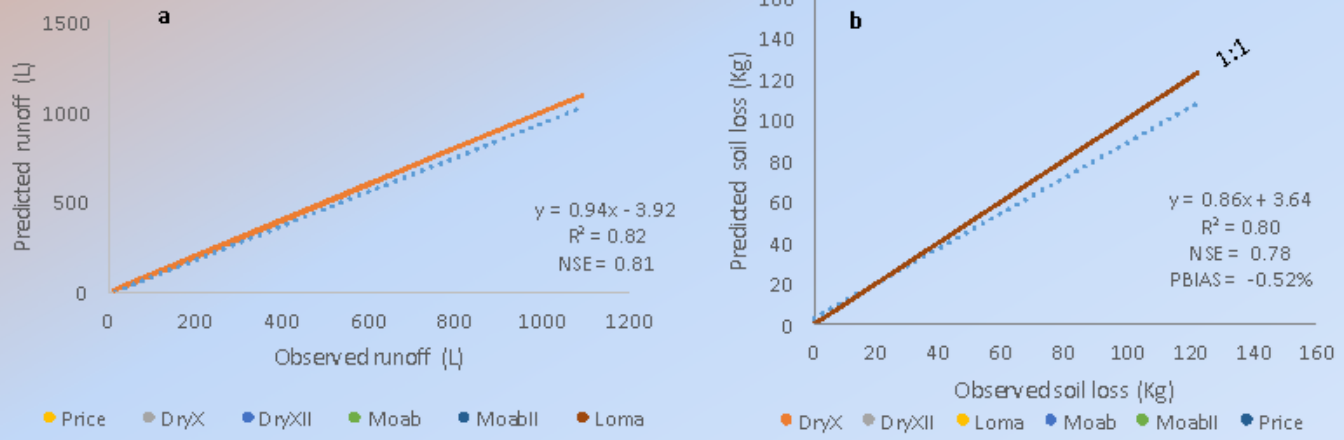
Ecohydrologic relationships already required for ESDs, but integration of hydrology and erosion is limited.

Integration of hydrologic functions, RHEM output, and ecohydrologic feedbacks into STMs improves utility of ESDs for assessing and managing rangeland ecosystems.

Problem Statement B: Key Accomplishments

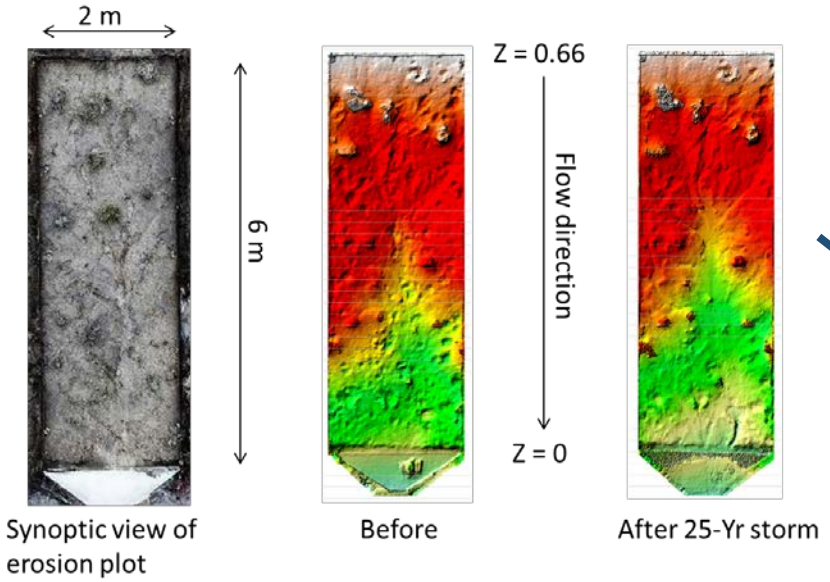
Soil Erosion Threats on the Sustainability of Rangelands

- Concentrated flow erosion processes have an enhanced ability to negatively impact soil health & sustainability due to off-site mobilization and transport.
- ARS scientists at Reno NV led a team to develop a new risk assessment tool (Rangeland Hydrology and Erosion Model) to assess potential soil loss due to concentrated flow erosion on saline and sodic soils.
- Tool allows land managers to assess site sustainability; when used with RHEM, allows managers to rapidly assess and prioritize areas needing conservation.



Runoff (a) and soil loss (b) predictions using the parameter-estimation equations developed for saline soils. Dots are colored based on the experimental site they represent in Utah and Colorado.

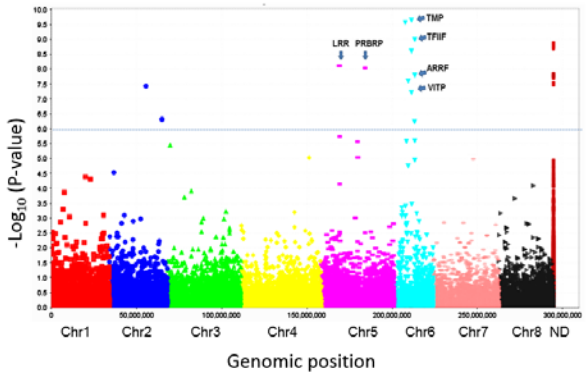
Problem Statement B: Additional Accomplishments



- Delaying germination can overcome bunchgrass seedling mortality (Burns OR)
- Unique perennial sorghum germplasm developed and hybrid released demonstrating increased forage production over a longer vegetative season (College Station TX)
- New scientific bibliography of salinity informs researchers on salt transport and informs federal policies around runoff and salt loading (Reno NV)
- Improved modeling of soil erosion processes on rangelands aid conservation management (Reno NV)

Problem Statement B: Additional Accomplishments

Molecular markers for Verticillium wilt (VW) resistance in alfalfa



Legends: Molecular markers for VW resistance in alfalfa were identified using genome-wide association mapping. spots above the dot line present markers significantly associated with VW resistance. Arrows indicate putative candidate genes linked to the resistance loci and play roles in the disease resistance.

- Identification of molecular markers for alfalfa Verticillium wilt resistance identified expedite development of resistant cultivars (Prosser WA)
- Holistic New Mexico grazing system increases soil carbon and nitrogen (Reno NV)
- Innovative approaches to remotely monitor land surface conditions enhance our ability to inform land managers (Las Cruces NM)
- Standardized techniques and new tools for rangeland monitoring provide information needed to improve land management on millions of acres of public and private land (Las Cruces NM)

Problem Statement C: Selected Highlights

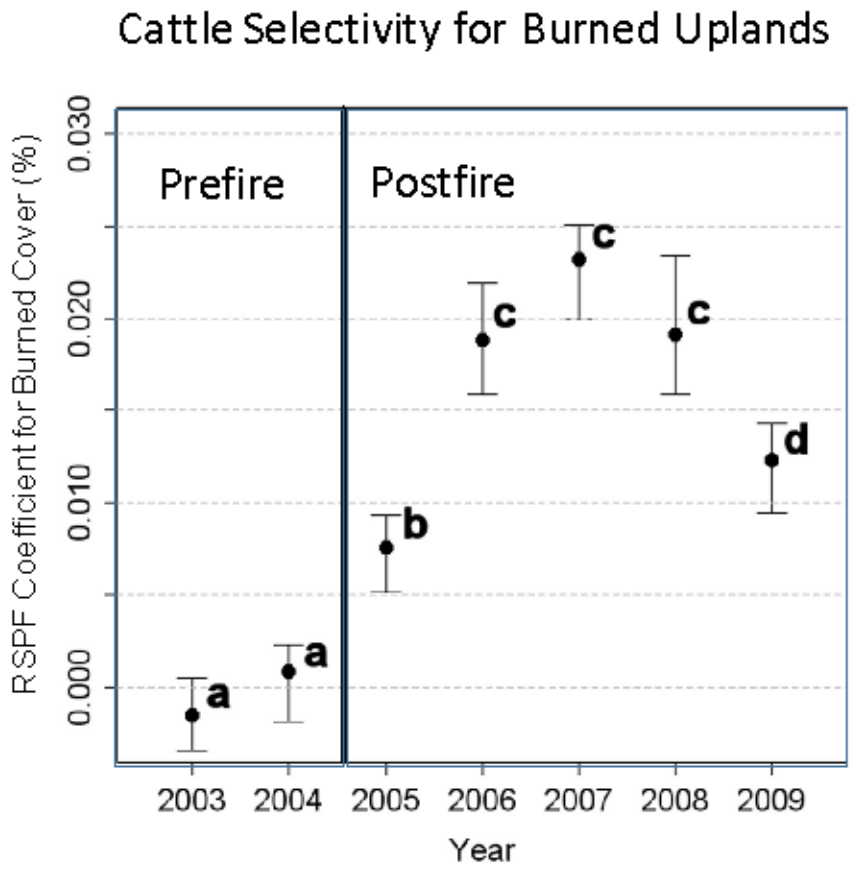
Greater fundamental understanding of ecological processes and interactions so that science-based management practices, technologies, and germplasm can be improved to meet production, conservation, and restoration objectives under changing climatic conditions

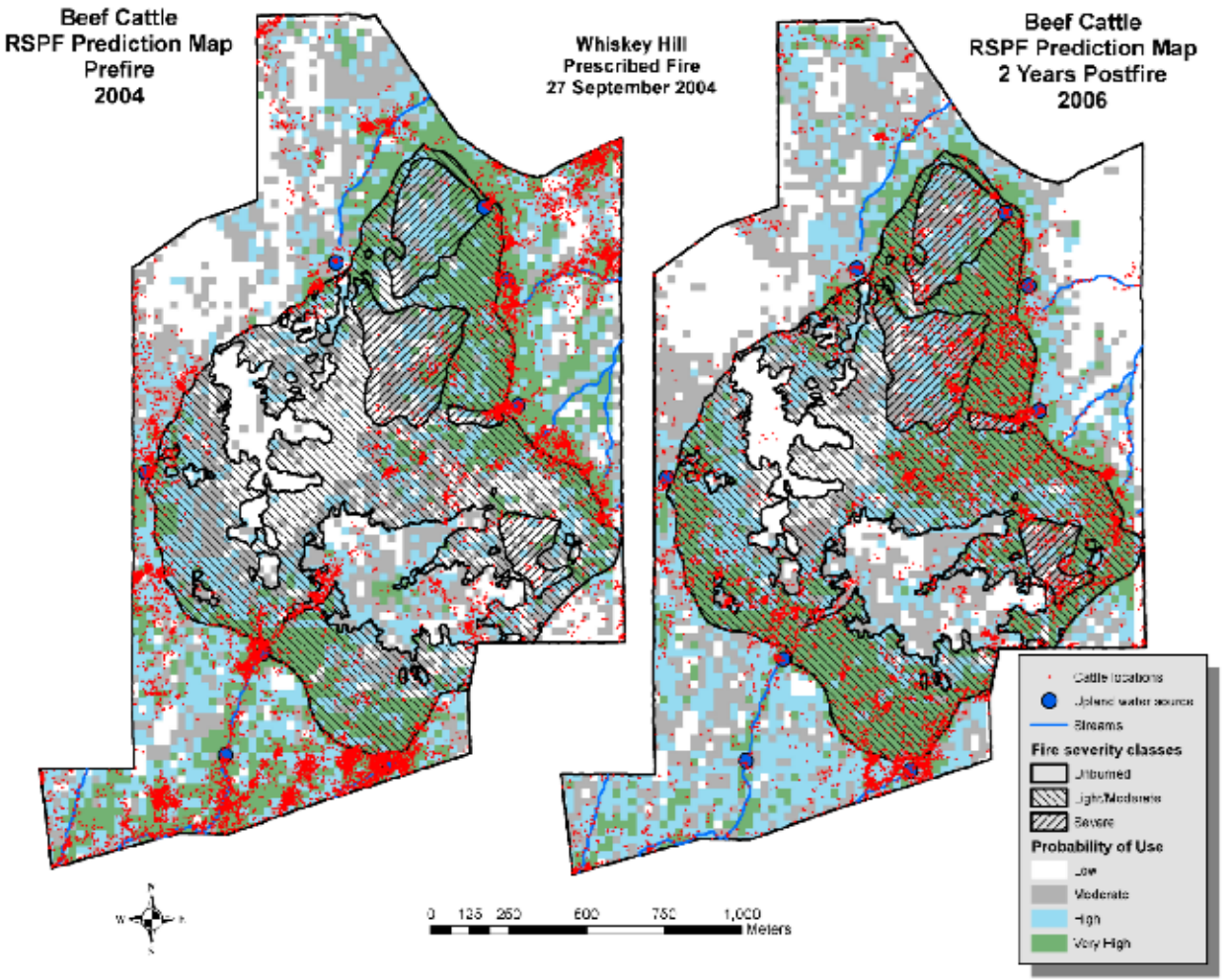
Warming favors Cheatgrass

- **Cause**: Expansion of phenological niche
- **Result**: 4-fold increase in biomass and seed set
- **Likely impact**: Greater cheatgrass dominance in the western Great Plains

Control Warmed eCO_2 Warmed*eCO_2

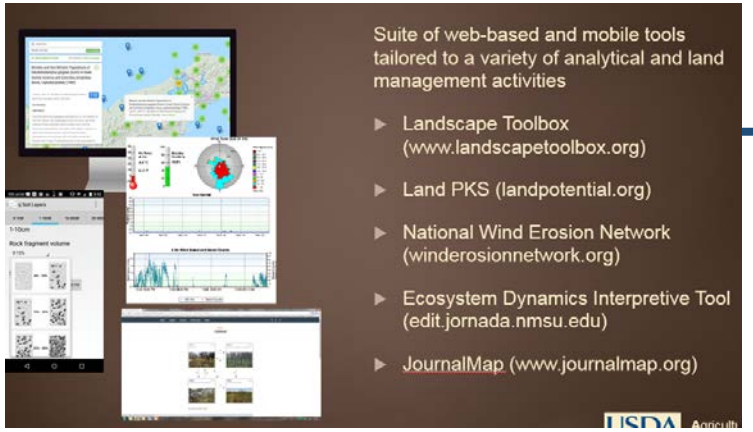
Managing cattle distribution, efficiencies, and impacts with prescribed fire

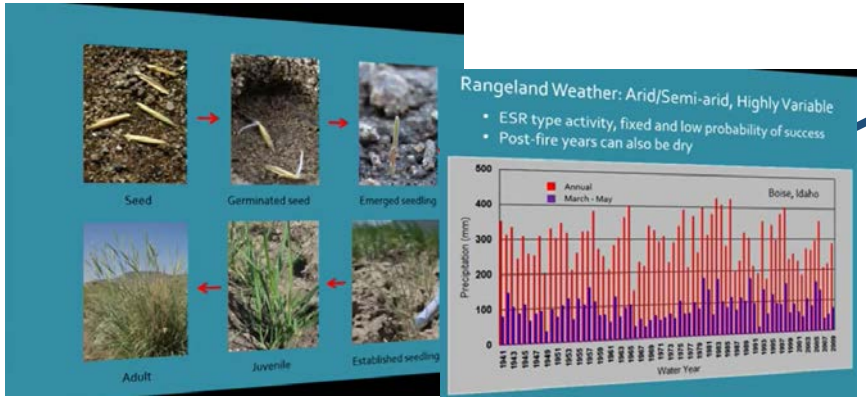




- Fall prescribed fire in sagebrush steppe increased cattle use of burned uplands and reduced riparian use.
- Effects on cattle distribution persisted for 5 years or more postfire.
- Cattle distribution responses were more clear-cut under a late-spring grazing regime than under mid-summer grazing.
- Cattle foraging efficiency increased in response to fire-induced increases in availability of high-quality foraging patches.

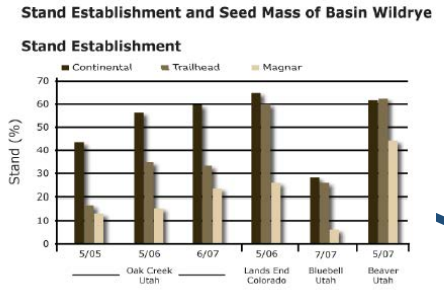
Problem Statement C: Additional Accomplishments





- Understanding the role of rapid evolution in the competitiveness of invasive mullein and implications for management (Fort Collins CO)
- Winter rangeland grazing management to reduce wildfire risk and severity (Burns OR)
- Climate-smart decision making tools translate scientific information into a land management resource for the Southwest (Las Cruces NM)
- Grazing management strategies that reduce fuel loads and prevent Western rangeland fires (Burns OR)
- Rangeland restoration efforts enhanced by incorporating climatology (Boise ID and Woodward OK)
- Sagebrush rehabilitation increases sage grouse habitat potential (Reno NV)

Problem Statement C: Additional Accomplishments



- Native range plant genetic diversity characterized, resulting in new plant materials (Logan UT)
- Improved native basin wildrye germinates rapidly for improved stand establishment (Logan UT)
- Centennial sand bluestem variety released for arid Southern Plains region for improved germination and emergence (Woodward OK)
- Arsenal meadow bromegrass released for improved grazing and drought tolerance (Logan UT)
- Charleston Peak slender wheatgrass germplasm with improved rangeland stand establishment (Logan UT)
- ForageCrest wheatgrass for enhanced rangeland productivity (Logan UT)
- Rapid selection of root system architecture will promote increased alfalfa yields (St Paul MN)

Component 1: Questions and Discussion

- Did the program accomplish what it set out to do in this component?

Component 2: Develop Improved Pasture Technologies and Management Systems

- **Problem Statement D:** Need for pasture-based livestock production systems that meet producer, environmental, and food security objectives and are adaptable to changing environmental and climatic conditions.
- **Problem Statement E:** Need for management strategies and practices that enhance and conserve pasture agro-ecosystems to provide multiple ecosystem services under changing environmental and climatic conditions.
- **Problem Statement F:** Need for science-based understanding of how soils, plants, animals, climate, and human activities interact to affect pasture ecosystem structure and function at multiple scales over time to improve the effectiveness of land management under changing environmental conditions.

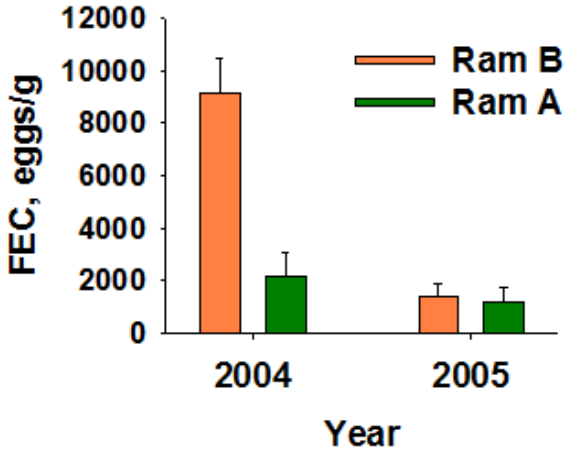
Presenter: Peter Kleinman / Kathy Soder, ARS
University Park PA

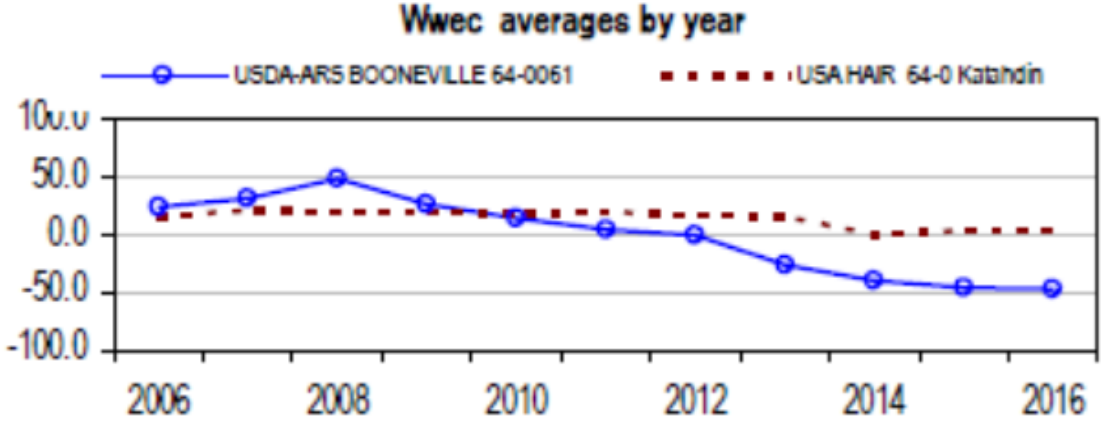
Problem Statement D: Selected Highlights

Pasture-based livestock production systems that meet producer, environmental, and food security objectives and are adaptable to changing environmental and climatic conditions

Improved breeding strategies for organic small ruminant production

- **Improved breeding strategies for organic small ruminant production**
  - **Greatest barrier to organic small ruminant production in the U.S. is reduced weight gains and death due to gastrointestinal parasites**
  - **ARS scientists at Booneville AR led a team to develop selection tools for control of gastrointestinal nematodes for organic production of small ruminants**
  - **Application of the tools through selection of replacement stock from parasite-resistant parents resulted in fewer animals requiring deworming and improved accuracies of Estimated Breeding Values for parasite resistance by the National Sheep Improvement Program**





Pasture Plant Diversity

Pasture Plants of the Northeastern United States

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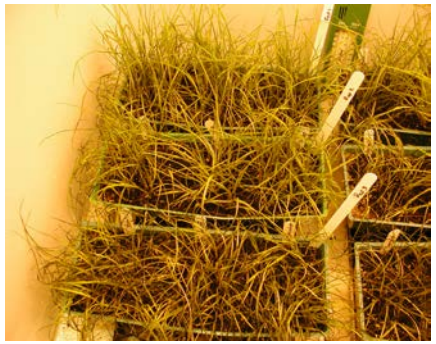
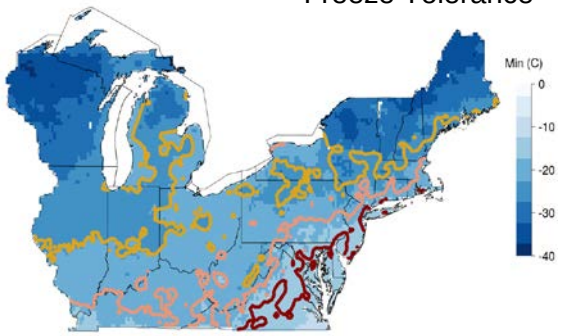
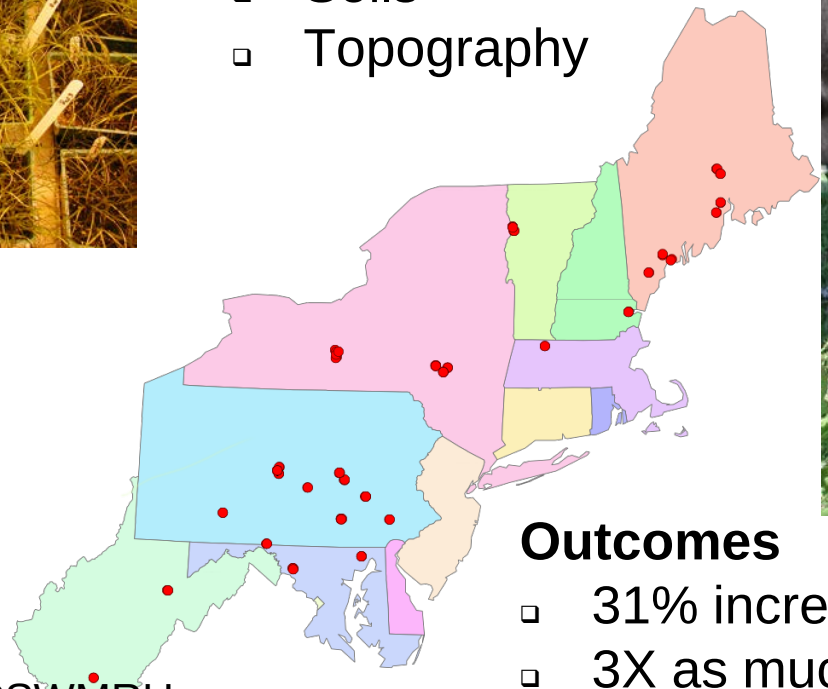
September 2014

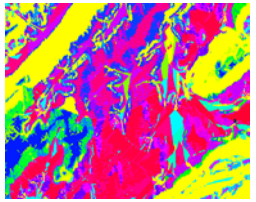


Data Sources

- Regional survey
- Small plots
- Greenhouse
- Remote sensing
- Climate
- Soils
- Topography







Products

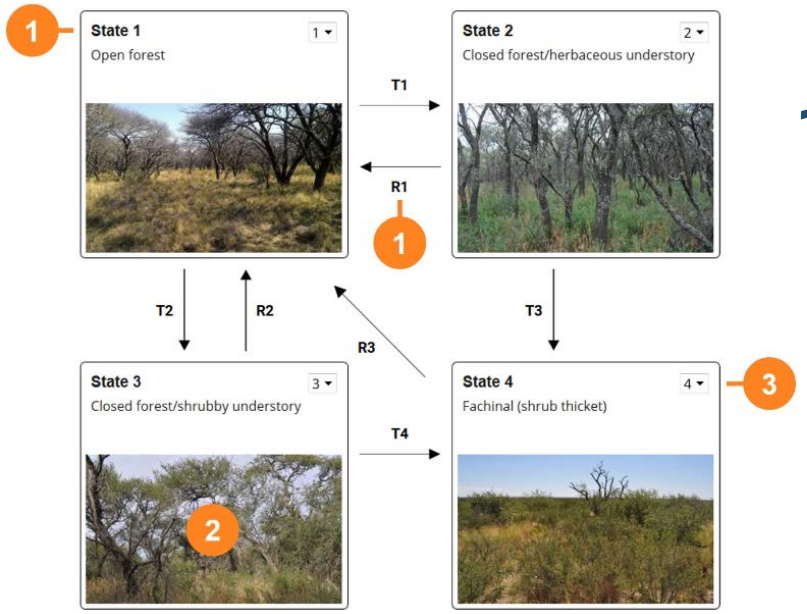
- Field guide
- Species distribution maps
- Community descriptions
- Forage Suitability Groups

Outcomes

- 31% increase in forage yield
- 3X as much soil carbon storage

Sarah Goslee, PSWMRU

Problem Statement D: Additional Accomplishments



- Historical data predict future climate-driven vegetation state changes (Las Cruces NM)
- Rapid estimation of pasture forage yield using a rising plate meter in diverse pastures (University Park PA)

Problem Statement E: Selected Highlights

Management strategies and practices that enhance and conserve pasture agro-ecosystems to provide multiple ecosystem services under changing environmental and climatic conditions

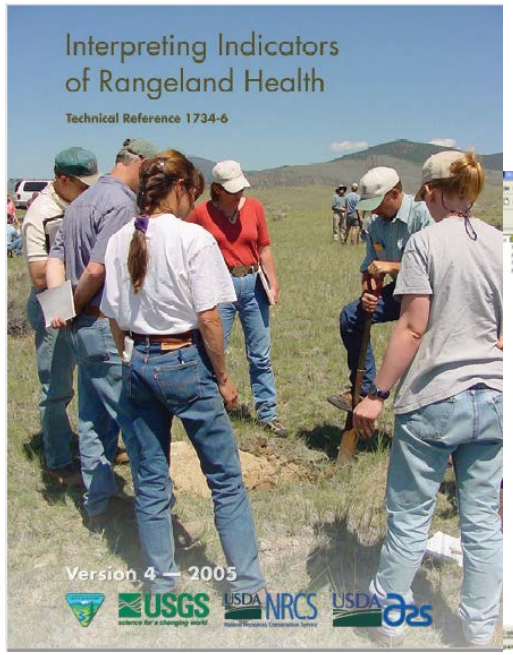
Rotational grazing with fenced riparian buffers and conversion of pastures to hayfields determined to be best management systems to decrease soil erosion from grassland

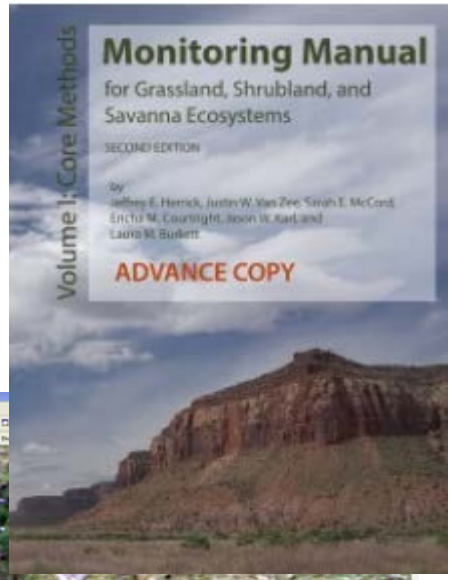
- Over grazing can increase soil erosion and sediment loading into aquatic systems.
- ARS scientists at Booneville and Fayetteville, AR conducted a 12-year study using 15 small watersheds to determine the effects of five management systems.
- Results showed rotational grazing in combination with fenced riparian buffers or converting pastures to hayfields were good options for reducing soil erosion and runoff to waterways.

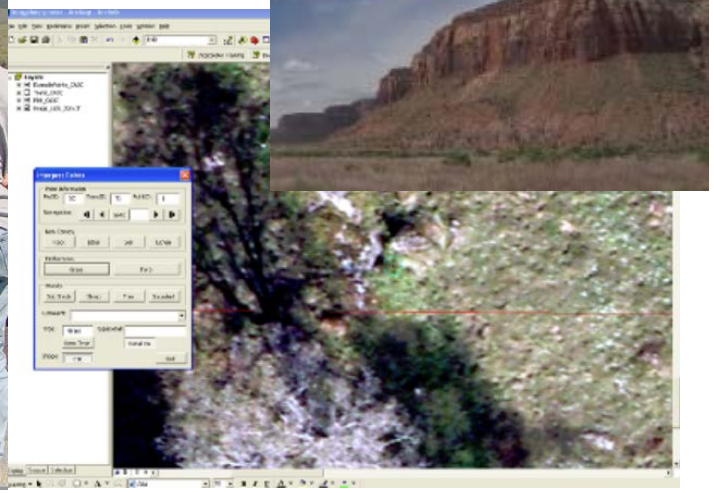
Multi-scale remote monitoring and standardized assessment result in new land management tools

Tools to improve public and private land assessment and management

- Collecting and Merging Data
- Standardizing Interpretation
- Facilitating Application







Problem Statement E: Additional Accomplishments

- CO_2 grassland emissions affected by weather, but not stocking rates (Mandan ND)
- Native Thurber's needlegrass increases rangeland productivity (Logan UT)
- Native forbs improve rangeland biodiversity and pollinator efficiency (Logan UT)
- Poultry litter application implement decreases nutrient losses and increases available nitrogen in perennial pastures (Woodward OK)

Problem Statement F: Selected Highlights

Science-based understanding of how soils, plants, animals, climate, and human activities interact to affect pasture ecosystem structure and function at multiple scales over time to improve the effectiveness of land management under changing environmental conditions

Chemical Seedhead Suppression of Tall Fescue can Enhance Beef Calf Weight Gains and Mitigate Fescue Toxicosis

Statement of Problem: Cattle selectively graze seedheads of endophyte-infected tall fescue as they emerge in the spring; unfortunately, the seedheads contain 2 to 4 times greater concentrations of toxic ergot alkaloids than leaf tissues. The higher ergot alkaloid loads in their vasculature systems exacerbates alkaloid-induced vasoconstriction that causes the animals to be vulnerable to severe heat stress with moderate air temperatures. Fescue toxicosis costs the U.S. beef industry an estimated 1 billion dollars per year.

Accomplishment: A series of grazing experiments determined that treatment of vegetative tall fescue with the active ingredient, metsulfuran, will suppress fescue seedheads to increase weight gain performance of steers and mitigate the effects of fescue toxicosis (Table 1). Although the number of cattle that seedhead suppressed pastures can support is reduced, we demonstrated that use of a rotational stocking system will boost pasture carrying capacity, as well as average daily weight gain and total body weight gain per hectare (Table 2).

Impact: It estimated that this research led to over 20,000 hectares of toxic tall fescue being treated in 2017 for suppression of seedheads.

Table 1. Average daily gain (ADG) and serum prolactin concentrations in steers grazing either seedhead suppressed or unsuppressed toxic endophyte-infected tall fescue. Statistical differences Were detected for both responses ($P < 0.05$)

Treatment	ADG	Prolactin*
	kg/steer/day	ng/mL
Suppressed	0.93	100
Unsuppressed	0.67	47

* Low prolactin is used as a marker for fescue toxicosis.

Table 2. Average stocking rate (ASR), average daily gain (ADG), and kg body weight gain per ha (BWG) between continuous and rotational stocking methods for grazing seedhead suppressed tall fescue. Differences were detected for all responses ($P < 0.05$).

Grazing method	ASR	ADG	BWG
	kg/ha	kg/steer/day	kg/ha
Continuous	874	0.89	278
Rotational	1099	1.04	393

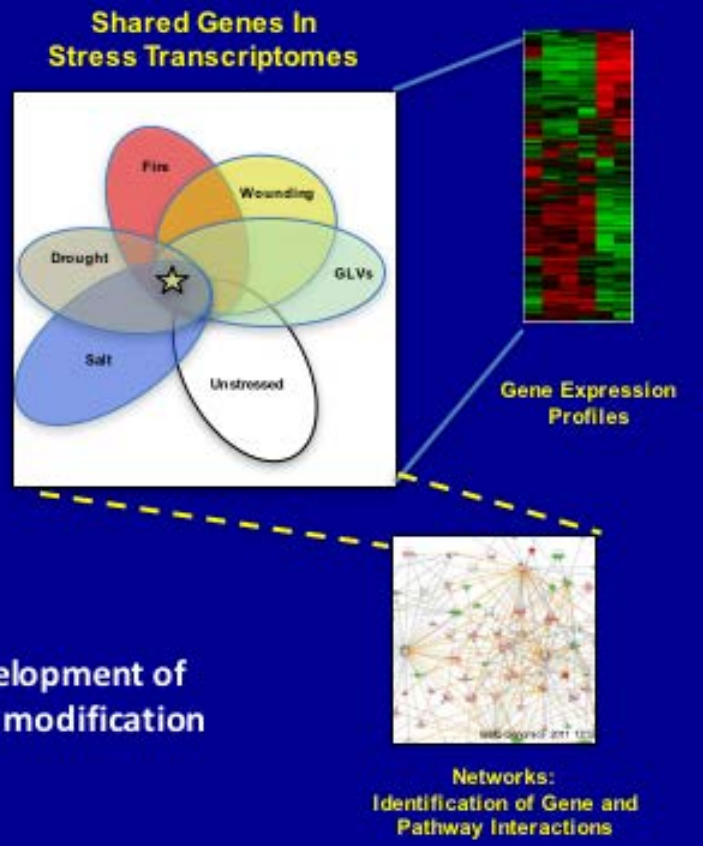
Lexington KY

Developed Molecular Resources for Grass Improvement

Grass plants in the field are subjected to multiple stresses at any given time, therefore identifying shared pathways or genes activated by different stresses will provide valuable molecular resources for improving crop performance under field conditions

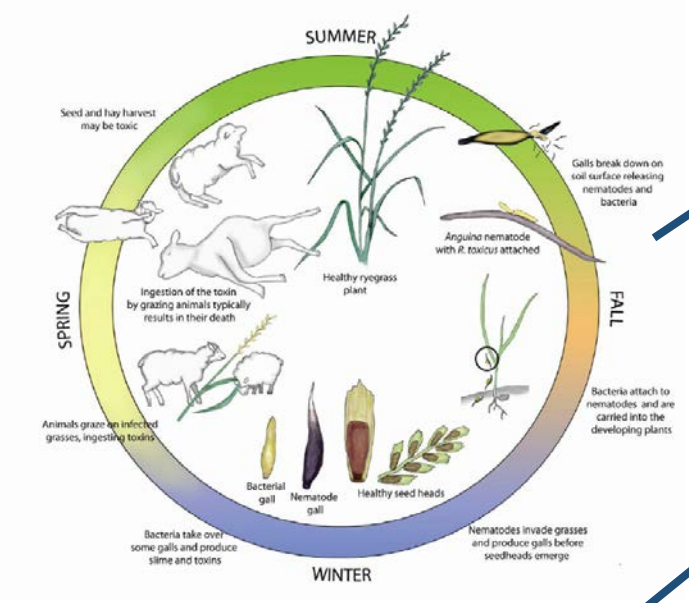
Goal: Understand Molecular Response of Grasses to Stress

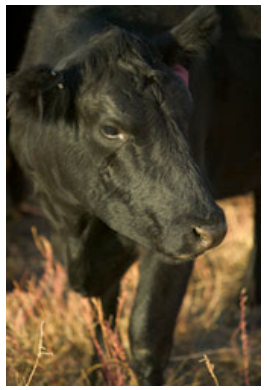
- Scientists at the USDA-ARS Corvallis OR created a *Lolium sp.* grass stress transcriptome to identify genes and pathways activated during stress.
- Identified shared components (★ key proteins, genes, signaling molecules and pathways) that are utilized by the plant to cope with various stresses (Fire, Wounding, Salinity GLV, Drought).

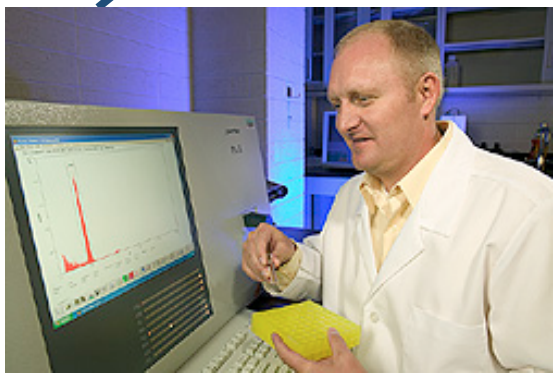


Impact: Shared stress components can be utilized for the development of genetic markers for germplasm selection or for direct modification of plants to improve tolerance to multiple stresses.

Problem Statement F: Additional Accomplishments

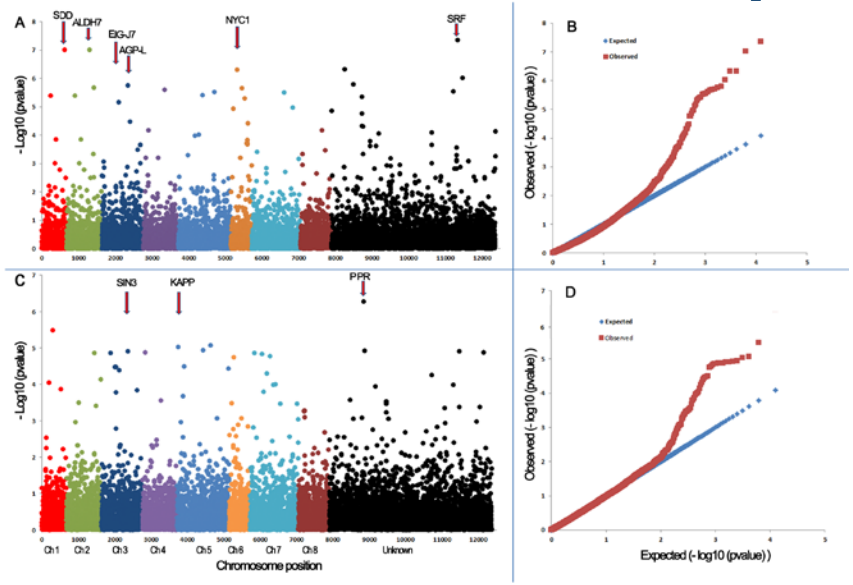






- New molecular diagnostic test for seed gall nematodes (Beltsville MD)
- New and effective diagnostic tool for root-knot nematodes (Beltsville MD)
- Improved germination and stand establishment in forage kochia (Logan UT)
- Improved genetic selection technology for complex grass genomes (El Reno OK)
- Enhancing the health and vigor of a native turfgrass (poverty oatgrass) (Beltsville MD)
- DNA-based paternity testing to speed rate of alfalfa improvement (Madison WI)

Problem Statement F: Additional Accomplishments



- Novel molecular tools for grass breeding (Logan UT)
- Discovery of novel plant endophytes for improved stress tolerance (Corvallis OR)
- Successful establishment of desirable forage species following cheatgrass control (Reno NV)
- Germplasm and molecular markers for alfalfa drought tolerance (Prosser WA)
- Hidden Valley meadow fescue improves management of humid temperate grazing systems (Madison WI)
- Antimicrobial metabolite from hops found to intervene against equine gut acidosis (Lexington KY)
- Naturally produced volatile compounds released by cut grass plants found to activate stress related signaling pathways in undamaged plants (Corvallis OR)

Component 2: Questions and Discussion

- Did the program accomplish what it set out to do in this component?

Component 3: Improve Harvested Forage Systems for Livestock, Bioenergy, and Bioproducts

- **Problem Statement G:** Need for improved plant materials for harvested forage and biomass production systems based on forage legumes and grasses that will increase the efficiency of livestock and bioenergy production systems while enhancing the environment.
- **Problem Statement H:** Need for improved harvested forage and biomass production systems that increase economic and energy efficiency while enhancing the environment to meet national energy and food security goals.

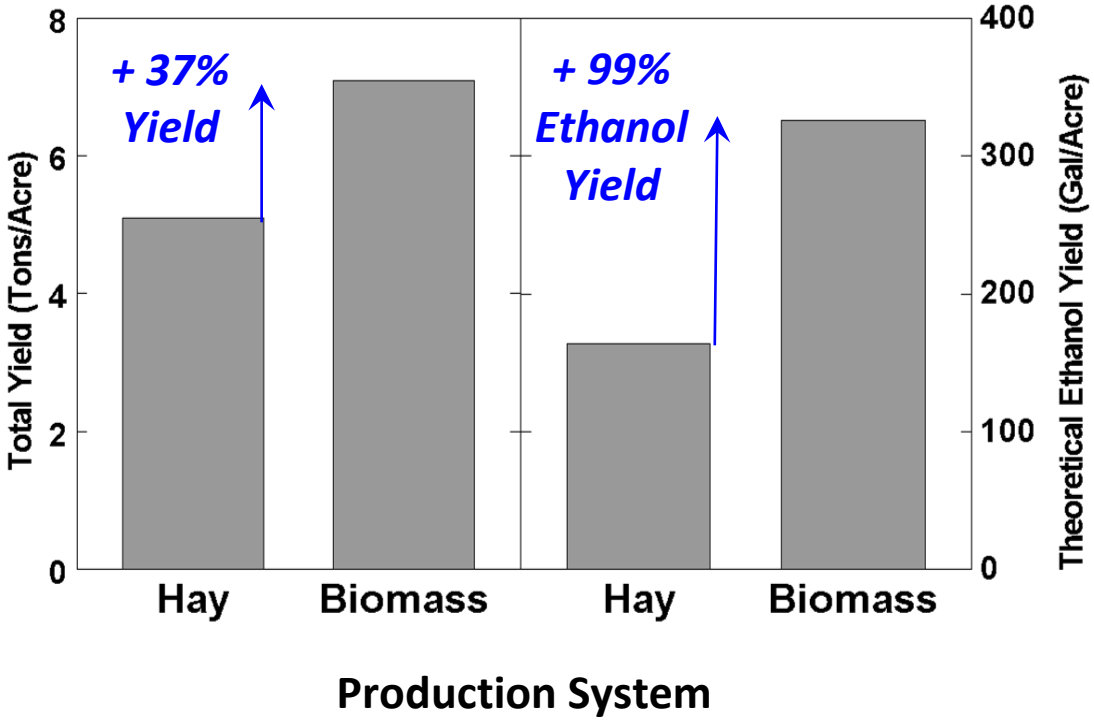
Presenter: Debby Samac, ARS St Paul MN

Problem Statement G: Selected Highlights

Improved plant materials for harvested forage and biomass production systems based on forage legumes and grasses that will increase the efficiency of livestock and bioenergy production systems while enhancing the environment

Biomass-Type Alfalfa & Biomass Management Doubles Ethanol Yield

- Novel biomass-type alfalfa harvested at late maturity to maximize stem and leaf yield
- Stems used for ethanol production
- Leaves used for high value protein products



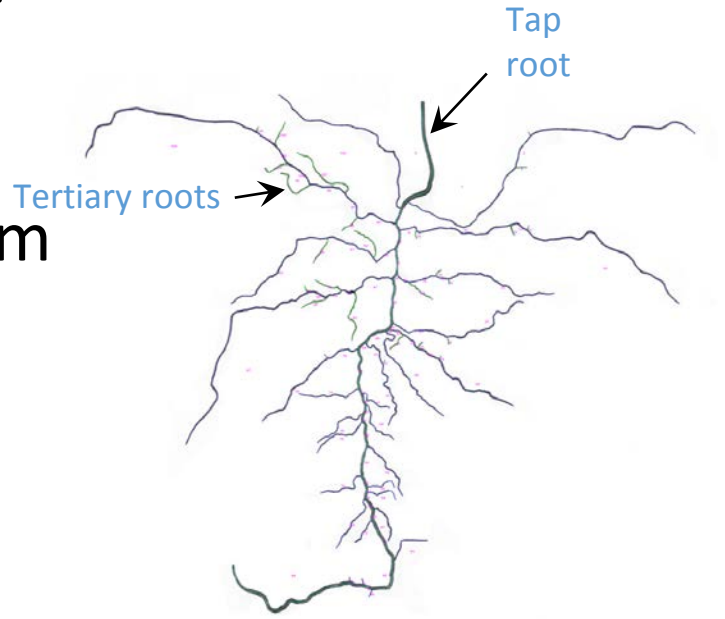
Biomass type alfalfa:

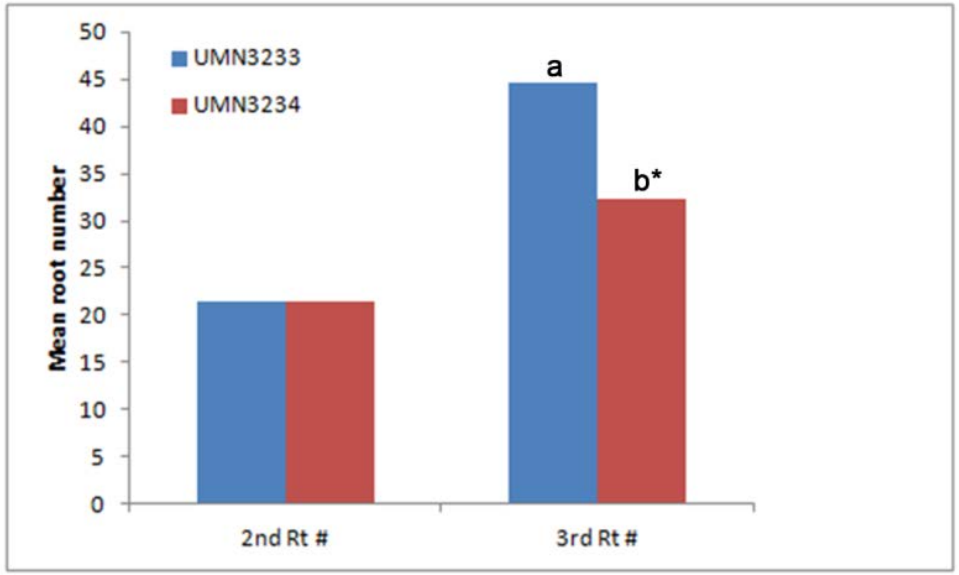
- **Large, lodging resistant stems**
- **Maintenance of leaf yield**
- **Winter hardiness**
- **Disease and pest resistance**

St. Paul, MN and Madison WI

Rapid selection of root system architecture to promote alfalfa yields

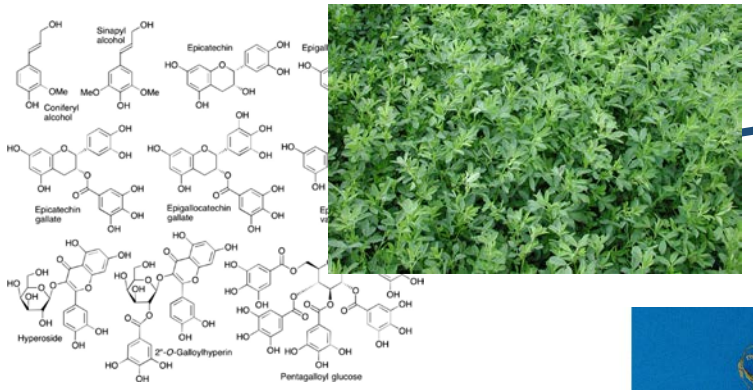
- Selection for root traits reduced from 22 weeks to 2 weeks
- Tertiary root number differentiates tap-rooted type (UMN3233) from branch-rooted type (UMN3234)
- Branch rooted types have greater forage yields and higher numbers of root nodules



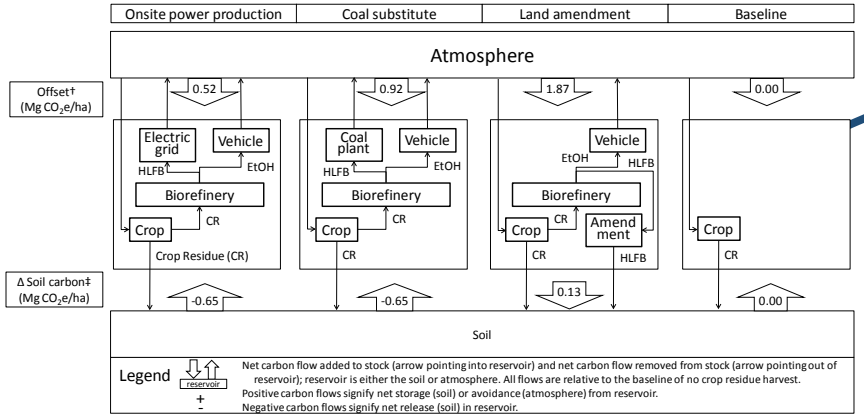


Plant Science Research Unit
St. Paul, MN

Problem Statement G: Additional Accomplishments



Early symptoms Late symptoms



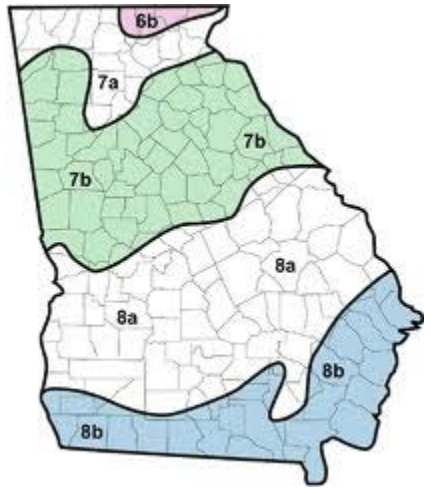
- Improving forage grass digestibility through cell wall modification (Madison WI)
- Improved bioenergy type cultivar with high biomass yield (Lincoln NE)
- Bacterial stem blight disease of alfalfa threats identified and an approach to identify resistance developed, leading to reduced forage production losses. (St Paul MN)
- New switchgrass hybrid for marginal climates and environments (Madison WI)
- Reducing the carbon footprint of cellulosic ethanol (University Park PA)
- Sowing multiple plant species increases forage yield while also increasing carbon sequestration and soil quality (University Park PA)

Problem Statement H: Selected Highlights

Improved harvested forage and biomass production systems that increase economic and energy efficiency while enhancing the environment to meet national energy and food security goals

Harvest timing affects napiergrass and energy cane biomass quantity and quality as well as soil nutrients

- It is essential to determine adaptability and harvest timing of high-biomass grasses in Georgia for subsequent use as a bioenergy feedstock.
- ARS scientists at Tifton, GA found that ethanol production from SSF of napiergrass was relatively unaffected by harvest date, but energy cane tended to produce less ethanol in later
- This information will be valuable for growers who will provide biomass feedstock to companies for conversion to bio-based products and fuels.



Determining that switchgrass is not invasive

Big bluestem encroachment into Cave-in-Rock and Trailblazer switchgrass harvested once per year in August or after frost following 10 years of management for bioenergy near Ithaca, NE.

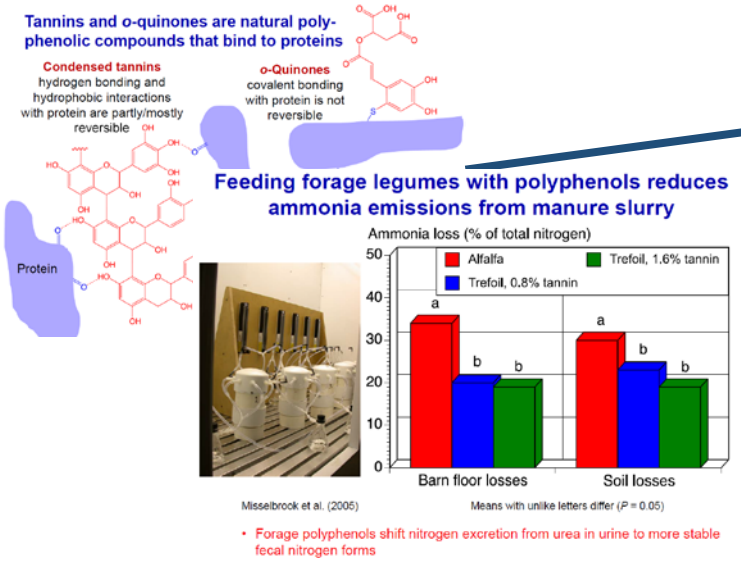
Switchgrass Cultivar	Harvest Date	Big bluestem density (No. of plants m^{-2})
Cave-in-Rock	August	0.25 ± 0.06 a*
	After frost	0.06 ± 0.02 b
Trailblazer	August	0.50 ± 0.10 c
	After frost	0.48 ± 0.10 c

After 10 years of biomass production:

- No evidence that switchgrass invaded adjacent fields or borders
- 0 N increased other grasses & caused switchgrass to decline
- Management is important to stand persistence
- 60 kg N ha^{-1} limited invasion by other grasses & maintained stands
- Harvesting after frost reduced invasions by other grasses
- Switchgrass appears to be more prone to being invaded than becoming invasive.

Mitchell & Vogel, 2015. Bioenergy Res. 9:50-56

Problem Statement H: Additional Accomplishments



- Rapid method for characterizing tannins to improve nitrogen use (Madison WI)
- New mineral seed treatment improves organic alfalfa production (St Paul MN)
- New research database for condensed tannins (Madison WI)
- Evaluation of organic fertilizer in the form of poultry litter for production of napiergrass for biomass (Tifton GA)
- New guidelines allow farmers better utilize nitrogen from alfalfa in rotation, resulting in reduced inputs and environmental benefits (St Paul MN)

Component 3: Questions and Discussion

- Did the program accomplish what it set out to do in this component?

Component 4: Turf Improvement

- **Problem Statement J:** Need for improved germplasm and management practices that are adapted to biotic and abiotic stresses, and meet the objectives of turf producers and users under changing climatic and environmental conditions.

Presenter: Karen Harris-Schultz, ARS Tifton GA

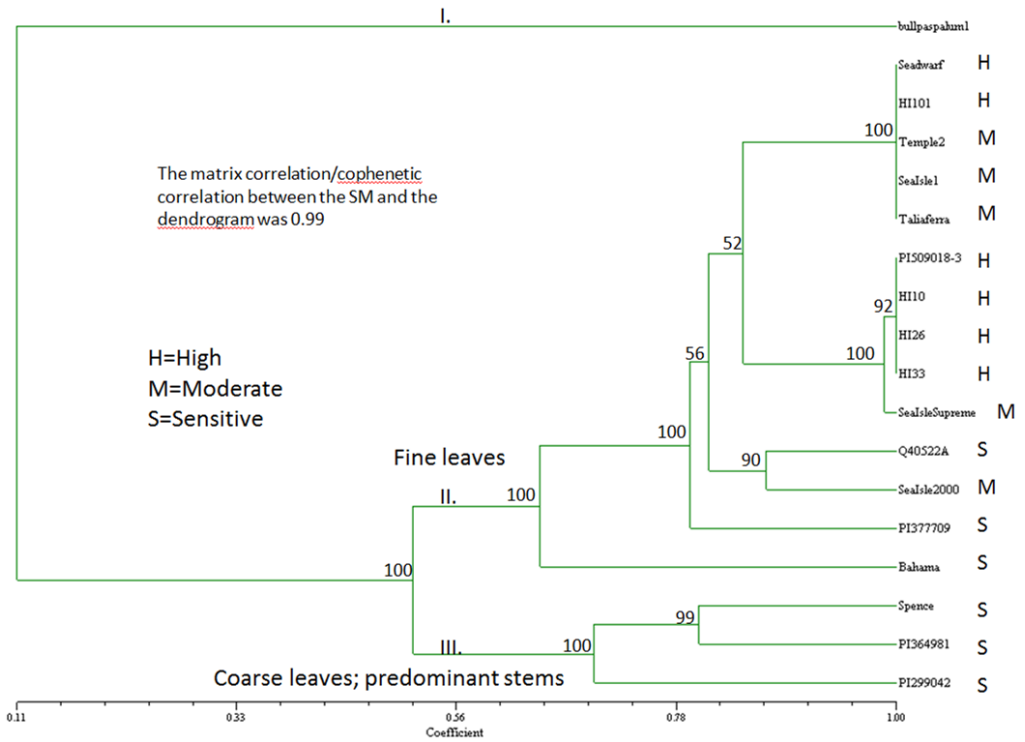
Problem Statement J: Selected Highlights

Improved germplasm and management practices that are adapted to biotic and abiotic stresses, and meet the objectives of turf producers and users under changing climatic and environmental conditions

Development and Characterization of Seashore Paspalum SSR markers

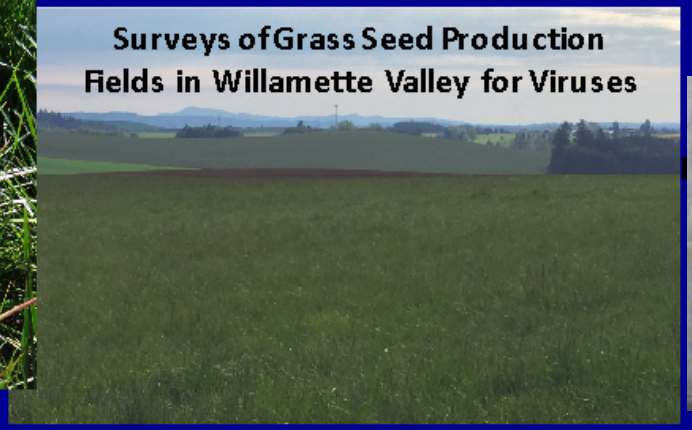
- Need for molecular tools to understand salt tolerance or other traits
- Salt tolerant line HI33 was sequenced using high throughput sequencing
- 35,460 SSR motifs identified; 1 characterized

- Selected accessions with different salt tolerance
- Grouping based on leaf type (fine vs coarse) and ploidy
  - Group II= 2x; Group III>2x



Discovery of New Emerging Viral Diseases in Grass Seed Production Fields

Roughly 40 % of the world's grass seed is grown in the Willamette Valley Oregon. The seed produced in this region is critical for forage, turf and grassland production throughout the US and worldwide.



- ARS researchers in Corvallis Oregon, discovered the presence of Barley Yellow Dwarf Virus, Cereal Yellow Dwarf Virus and Cocksfoot Mottle Virus in grass seed production fields throughout the Willamette Valley. These viruses were found in areas of field die off, which may contribute to lower seed yields and increase the frequency that fields need to be replanted.
- Mitigation strategies were developed to lessen disease impact.
- Field trials were initiated to determine virus susceptibility of different grass species and varieties and the effect of these viruses on stand persistence.

Problem Statement J: Additional Accomplishments

- Educating the public on importance and benefits of turfgrass (National Arboretum)
- Golf course putting greens that require fewer inputs (National Arboretum)
- TifGrand, a bermudagrass developed with collaborators from the University of Georgia, is shade tolerant and extremely wear resistant (Tifton GA)

Component 4: Questions and Discussion

- Did the program accomplish what it set out to do in this component?

Conclusion

- Did NP215 program accomplish what it set out to do, from an overall perspective?