BEFORE THE OFFICE OF ADMINISTRATIVE HEARINGS

STATE OF KANSAS

IN THE MATTER OF

THE APPLICATION OF THE CITIES OF HAYS, KANSAS AND RUSSELL, KANSAS FOR APPROVAL TO TRANSFER WATER FROM EDWARDS COUNTY, KANSAS PURSUANT TO THE KANSAS WATER TRANSFER ACT.	)	**OAH NO. 23AG0003 AG**

Pursuant to K.S.A. Chapter 77.

DIRECT TESTIMONY OF KEITH HARMONEY, Ph.D.

ON BEHALF OF

THE CITIES OF HAYS AND RUSSELL, KANSAS

RELATING TO

EXPERT REPORT TITLED:

RETURNING GRASSLANDS TO THE R9 RANCH

Q. Please state your name and present position.

A. My name is Keith Harmoney, and I am currently a Range Scientist for Kansas State University.

Q. On whose behalf are you submitting testimony?

A. The City of Hays, Kansas and the City of Russell, Kansas (the "Cities").

Q. Please describe your educational background and employment experience.

A. I received a B.S. degree in Agronomy from the University of Nebraska-Lincoln in 1993 and a Ph.D. in Agronomy with a major in crop production and physiology from Iowa State University in 1999. After working as an Assistant Field Agronomist with Central States Agronomics in 1991–1992, I spent a year with the University of Nebraska as a Field and Laboratory Technician before working as a Research Assistant at Iowa State University from 1994–1999. I was hired by Kansas State University as an Assistant Professor in Range Science at KSU's Agricultural Research Center in Hays, Kansas and worked in that role from 1999–2005. From 2005–2012, I served as Associate Professor for KSU at the Research Center and was promoted to Full Professor in 2012, in which I have remained through to the present time. In all, I have been employed at KSU's Agricultural Research Center for about 24 years, performing research on the suitability of different forages for grazing or hay in the western Kansas environment, the effects of grazing systems on animal performance, native rangeland soil cover and plant population dynamics, and the characteristics of some invading rangeland plant species and how to control them. I have also contracted with the City of Hays for the past three growing seasons to assess the success of grassland reestablishment efforts on the R9 Ranch, and to give some consulting and management advice on those reestablishment efforts, animal stocking, and weed suppression.

Q. Has this direct testimony been prepared by you or under your direct supervision?

A. Yes, it has.

Q. Have you previously testified before the Kansas Department of Agriculture–Division of Water Resources or any other regulatory commission?

A. No, I have not.

Have you testified in any litigation in the prior four years?

A. No, I have not.

Q. Are you sponsoring any exhibits with your direct testimony?

A. Yes. I Sponsor Exhibit KRH-01, which is my expert report titled "Returning Grasslands to the R9 Ranch," which is incorporated into my testimony as if set forth in full herein.

Q. What is the purpose of your direct testimony?

A. My opinions are set forth in detail in my expert report, but in general, my testimony relates to the environmental, habitat, and erosion impacts of converting the R9 Ranch circle land units from a tilled and cropped monoculture back to a mixture of managed native grasses.

Q. In summary, what did you conclude?

A. The majority of the circle land units on the R9 Ranch have become, and the others will become, much more similar to the diverse native grassland ecosystem that once covered these lands. After conversion back to native grasses, these circle land units should: (1) function similarly to the grassland dominated ecological sites that once covered the landscape; (2) have reduced erosion, in terms of water and especially wind erosion, than prior tilled croplands; (3) provide a year-round vegetative ground cover with less water loss and water consumption than prior harvested field crops; and (4) provide critical habitat to native grassland birds and other wildlife.

Q. Please describe how you arrived at your conclusions.

A. As explained in more detail in my report, by converting the R9 Ranch to native grassland, it will function similarly to the historical ecological sites that covered the landscape prior to its use as farmland. The warm-season grasses that existed on the Ranch prior to its conversion to tilled cropland, require only enough precipitation to form leaf material during the growing season to produce sugars for storage and survival, rather than a need for precipitation to produce a seed crop for propagation. At this time, all 42 circle land units have been seeded back to a predominantly native grass mixture, with successful establishment on a majority of the circles. Stopping tillage and returning the land units back to grassland should stop the loss or degradation of soil quality, which will improve nutrient availability and cycling, water infiltration, retention and holding capacity, resistance to erosion, and plant root growth and penetration.

The seeded native grasses are C4 photosynthetic pathway plants, which, unlike the prior irrigated crops on the R9 Ranch, have greater water use efficiency to survive hot and dry periods and can form leaf tissue for photosynthesis and production of sugars to sustain meristems and perennial buds each year based on precipitation alone.

Conversion of the R9 Ranch back to perennial native grassland as opposed to short-lived crops, will also reduce water and wind erosion due to the aboveground vegetative structure and increase in continuous ground cover with fewer canopy gaps, which slow winds near the land surface. It will also improve water and air quality as a result of a reduction in air particles and chemical particles with a significant decrease in herbicide and pesticide use compared to croplands. This conversion, in turn, will also improve wildlife habitat on the R9 Ranch, particularly for grassland birds.

Q. Does that concludes your testimony?

A. Yes, it does.

VERIFICATION

STATE OF Kansas)
)
COUNTY OF Ellis)

I, Keith Harmoney, Ph.D., being duly sworn, on oath state that I have read the foregoing and know the contents thereof, and that the facts set forth therein are true and correct to the best of my knowledge and belief.

By: [signature]
Keith Harmoney, Ph.D.

The foregoing was subscribed and sworn to before me this 22 day of May, 2023.

NOTARY PUBLIC - State of Kansas
SHELLI L. DOWD
My Appt. Exp. 4-12-24

Shelli L. Dowd
Notary Public

My Commission Expires:

4-12-24

RETURNING GRASSLANDS TO THE R9 RANCH

I. Introduction and qualifications

My name is Keith Harmoney, and I am currently a Range Scientist for Kansas St. University, with a home office at the KSU Agricultural Research Center in Hays, KS.

I have been employed by KSU for nearly 23 years in the same rangeland research position I currently hold. My CV is attached as an Appendix to this statement. I started my position at KSU directly following completion of my BS degree at the University of Nebraska-Lincoln and my PhD degree at Iowa State University. I have spent nearly 23 years at KSU performing research on the suitability of different forages for grazing or hay to the western Kansas environment, the effects of grazing systems on animal performance and native rangeland soil cover and plant population dynamics, and the characteristics of some invading rangeland plant species and how to control them. I've performed studies on seeded or planted forages, such as alfalfa and other non-native forage species, and the use of some forages as an alternative bulk fuel for bioenergy production. In conjunction with the various studies mentioned above, I manage approximately 5000 acres of rangeland and pastureland used in production and research trials for KSU.

I have also contracted with the City of Hays for the past three growing seasons to assess the success of grassland reestablishment efforts on the R9 Ranch, and to give some consulting and management advice on those reestablishment efforts, animal stocking, and weed suppression. Attached as Appendix A to this Report is a PowerPoint presentation of the assessment methodology and status of the City's program for converting the R9 Ranch back to perennial grasslands, as well as illustrations and photographs of the assessment. For the time spent collecting data or consulting in regard to the R9 Ranch, I am compensated at a rate of $26/hour. I have not had any occasion to provide testimony at a trial or through deposition within the past four years.

II. Summary of Opinions

I have been asked to give my opinion as an expert in rangeland science and native grasses on the impacts of converting the R9 Ranch circle land units from a tilled and cropped monoculture back to a mixture of managed native grasses. All of my opinions on these matters are presented within a reasonable degree of scientific and professional certainty.

The majority of the circle land units on the R9 Ranch have become, and the others will become, much more similar to the diverse native grassland ecosystem that once covered these lands. After conversion back to native grasses, these circle land units should:

1) function more similarly to the grassland dominated ecological sites that once covered the landscape,

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2) have reduced erosion, in terms of water and especially wind erosion, than prior tilled croplands,

3) provide a year-round vegetative ground cover with less water loss and consumption than prior harvested field crops, and

4) provide critical habitat to native grassland birds and other wildlife.

III. Detailed discussion of the bases and reasons for opinions and supporting facts

A. Following conversion of the R9 Ranch back to native grasses, the circle land units will function similarly to the historical native grassland and improve soil quality.

The R9 Ranch at one time had 43 land units with partial or complete circle pivot irrigation systems. Of these units, 42 have a more recent history of being in some form of crop production. Beginning around 2007, a small number of cropped circle land units were removed from crop production in certain years, the pivot structures were removed, and the land units were seeded back to a mixture of predominantly native grasses and alfalfa, a non-native legume.

Historically, the land area occupied by the R9 Ranch was a diversified and resilient native grassland dominated ecosystem, with minor native forb and native shrub components also occurring throughout the landscape. The ecological sites, or combinations of the sandy soils, vegetation, and hydrology, found on the R9 Ranch formed this grassland ecosystem.

The major vegetative components of these ecological sites and grassland ecosystem consisted of mostly perennial warm-season (C4 photosynthetic pathway) grasses that are able to grow and remain productive with greater water use efficiencies during periods of elevated summer heat and/or reduced moisture compared to cool-season (C3 photosynthetic pathway) grasses (Abraha et. al. 2016, Brown 1978, Hendrickson et. al. 2013, Rogers et. al. 2015). Specifically, these native warm-season grasses would include tallgrasses such as sand bluestem (*Andropogon hallii*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), prairie sandreed (*Calamovilfa longifolia*), and midgrasses such as little bluestem (*Schizachirium scoparium*), sideoats grama (*Bouteloua curtipendula*), and sand lovegrass (*Eragrostis trichodes*). Other warm-season grasses, such as tall dropseed (*Sporobolus asper*), sand dropseed (*Sporobolus cryptandrus*), purple lovegrass (*Eragrostis spectabilis*), Scribner's panicum (*Panicum scribnerianum*), sand paspalum (*Paspalum setaceum*), blue grama (*Bouteloua gracilis*), and hairy grama (*Bouteloua hirsuta*) also contributed to the historical plant population, but usually in lesser amounts. Detailed but brief descriptions of these grasses are available online (Fick 2022).

Together, these grasses would produce approximately 80-90% of the total yield annually grown in this grassland dominated ecosystem, and would have persisted and been productive with only natural precipitation, which averages 23-25 inches per year at the R9 ranch. These grasses grow every year from buds at the base of the plant (known as the crown), or from buds along underground lateral stems called rhizomes, rather than from seeds. Sugars stored in the grass crowns, roots, and rhizomes allow the buds to start growth each year to produce leaves. Once 2-3 leaves have been produced on a grass tiller and enough leaf area for photosynthesis remains in place, sugars from photosynthesis are then used to produce more leaf material and sugars are also translocated back into those storage areas. New growth can begin again from buds and meristems using these sugars if the grass leaf area is removed by grazing or fire during the growing season, or the sugars are used for buds to survive winter and regrow to start the next growing season (Waller et al. 1985). Although these native grasses may eventually produce seed in a growing season, most all growth each season originates from these perennial buds in a well established grass stand. Therefore, these grasses require only enough precipitation to form leaf material during the growing season to produce sugars for storage and survival, rather than a need for precipitation to produce a seed crop for propagation. When one species of grass encountered conditions that may have resulted in stress and less growth, another grass species may experience better growing conditions under the same circumstances and would be able to provide increased growth. The robust diversity of grasses in this ecosystem, the periodic occurrences of fire across the landscape that prevented tree and brush encroachment, and the tolerance of grasses to grazing maintained grass as the dominant form of vegetation.

The ecological sites of Sand Plains and Choppy Sands comprise the overwhelming majority of the R9 Ranch grassland ecosystem, and these sites are included in the USDA Major Land Resource Area 079X, called the Great Bend Sand Plains. The Natural Resources Conservation Service developed descriptions of these ecological sites, of which detailed descriptions of Sand Plains and Choppy Sand sites and the reference plant community prior to European settlement are available online (https://edit.jornada.nmsu.edu/catalogs/esd/079X/R079XY121KS, https://edit.jornada.nmsu.edu/catalogs/esd/079X/R079XY103KS).

All 42 circle land units have been seeded back to a predominantly native grass mixture. When the circle land units were tilled to create monoculture crop fields, the original function of the ecosystem was broken. Breaking of virgin sandy soils with tillage induces a rapid loss of organic matter, soil carbon, soil nitrogen, and soil cover, and overall negatively impacts soil structure (Bowman et al. 1990, Reeder et al. 1998). Loss of soil structure usually makes it more difficult for perennial grass or crop roots to penetrate through the soil (Dupont et al. 2014). More losses of these important soil quality traits occur over time as tillage systems continue to be used on the soil (Bowman et al. 1990, Brye and Pirani 2005). Stopping tillage and returning the land units back to grassland should stop the loss or degradation of the aforementioned soil quality parameters. These soil quality parameters are important for improving nutrient availability and cycling, for water infiltration, retention and holding capacity, for resistance to erosion, and for plant root growth and penetration (Karlen et al. 1997).

The seeded native grasses included the common warm-season grasses that were once dominant and subdominant species in the natural landscape, namely sand bluestem or big bluestem, indiangrass, switchgrass, sand lovegrass, little bluestem, sideoats grama, and blue grama. Alfalfa (*Medicago sativa*) was also added in the mixture, likely to provide a supply of natural nitrogen to the soil. However, alfalfa (a C3 photosynthetic pathway forb) is not a native plant that developed within this environment, and it has a greater requirement for water than the native grass species (C4 photosynthetic pathway grasses) seeded to survive and persist in this environment.

The photosynthetic mechanism of most C3 plants, such as alfalfa, uses an enzyme called Rubisco to first capture carbon dioxide (CO2) that enters into the leaf through stomata (tiny holes operated like valves in the leaf surface) from the atmosphere. This Rubisco enzyme also has a tendency to capture oxygen (O2) from the atmosphere when CO2 concentrations are low. During hot and dry conditions of the summer growing season, most plants (including alfalfa) close their stomata to conserve water. When these stomata are closed, CO2 cannot enter into the leaf and concentrations of CO2 go down within the leaf. This causes the Rubisco within C3 plants to capture more O2 than when stomata are open, and reduces the efficiency of photosynthesis. In order for C3 plants to keep photosynthesizing efficiently during these hot, dry periods, they need to use water to keep the stomata open and allow CO2 to keep entering the leaf.

In contrast, the native C4 grasses utilize a photosynthetic mechanism that first captures CO2 within the leaf with an enzyme called PEP Carboxylase, which only binds to CO2. Even when hot and dry conditions occur and native C4 grasses close their stomata to conserve water, photosynthesis continues more efficiently because PEP Carboxylase continues to only capture CO2, even with lower CO2 concentrations within the leaf. Therefore, in this periodically hot and dry environment, alfalfa either closes its stomata to conserve water and becomes less efficient than native C4 grasses at photosynthesis and capturing CO2, or it uses more available water resources than the C4 grasses to keep its stomata open. In both instances, native C4 grasses have a competitive edge in that they have greater water use efficiency than alfalfa to survive hot and dry periods. A basic summary of these photosynthetic pathway traits for C3 plants mentioned in the prior paragraph and of C4 plants mentioned in this paragraph is found in the text of Salisbury and Ross (1992). Without additional water through irrigation, alfalfa did not establish well or persist well on the circle land units when recently reseeded. Alfalfa was found on only 4 of the 42 recently seeded circle land units, and was found in only trace amounts on 3 of those 4 units.

Corn (*Zea mays*) was grown on some of the circle units prior to being seeded back to native grasses. Current corn hybrids are genetic derivatives of the corn plants grown in Mexico for centuries. Corn also has a C4 photosynthetic pathway, has a water use efficiency similar to native grasses in regions with greater rainfall, and in some instances has even been shown to have a slightly greater water use efficiency than some native grasses because of its ability to produce abundant amounts of dry matter if water and nutrient resources are available (Abraha et al. 2016, Hamilton et al. 2015). However, corn is typically grown for grain, and the plant needs to use water to produce the plant structural framework required prior to any grain being produced. Water used for biomass production prior to grain production is called threshold evapotranspiration, or threshold ET. In Kansas, corn commonly uses about 11 inches of water during the growing season just to reach its threshold ET in order to initiate any grain production (Rogers et al. 2015). Dryland corn is usually lower yielding than irrigated corn because it has to use a portion of its limited amount of moisture to reach its threshold ET and produce the vegetative framework for later grain production. For corn to reach its grain production potential, more water is required beyond what usually falls naturally as precipitation on dryland acres, while irrigation is able to supply this additional water. This is evident by looking at the wide gap between annual average corn yields for dryland and irrigated acres in Kansas (Rogers and Aguilar 2017). The 2017 Census of Agriculture also showed that corn acres in Kansas in which the whole field was irrigated yielded an average of 197 bushels/acre, while corn acres in Kansas in which the whole field was dryland yielded an average of 112 bushels/acre (USDA 2017). Typically in western Kansas, corn requires 10-20 inches of irrigation to reach its potential yield (Rogers and Aguilar 2017, Rogers et al. 2015). In contrast to corn, natural precipitation is sufficient for native C4 grasses to form leaf tissue for photosynthesis and production of sugars to sustain meristems and perennial buds each year. Even if precipitation is able to fulfill the requirements for potential high corn grain production within a growing season, land converted to perennial grassland cover from grain production would still provide valuable environmental and societal benefits, which are discussed later in this text.

The sandy soils of the R9 Ranch with low water holding capacity make establishing any desirable new crop or grass seedlings a challenge, and it is even more difficult in a temperate, dry-mesic climate zone with the removal of irrigation water to aid the establishment of new seedlings. Grass reestablishment on the R9 Ranch land units has used only natural precipitation and success has varied, as would be expected when relying on variable environmental precipitation conditions.

As shown in Appendix A, after the first full round of overseeding, 21 of the 42 circle land units had good to excellent grass seedling establishment, with 0.75-1.75 seedlings or mature grass plants/ft^2 having established at the time of assessment. Acceptable seedling or plant densities of 0.63-0.75 plants/ft^2 were counted on 4 of the circle land units, and should establish acceptable mature grass stands over a short span of years by allowing established plants to increase in plant size and to provide some further natural seeding and vegetative propagation.

Of the 17 circle units remaining, the 4 circles with the poorest establishment were successfully overseeded in 2021, with acceptable initial establishment of 0.63-2.26 seedlings/ft^2 on the 4 circles. In 2022, 2 of these 4 circles continued with excellent establishment while the summer drought caused 2 of the 4 circles to slip into marginal establishment. Another 4 circle land units with low initial grass establishment were recommended for overseeding in 2022 and were assessed for seedling establishment at the end of the growing season. These 4 circles remained in poor to marginal establishment after the dry growing season of 2022. Nine circles with marginal stands between 0.22 and 0.55 grass seedlings/ft^2 are still being assessed annually for any increases in grass density, and may be recommended for overseeding in the future if grass densities remain lower than desired (NRCS 2012).

B. Conversion of the R9 Ranch to native grassland will have beneficial impacts, including a reduction of water erosion and a significant reduction in wind erosion as compared to prior tilled croplands.

The sandy soils of the R9 Ranch are highly susceptible to erosion. Reestablishing the R9 Ranch back to a dominant grassland ecosystem should significantly reduce the erosion that does occur on the Ranch compared to a cropping system. Conversion of other croplands back to grasslands throughout the southern Great Plains has resulted in significant soil savings accumulated over years. Former cropland entered into the Conservation Reserve Program (CRP) has an estimated average annual savings of 2.1 tons of soil/acre from water erosion and 10.0 tons of soil/acre from wind erosion, for a combined total annual savings of more than 12 tons of soil/acre by seeding cropland back to grassland (FAPRI 2007). Course textured or sandy soils are less prone to water erosion, with the exception of steep slopes, but are more prone to wind erosion and organic matter loss than fine textured soils (Lyles and Tatarko 1986, Zobeck and Van Pelt 2011). Therefore, after establishing permanent grassland cover on the predominantly sandy soils of the R9 Ranch, soil savings may be greater than this national average.

The pre-settlement grasslands provided the consistent, roughened aboveground vegetative structure required to slow winds near the soil surface and reduce wind erosion potential (Okin 2008). Conversion of the R9 Ranch from cropland back to grassland should achieve a similar result. Wind erosion and water erosion are lessened with more vegetative cover, more consistent spatial and temporal vegetative cover, and less bare ground (Webb et al. 2014). Grasslands tend to have less wind erosion than many other vegetation types because of more continuous ground cover with fewer canopy gaps (Breshears et al. 2003).

The soil conservation properties of seeding croplands back to grasslands has other impacts that benefit the environment, the economy, and the public as a whole. Examples of benefits or ecological services with positive economic impacts that have been demonstrated in other regions include: improved water quality, improved air quality, improved fish and wildlife habitat, reduced health risks (i.e. respiratory illnesses), reduced infrastructure maintenance (i.e. ditch and culvert cleaning, water treatment facilities, flood damage and control), and opportunities for recreational viewing, hunting, and fishing (Feather et al. 1999; Ribaudo 1989).

It is my opinion, with a reasonable degree of scientific certainty, that fewer air particles from less wind erosion, and fewer soil and chemical particles from less water erosion and much less herbicide and pesticide use on grasslands compared to croplands (USDA 1998) should result in locally better air quality and water quality on and near the R9 Ranch. Improved wildlife habitat on the R9 Ranch should also locally increase wildlife abundance and use of the property (Gould and Jenkins 1993, Fletcher and Koford 2002, Plumb et al. 2019), including the potential use by the regionally and locally threatened lesser prairie chicken (Spencer et al. 2017, Sullins et al. 2018, Tanner et al. 2020), and offer opportunities for other wildlife viewing and hunting.

C. Conversion of the R9 Ranch back to native grass will provide a year-round vegetative cover, reducing water use and runoff, and improving water and soil quality.

Temporal increases in exposed bare soil from annual or short-lived perennial vegetation systems can also increase erosion potential compared to long-lived perennial vegetation. Therefore, conversion of land with other canopy structures and life cycles, such as in cropping systems, to a perennial grassland vegetation should decrease susceptibility of the soil to wind erosion (Bergametti and Gillette 2010). In other words, the more often vegetative cover is removed from a landscape, such as from tillage or harvesting a crop, the more susceptible it will be to the forces that cause erosion.

Water runoff and water erosion potential of sandy soils is often lessened because of its soil porosity, but the percentage of bare soil and the level of vegetation and soil cover still affect erosion. Reducing bare soil and having continuous vegetative cover are still the greatest factors in preventing water erosion that results in water runoff and sediment in water (Hoffman and Ries 1991).

A study of watersheds with paired grassland or cropland sites in Oklahoma and Texas showed that sediment in water runoff was similar in grassland and cropland within one watershed type, but sediment was 5-40 times greater in cropland runoff than in grassland runoff in three other watershed types studied (Smith et al. 1983). The high soil sand content of the R9 Ranch would have less sediment potential than any of the soils in the above study, but the study still displays the overriding concept that soils within grasslands are more stable soils than within croplands. Soil erosion from cropland not only results in greater soil loss than from grasslands, but also results in a greater loss of associated soil nutrients. A comparison of three North Dakota soil types in native grasslands and land converted to cultivated crops showed significant organic carbon, soil nutrient, and upper soil depth losses after 44 years of cultivation (Aguilar et al. 1988). Soil loss from former croplands that have been converted back to grassland through the Conservation Reserve Program is significantly less than soil loss from adjacent tilled cropland (Gilley and Doran 1997).

The fibrous root systems of the pre-settlement predominant grasses of the R9 Ranch helped to stabilize the erosion prone soil and hold it in place (Zheng et al. 2004), even under circumstances in which the above-ground vegetation may have momentarily disappeared, such as following heavy grazing and trampling events by nomadic grazing herds, or following periodic landscape fire (Arterburn et al. 2017, Vermeire et al. 2005). The conversion of the R9 Ranch back to native grasses should result in the return of fibrous root systems in the upper soil layer holding the soil surface in place to reduce erosion potential.

The highly erodible soils of the R9 Ranch have been undergoing a planned sequential conversion from cropland back to grassland for the past several years, in which a small portion of cropped acres were removed from crop production each year and seeded back to a mixture of native grasses. Soil quality improves with time after croplands are converted back to grasslands. Converted grasslands that have been established for a long period of time have active carbon and nitrogen pools (Baer et al. 2000, Reeder et al. 1998) and soil quality characteristics that more closely resemble native prairie than newly seeded grasslands.

Over time, these seeded grasslands of the R9 Ranch will more closely resemble the native grassland ecosystem that was in place before the ground was cultivated for crop production. This bodes well for the R9 Ranch land resource under possible future climate scenarios. Modeled future scenarios of a changed climate in the Central Plains, with greater intensity of heavy rainfall events, and longer periods between events, show that croplands will still have greater erosion and water loss from soil surface runoff than grasslands. An Oklahoma study of future climate models with elevated temperatures and more intense rainfall events compared erosion on land using conventional and conservation cropping practices to cropland converted back to grassland, and showed that converting cropland to grassland produced the least amount of modeled future erosion (Garbrecht et al. 2015).

Other models indicate additional benefits of keeping soils in grasslands. Models were created to estimate how land conversion from grasslands and how climatic change with rises in temperature would affect the future of a large agricultural watershed region. Conversion of intact grassland to irrigated cropland in sandy soils along the South Platte River basin resulted in models showing 37% more water loss annually due to evaporation and transpiration compared to the intact grassland (Baron et al. 1998). This water loss is a result of more exposed soil surface from cropland allowing evaporation of water from the soil and greater transpiration or water use by crops compared to land areas that remained as intact grasslands. Modeled water loss through the same mechanisms was also greatest for land areas converted to irrigated crops. Furthermore, other regional models show a high correlation exists for Oklahoma land areas with greater High Plains Aquifer water levels also having a greater percentage of cropland converted back to CRP grassland (Rao and Yang 2010). Therefore, this research shows that fewer crop acres and more grassland acres in a region reduces water losses to the atmosphere and retains more water in below surface aquifers from less irrigation. It is reasonable to expect that converting the R9 Ranch to native grasses from irrigated cropland acres will have a similar outcome.

D. Conversion of the R9 Ranch back to native grassland will provide critical habitat to native wildlife, particularly grassland birds.

Conversion of the R9 Ranch from cropland back to grasslands should have a marked improvement in the region on the quality of habitat for grassland birds, such as grasshopper sparrows and lesser prairie chickens, which have declined in population with the loss of grasslands to cultivation. Land converted from cropland back to grassland, especially seen through CRP grasslands, have increased the availability and connectivity of suitable grassland habitat and mitigated the loss of native prairie for the above-mentioned vulnerable bird species (Herkert 1998, Spencer et al. 2017, Sullins et al. 2018, Tanner et al. 2020).

The abundance and biomass of several insect orders is often greater in mixed grassland CRP than monoculture crop fields (Doxon and Carroll 2007), thus providing a food source for many native grassland birds. The insects measured in that study were chosen because of their importance to the diet of ring-necked pheasant and bobwhite quail chicks, but also could be consumed by many other species. Many bird species will use mixed seedings of native grasses for preferred nesting habitat compared to monoculture crop fields (Best et al. 1997). Although not a native bird species, ring-necked pheasant also highly prefer seeded native warm-season grass stands as nesting cover over cool-season grasses or even cover crops (Annis 2019; Shirley and Janke 2022). Northern bobwhite quail find preferred habitat for nest survival and brood rearing predominantly in grasslands, even in regions with a high percentage of agricultural use (Taylor et al. 1999). However, bobwhite quail also have high nest and brood survival in grasslands when interspersed with some shrubs and when managed with intermittent grazing and prescribed fire (Thompson et al. 2022; Sinnott et al. 2022). With the interspersed sand plums (the main native shrub found on the R9 Ranch property) in the untilled margins of the circles reseeded at the R9 Ranch, it is likely that quail populations will increase on the R9 Ranch with more grassland habitat compared to cropland monocultures.

Reseeded mixed grasslands provide a habitat that is suitable for grassland bird species, and bird abundance has been similar between these restored grasslands and native prairie (Fletcher and Koford 2002). Grassland birds should also return to the reseeded lands of the R9 Ranch and use it similarly to native grasslands. Furthermore, the removal of man-made vertical structures, such as irrigation pivots, should also improve the quality of habitat for the lesser prairie chicken (Plumb et al. 2019, Sullins et al. 2019, Tanner et al. 2020).

The R9 Ranch is within the historic home range, and is in close proximity to the two largest current home ranges of lesser prairie chickens in Kansas (Houts et al. 2008). The R9 Ranch is in the process of creating a large portion of the connected, intact grassland habitat needed by lesser prairie chickens, and could be used to help bridge the gap between the two main known home ranges of lesser prairie chickens in Kansas. A lesser prairie chicken conservation plan was created in 2013 to help prioritize areas in need of grassland conservation to provide habitat for the dwindling lesser prairie chicken population (Van Pelt et al. 2013). The Kansas map of prioritized areas of focus to preserve grassland habitat included the acres of the R9 Ranch, which sits toward the northern edge of the southern mixed-grass home range, to serve as a channel to bridge the gap with the shortgrass/CRP home range (Fig. 1; https://www.wildlife.k-state.edu/images/fullsize9405.jpg). The lesser prairie chicken in Kansas is now listed as threatened (US Department of the Interior 2022), so these areas of habitat conservation have increased importance.

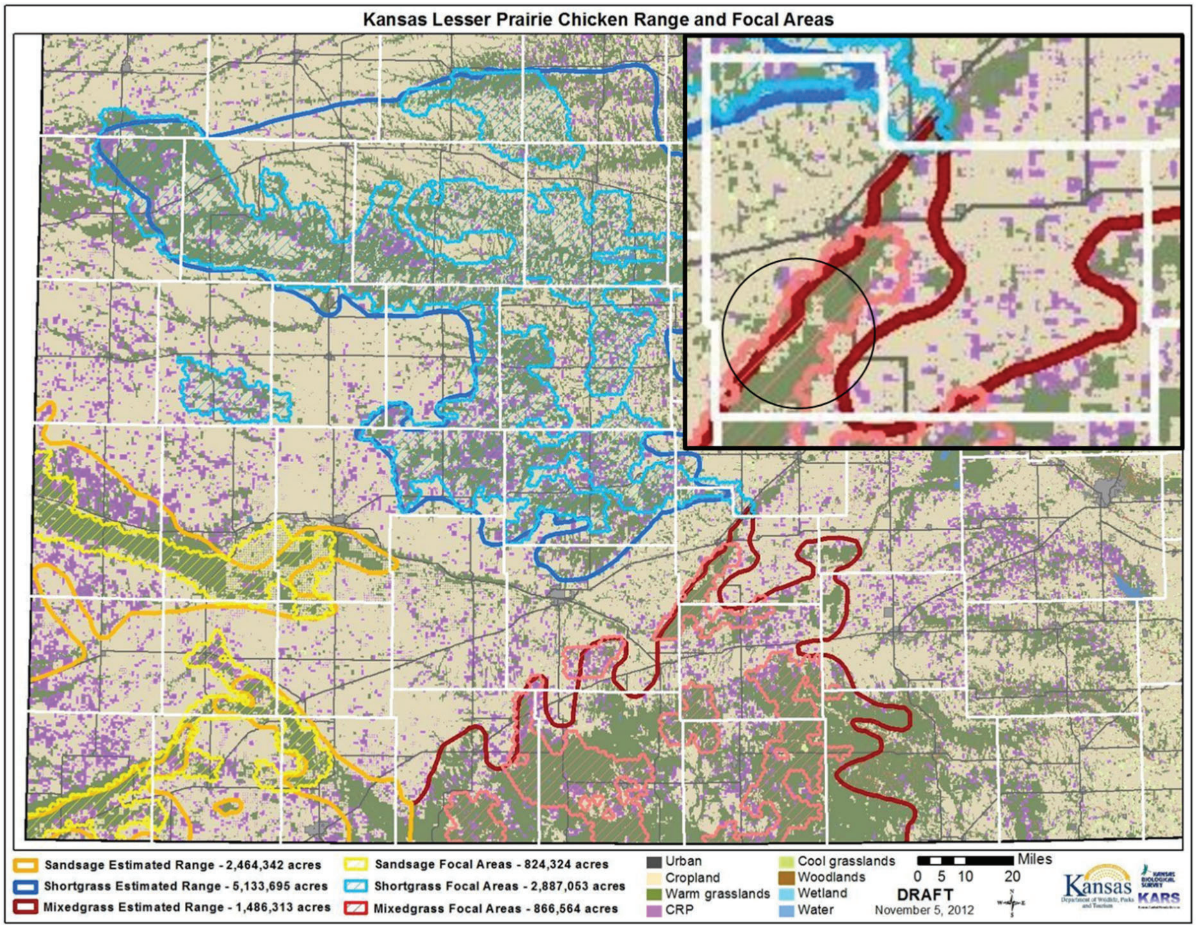


Fig. 1. Lesser prairie chicken habitat ranges and focal areas for the initial range-wide conservation plan. The imbedded enlarged region of Edwards County shows the circled location of the R9 Ranch as cropland prior to conversion back to grassland, and its importance to grassland connectivity.

Other species, such as young deer, also prefer to use CRP grasslands for cover while bedding compared to tree cover or croplands (Grovenburg et al. 2010), and mature deer heavily use CRP grasslands for bedding and cover in the spring, summer, and fall compared to other land use types, such as croplands or woodlands (Gould and Jenkins 1993). With more land area in grassland habitat, it is reasonable to expect deer to use more of the R9 Ranch for bedding and cover than when planted to monoculture croplands.

IV. Conclusion

In the end, based on my professional knowledge and work on the R9 Ranch, I conclude with a reasonable degree of certainty that the main result of the conversion of the R9 Ranch back to native grassland species is that the land area will more closely resemble and function similar to the way it did prior to European settlement, especially when compared to the same land area used in cropping systems. Water erosion and particularly wind erosion should be reduced by converting the R9 back to grasslands. A permanent cover of perennial grass vegetation will better protect the soil from the natural forces that cause erosion compared to the former croplands. The perennial grassland cover will also provide needed critical habitat for locally declining grassland bird species. Although not a mirror image, the landscape will become a much closer picture of how the vegetation, soils, and environment interacted centuries ago.

Statement of Keith R. Harmoney, Range Scientist

Date 3/27/2023

V. Bibliography

Annis, A. C. 2019. Ring-necked pheasant survival, nest habitat use, and predator occupancy in Kansas spring cover crops. Thesis, Kansas State University, Manhattan, USA.

Abraha, M., I. Gelfand, S.K. Hamilton, C. Shao, Y. Su, G.P. Robertson, and J. Chen. 2016. Ecosystem water-use efficiency of annual corn and perennial grasslands: contributions from land-use history and species composition. Ecosystems 19:1001-1012. DOI: 10.1007/s10021-016-9981-2

Aguilar, R., E.F. Kelly, R.D. Heil. 1988. Effects of cultivation on soils in Northern Great Plains rangeland. Soil Science Society of America Journal 52:1081-1085. https://doi.org/10.2136/sssaj1988.03615995005200040034x

Arterburn, J.R., D. Twidwell, W.H. Schacht, C.L. Wonkka, D.A. Wedin. Resilience of sandhills grassland to wildfire during drought. 2017. Rangeland Ecology and Management 71:53-57.

Baer, S.G., C.W. Rice and J.M. Blair. 2000. Assessment of soil quality in fields with short and long term enrollment in the CRP. Journal of Soil and Water Conservation 55:142-146.

Baron, J.S., M.D. Hartman, T.G.F. Kittel, L.E. Band, D.S. Ojima, and R.B. Lammers. 1998. Effects of land cover, water redistribution, and temperature on ecosystem processes in the

South Platte basin. Ecological Applications 8:1037-1051. https://doi.org/10.1890/1051-0761(1998)008[1037:EOLCWR]2.0.CO;2

Bergametti, G., and D. Gillette. 2010. Aeolian sediment fluxes measured over various plant/soil complexes in the Chihuahuan desert. Journal of Geophysical Research, American Geophysical Union, 10.1029/2009JF001543. hal-02324434.

Best, L.B., H. Campa III, K.E. Kemp, R.J. Robel, M.R. Ryan, J.A. Savidge, H.P. Weeks Jr., and S.R. Winterstein. 1997. Bird abundance and nesting in CRP fields and cropland in the midwest—a regional approach. Wildlife Society Bulletin 25:864–877.

Bowman, R.A., J.D. Reeder, and R.W. Lober. 1990. Changes in soil properties in a central plains rangeland soil after 3, 20, and 60 years of cultivation. Soil Science 150: 851-857.

Breshears, D. D., J.J. Whicker, M.P. Johansen, and J.E. Pinder. 2003. Wind and water erosion and transport in semi-arid shrubland, grassland and forest ecosystems: quantifying dominance of horizontal wind-driven transport. Earth Surface Processes and Landforms 28:1189–1209.

Brown, R.H. 1978. A difference in N use efficiency in C3 and C4 plants and its implications in adaptation and evolution. Crop Science 18:93-98. https://doi.org/10.2135/cropsci1978.0011183X001800010025x

Brye, K.R. and A.L. Pirani. 2005. Native soil quality and the effects of tillage in the Grand Prairie region of eastern Arkansas. American Midland Naturalist 154:28-41.

Dhakal, M., C.P. West, S.K. Deb, C. Villalobos, G. Kharel. 2020. Row spacing of alfalfa interseeded into native grass pasture influences soil-plant-water relations. Agronomy Journal 112:274-287. DOI: 10.1002/agj2.20012

Doxon, E.D., and J.P. Carroll. 2007. Vegetative and invertebrate community characteristics of conservation reserve program fields relative to gamebirds in western Kansas. American Midland Naturalist 158:243–259.

Dupont, S.T., J. Beniston, J.D. Glover, A. Hodson, S.W. Culman, R. Lal, and H. Ferris. 2014. Root traits and soil properties in harvested perennial grassland, annual wheat, and never-tilled wheat. Plant Soil 381:405-420. DOI 10.1007/s11104-014-2145-2

FAPRI. 2007. Estimating water quality, air quality, and soil carbon benefits of the Conservation Reserve Program. University of Missouri Food and Agricultural Policy Research Institute. FAPRI-UMC Report #01-07. 76 pgs.

Feather, P.M., D. Hellerstein, and L. Hansen. 1999. Economic valuation of environmental benefits and the targeting of conservation programs: the case of the CRP. USDA Agricultural Economics Report No. 778.

Fick, W. 2022. Rangeland and pasture grasses of Kansas. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, publication C567.

Fletcher, R., and R. Koford. 2002. Habitat and landscape associations of breeding birds in native and restored grasslands. Journal of Wildlife Management 66:1011-1022.

Garbrecht, J.D., M.A. Nearing, J.L. Steiner, X.J. Zhang, M.H. Nichols. 2015. Can conservation trump impacts of climate change on soil erosion? An assessment from winter wheat cropland in the Southern Great Plains of the United States. Weather and Climate Extremes 10:32-39.

Gilley, J.E., and J.W. Doran. 1997. Tillage effects on soil erosion potential and soil quality of a former Conservation Reserve Program site. Journal of Soil and Water Conservation 52:184-188.

Gould, J.H., and K.J. Jenkins. 1993. Seasonal use of conservation reserve program lands by white-tailed deer in east-central South Dakota. Wildlife Society Bulletin 21:250-255.

Grovenburg, T.W., C.N. Jacques, R.W. Klaver, and J.A. Jenks. 2010. Bed site selection by neonate deer in grassland habitats on the Northern Great Plains. Journal of Wildlife Management 74:1250-1256. https://doi.org/10.2193/2009-399

Hamilton, S.K., M Z Hussain, A K Bhardwaj, B Basso, and G P Robertson. 2015. Comparative water use by maize, perennial crops, restored prairie, and poplar trees in the US Midwest. Environmental Research Letters doi:10.1088/1748-9326/10/6/064015

Van Pelt, W.E., S. Kyle, J. Pitman, D. Klute, G. Beauprez, D. Schoeling, A. Janus, and J. Haufler, 2013. The lesser prairie-chicken range-wide conservation plan. Western Association of Fish and Wildlife Agencies, Cheyenne, Wyoming, pp. 367.

Hendrickson J.R., M.R. Schmer, and M.A. Sanderson. 2013. Water use efficiency by switchgrass compared to a native grass or a native grass alfalfa mixture. Bioenergy Res 6:746–54.

Herkert, J.R. 1998. The Influence of the CRP on grasshopper sparrow population trends in the mid-continental United States. Wildlife Society Bulletin 26:227-231.

Hofmann, L., and R. E. Ries. 1991. Relationship of soil and plant characteristics to erosion and runoff on pasture and range. Journal of Soil and Water Conservation 46:143-147.

Houts, M.E., R.D. Rodgers, R.D. Applegate, and W.H. Busby. 2008. Using local knowledge and remote sensing to map known and potential prairie-chicken distribution in Kansas. The Prairie Naturalist 40:87-93.

Karlen, D.L., M.J. Mausback, J.W. Doran, R.G. Cline, R.F. Harris, and G.E. Schuman. 1997. Soil quality: a concept, definition, and framework for evaluation (a guest editorial). Soil Science Society of America Journal 61:4-10.

Li, C., K.S. Veum, K.W. Goyne, M.R. Nunes, and V. Acosta-Martinez. 2021. A chronosequence of soil health under tallgrass prairie reconstruction. Applied Soil Ecology 164: 103939 https://doi.org/10.1016/j.apsoil.2021.103939

Lindenmayer, R.B., N.C. Hansen, J. Brummer, and J.G. Pritchett. 2010. Deficit irrigation of alfalfa for water-savings in the Great Plains and Intermountain West: a review and analysis of the literature. Agronomy Journal 103:45–50. https://doi.org/10.2134/agronj2010.0224

Lyles, L., and J. Tatarko. 1986. Wind erosion effects on soil texture and organic matter. Journal of Soil and Water Conservation 41:191-193.

NRCS. 2012. Natural Resources Conservation Service Construction Specifications: Range planting. Bulletin S-550-1.

Okin, G.S. 2008. A new model of wind erosion in the presence of vegetation. Journal of Geophysical Research, 113, F02S10, doi:10.1029/2007JF000758.

Plumb, R.T., J.M. Lautenbach, S.G. Robinson, D.A. Haukos, V.L. Winder, C.A. Hagen, D.S. Sullins, J.C. Pitman, and D.K. Dahlgren. 2019. Lesser prairie-chicken space use in relation to anthropogenic structures. The Journal of Wildlife Management. 83:216-230.

Rao, M.N., and Z. Yang. 2010. Groundwater impacts due to conservation reserve program in Texas County, Oklahoma. Applied Geography 30:317-328.

Reeder, J.D., G.E. Schuman, and R.A. Bowman. 1998. Soil C and N changes on conservation reserve program lands in the Central Great Plains. Soil and Tillage Research 47:339-349.

Ribaudo, M. 1989. Water quality benefits from the Conservation Reserve Program. USDA Economic Research Service, Agricultural Economic Report No. 606.

Rogers, D.H, and J. Aguilar. 2017. Kansas irrigation trends. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, publication MF2849(Rev.).

Rogers, D., J. Aguilar, I. Kisekka, P.L. Barnes, and F.R. Lamm. 2015. Irrigation Management Series: agricultural crop water use. Kansas St. University Agricultural Experiment Station and Cooperative Extension Service, publication L934. 12 pgs.

Salisbury, F.B., and C.W. Ross. 1992. Plant Physiology, Fourth Edition. Wadsworth Publishing Company, Wadsworth, Inc., Belmont, CA.

Shirley, T.R. and A.K. Janke. 2022. Ring-necked pheasant nest site selection in a landscape with high adoption of fall-seeded cover crops. Wildlife Society Bulletin https://doi.org/10.1002/wsb.1394

Sinnott, E.A., F.R. Thompson III, M.D. Weegman, and T.R. Thompson. 2022. Northern bobwhite juvenile survival is greater in native grasslands managed with fire and grazing and lower in non-native field borders and strip crop fields. Ornithological Applications 124:1-15. https://doi.org/10.1093/ornithapp/duab057

Smith, S.J., R.G. Menzel, E.D. Rhoades, J.R. Williams, and H.V. Eck. 1983. Nutrient and sediment discharge from southern plains grasslands. Journal of Range Management 36:435-439.

Spencer, D., D. Haukos, C. Hagen, M. Daniels, and D. Goodin. 2017. Conservation Reserve Program mitigates grassland loss in the lesser prairie-chicken range of Kansas. Global Ecology and Conservation 9:21-38. https://doi.org/10.1016/j.gecco.2016.11.004

Sullins, D.S., J.D. Kraft, D.A. Haukos, S.G. Robinson, J.H. Reitz, R.T. Plumb, J.M. Lautenbach, J.D. Lautenbach, B.K. Sandercock and C.A. Hagen. 2018. Demographic consequences of conservation reserve program grasslands for lesser prairie-chickens. The Journal of Wildlife Management 82:1617-1632.

Tanner, E.P., S.D. Fuhlendorf, R.D. Elmore, and C.A. Davis. 2020. Final report: Influence of human policies on lesser prairie-chicken (Tympanuchus pallidicinctus) ecology in a fragmented landscape. USDA Natural Resources Conservation Service Report. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcseprd1536418.pdf

Taylor, J.S., K.E. Church, and D.H. Rusch. 1999. Microhabitat selection by nesting and brood-rearing northern bobwhite in Kansas. Journal of Wildlife Management 63: 686–694.

Thompson, F.R. III, M.D. Weegman, E.A. Sinnott, A.R. Mosloff, K.R. Hedges, F.L. Loncarich, T.R. Thompson, N.C. Burrell, S. Whitaker, and D.E. Hoover. 2022. Northern bobwhite demographics and resource selection are explained by prescribed fire with grazing and woody cover in southwest Missouri. National Quail Symposium Proceedings: Vol. 9 , Article 9. https://doi.org/10.7290/nqsp09hN61

USDA. 2017. Census of Agriculture, Kansas State and County Data. USDA National Agricultural Statistics Service.

USDA. 1998. National Agricultural Statistics Service Agricultural Chemical Usage: 1998 Field Crops Summary.

USDI. 2022. Endangered and Threatened Wildlife and Plants; Lesser Prairie Chicken; Threatened Status with Section 4(d) Rule for the Northern Distinct Population Segment and Endangered Status for the Southern Distinct Population Segment. Federal Register 87:No 226. US Department of the Interior.

Vermeire, L.T., D.B. Wester, R.B. Mitchell, and S.D. Fuhlendorf. 2005. Fire and grazing effects on wind erosion, soil water content, and soil temperature. Journal of Environmental Quality 34:1559-1565 doi:10.2134/jeq2005.0006.

Waller, S.S., L.E. Moser, and P.E. Reece. 1985. Understanding grass growth: The key to profitable livestock production. Trabon Printing Co., Inc., Kansas City, MO.

Wang, T., J. Wu, X. Kou, C. Oliver, P. Mou, and J. Ge. 2010. Ecologically asynchronous agricultural practice erodes sustainability of the Loess Plateau of China. Ecological Applications. 20:1126-1135. https://doi.org/10.1890/09-0229.1.

Webb, N.P., J.E. Herrick, and M.C. Duniway. 2014. Ecological site-based assessments of wind and water erosion: informing accelerated soil erosion management in rangelands. Ecological Applications 24:1405-1420. https://doi.org/10.1890/13-1175.1.

Zheng, F., S.D. Merrill, C. Huang, D.L. Tanaka, F. Darboux, M.A. Liebig, and A.D. Halvorson. 2004. Runoff, soil erosion, and erodibility of Conservation Reserve Program land under crop and hay production. Soil Science Society of America Journal. 68:1332-1341. https://doi.org/10.2136/sssaj2004.1332

Zobeck, T.M., and R.S. Van Pelt. 2011. Chapter 14: Wind Erosion, in *Soil Management: Building a Stable Base for Agriculture,* J. Hatfield and T.J. Sauer (eds.). pgs 209-227.

APPENDIX

Curriculum Vitae of Keith R. Harmoney, Ph.D.

Keith R. Harmoney

Kansas State University Agricultural Research Center - Hays
1232 240th Ave.
Hays, KS 67601
(785) 625-3425 ext. 221
E-mail: kharmone@ksu.edu

Expertise: Rangeland and Forage Management

Education:

Ph.D. Agronomy, Iowa State University, August 1999
  Department: Agronomy Major: Crop Production and Physiology
  GPA: 3.84/4.0
B.S. Agronomy, University of Nebraska-Lincoln, December 1993
  Major: Agricultural Honors
  GPA: 4.0/4.0 Summa Cum Laude

Professional Experience:

Professor, Range Science, Kansas State University Western Kansas Agricultural Research Center-Hays, 2012-present
Associate Professor, Range Science, Kansas State University Western Kansas Agricultural Research Center-Hays, 2005-2012
Assistant Professor, Range Science, Kansas State University Western Kansas Agricultural Research Center-Hays, 1999-2005
Research Assistant, Iowa State University 1994-1999
Field and Laboratory Technician, University of Nebraska-Lincoln 1992-93
Assistant Field Agronomist, Central States Agronomics 1991-1992

Teaching Experience:

Instructor, Agronomy 334, Forage Management, ISU 1998
Teaching Assistant, Agronomy 526, Field Plot Techniques in Agronomy, ISU 1997
Teaching Assistant, Agronomy 534, Forage Quality and Utilization, ISU 1995

Professional and

Honorary Memberships:

American Forage and Grassland Council
American Society of Agronomy
Crop Science Society of America
Society for Range Management
Gamma Sigma Delta
Golden Key National Honor Society

Publications:

Refereed:

Harmoney, K.R., K.J. Moore, J.R. George, E.C. Brummer, and J.R. Russell. 1997. Determination of pasture biomass using four indirect methods. Agronomy Journal 89:665-672.

Hintz, R.L., **K.R. Harmoney**, K.J. Moore, J.R. George, and E.C. Brummer. 1998. Establishment of switchgrass and big bluestem in corn with atrazine. Agronomy Journal. 90:591-596.

Harmoney, K. R., K.J. Moore, E.C. Brummer, C.L. Burras, and J.R. George. 2001. Spatial legume composition and diversity across seeded landscapes. Agronomy Journal 93(5):992-999.

Brueland, B.A., **K.R. Harmoney**, K.J. Moore, J.R. George, and E.C.Brummer. 2003. Developmental morphology of smooth bromegrass following spring grazing. Crop Science. 43:1789-1796.

Stevenson, J.S., G.C. Lamb, S.K. Johnson, M.A. Medina_Britos, D.M. Greiger, **K.R. Harmoney**, J.A. Cartmill, S.Z. El_Zarkouny, C.R. Dahlen, and T.J. Marple. 2003. Supplemental norgestomet, progesterone, or melengestrol acetate increases pregnancy rates in suckled beef cows after timed insemination. Journal of Animal Science. 81:571-586.

Bock, B.J., J.R. Brethour, **K.R. Harmoney**, and S.R. Goodall. 2004. Influence of betaine on pasture, finishing, and carcass performance in steers. Professional Animal Scientist. 20:53-57.

Harmoney, K.R., and K.R. Hickman. 2004. Comparative morphology of Caucasian old world bluestem and native grasses. Agronomy Journal 96:1540-1544.

Harmoney, K.R., P.W. Stahlman, and K.R. Hickman. 2004. Herbicide effects on established yellow old world bluestem (Bothriochloa ischaemum). Weed Technology 18:545-550.

Harmoney, K. R. 2005. Growth responses of perennial cool-season grasses grazed intermittently. Online. Forage and Grazinglands doi:10.1094/FG-2005-0105-01-RS.

Harmoney, K. R., and Thompson, C. A. 2005. Fertilizer rate and placement alters triticale forage yield and quality. Online. Forage and Grazinglands doi:10.1094/FG-2005-0512-01-RS.

Harmoney, K.R. 2007. Grazing and burning Japanese brome (Bromus japonicus) on mixed grass rangelands. Rangeland Ecology and Management. 60:479-486.

Harmoney, K.R. 2007. Persistence of heavily-grazed cool-season grasses in the Central Great Plains. Online. Forage and Grazinglands doi:10.1094/FG-2007-0625-01-RS.

Harmoney, K.R., P.W. Stahlman, and K.R. Hickman. 2007. Suppression of Caucasian old world bluestem with split application of herbicides. Weed Technology 21:573-577.

Evans, L., Z. Kahn-Jetter, C. Marks and **K. Harmoney**. 2008. Mechanical properties and anatomical components of stems of 42 grass species. Journal of the Torrey Botanical Society 134:458-467.

Schmidt, C., K. Hickman, R. Channell, **K. Harmoney**, and W. Stark. 2008. Competitive abilities of native grasses and non-native (Bothriochloa spp.) grasses. Plant Ecology 197:69-80.

Heisler-White, J.L., J.M. Blair, E.F. Kelly, **K. Harmoney**, and A.K. Knapp. 2009. Contingent productivity responses to more extreme rainfall regimes across a grassland biome. Global Change Biology 15: 2894-2904.

Harmoney, K. R., and Thompson, C. A. 2010. Using long-term relative yield and quality to select adapted small grain forages. Online. Forage and Grazinglands doi:10.1094/FG-2010-0125-01-RS.

Smart, A.J., J.D. Derner, J.R. Hendrickson, R.L. Gillen, B.H. Dunn, E.M. Mousel, P.S. Johnson, R.N. Gates, K.K. Sedivec, **K.R. Harmoney**, J.D. Volesky, and K.C. Olson. 2010. Effects of grazing pressure on efficiency of grazing on North American Great Plains rangelands. Rangeland Ecology and Management 63:397-406.

Harmoney, K.R. 2010. Rate and timing of glyphosate application to control Caucasian old world bluestem (Bothriochloa bladhii). Invasive Plant Science and Management 3:310-314.

Harmoney, K.R., and J.R. Jaeger. 2011. Animal and vegetation response to modified-intensive early stocking on shortgrass rangeland. Rangeland Ecology and Management 64:619-624.

Harmoney, K. R., and K.R. Hickman. 2012. Comparing morphological development and nutritive value of Caucasian old world bluestem and native grasses. Online. Forage and Grazinglands doi:10.1094/FG-2012-0127-01-RS.

Harmoney, K.R., P.W. Stahlman, P.W. Geier, and R. Rupp. 2012. Effects of a new herbicide (aminocyclopyrachlor) on buffalograss and forbs in shortgrass prairie. Weed Technology 26:455-459.

Jaeger, J.R., J.W. Waggoner, K.C. Olson, **K.R. Harmoney**, and J.W. Bolte. 2012. Growth and reproductive performance of beef replacement heifers fed development diets containing soybean meal or wet distillers grains. Professional Animal Scientist 28:300-305.

Lamm, F.R., **K.R. Harmoney**, A.A. Aboukheira, and S.K. Johnson. 2012. Alfalfa production with subsurface drip irrigation in the central great plains. Transactions of the American Society of Agricultural and Biological Engineers (ASABE) 55:1203-1212.

Harmoney, K. R., Lamm, F. R., Johnson, S. K., and Aboukheira, A. A. 2013. Reducing water inputs with subsurface drip irrigation may improve alfalfa nutritive value. Online. Forage and Grazinglands doi:10.1094/FG-2013-117-01-RS.

Lee, D., Aberle, E., Chen, C., Egenolf, J., **Harmoney, K.**, Kakani, G., Kallenbach, R., and Castro, J. 2013. Nitrogen and harvest management of Conservation Reserve Program (CRP) grassland for sustainable biomass feedstock production. GCB Bioenergy 5:6-15.

Robertson, S., K.R. Hickman, **K.R. Harmoney**, and D.M. Leslie, Jr. 2013. Combining glyphosate with burning or mowing improves control of yellow bluestem (Bothriochloa ischaemum). Rangeland Ecology & Management: 66:376-381.

Harmoney, K.R. 2014. Cool-season grass biomass in the southern mixed-grass prairie region of the USA. BioEnergy Research. 10.1007/s12155-014-9514-9.

Ruppert, J.C., **K. Harmoney**, Z. Henkin, H.A. Snyman, M. Sternberg, W. Willms, and A. Linstädter. 2015. Quantifying drylands' drought resistance and recovery: the importance of drought intensity, dominant life history and grazing regime. Global Change Biology 21:1258–1270. DOI: 10.1111/gcb.12777.

Harmoney, K.R., and J.R. Jaeger. 2015. Animal finishing-phase response to modified intensive-early stocking on shortgrass rangeland. Professional Animal Scientist 31:529-534.

Anderson, E.K., E. Aberle, C. Chen, J. Egenolf, **K. Harmoney**, V.G. Kakani, R. Kallenbach, M. Khanna, W. Wang, and D.K. Lee. 2016. Impacts of management practices on bioenergy feedstock yield and economic feasibility on conservation reserve program (CRP) grasslands. Global Change Biology Bioenergy DOI: 10.1111/gcbb.12328.

Harmoney, K.R. 2016. Controlling honey locust (*Gleditsia triacanthos*) with cut stump- and basal bark-applied herbicides for grazed pasture. Weed Technology 30:801-806.

Harmoney, K.R., D.K. Lee, R.L. Kallenbach, and E.Z. Aberle. 2016. Species composition changes in Conservation Reserve Program (CRP) grassland when managed for biomass feedstock production. Bioenergy Research 9:1180-1188.

Harmoney, K.R. 2017. A new ending to an old classical stocking rate study. Great Plains Research 27:117–129.

Obour, A.K., **K. Harmoney**, and J.D. Holman. 2017 Nitrogen fertilizer application effects on switchgrass herbage mass, nutritive value and nutrient removal. Crop Sci. 57:1754-1763.

Zilverberg, C.J., J. Williams, C. Jones, **K. Harmoney**, J. Angerer, L.J. Metz, and W. Fox. 2017. Process-based simulation of prairie growth. Ecological Modeling 351:24-35.

Hickman, K.R., **K. Harmoney**, and A. White. USDA Forest Service. 2018. Field guide for managing yellow and Caucasian (Old World) bluestems in the southwest. Southwestern Region TP-R3-16-36, Albuquerque, NM.

Lee, DK; Aberle, E; Anderson, E; Anderson, W; Baldwin, B; Baltensperger, D; Barrett, M; Bonos, S; Bouton, J; Brummer, C; Burks, P; Chen, C; Daly, C; Egenolf, J; Farris, R; Fike, J; Gaussoin, R; Gill, J; Gravois, K; Halbleib, M; Hale , A; Hanna, W; **Harmoney, K**; Heaton, E; Heiniger, R; Hoffman, L; Hong, C; Kakani, VG; Kallenbach, R; Macoon, B; Medly, J; Missaoui, A; Mitchell, R; Moore, K;

Morrison, J; Odvody, G; Ogoshi, R; Parrish, J; Quinn, ; Richard, E; Rooney, B; Rushing, B; Schnell, R; Sousek, M; Staggenborg, S; Tew, T; Uehara, G; Viands, D; Voigt, T; Williams, D; Williams, L; Wilson, L; Wycislo, A; Yang, Y; and Owens, V. 2018. Biomass production of herbaceous energy crops in the United States: field trial results and yield potential maps from the multiyear regional feedstock partnership. Global Change Biology Bioenergy 10:698-716. doi: 10.1111/gcbb.12493.

Zilverberg, C.J., J. Angerer, J. Williams, L.J. Metz, **K. Harmoney**. 2018. Sensitivity of diet choices and environmental outcomes to a selective grazing algorithm. Ecological Modelling 390:10-22. https://doi.org/10.1016/j.ecolmodel.2018.10.007.

Yu, J., M. Vandeveer, J.D. Volesky, and **K. Harmoney**. 2019. Estimating the basis risk of rainfall index insurance for pasture, rangeland, and forage. J. Ag. & Resource Econ. 44:179-193.

Fick, W.H. and **K.R. Harmoney**. 2019. Great plains yucca (*Yucca glauca*) control on shortgrass rangelands. Weed Technology DOI: 10.1017/wet.2018.85.

Harmoney, K. and J. Jaeger. 2019. Tall wheatgrass and western wheatgrass used for complementary cool-season forage systems. Crop, Forage, and Turfgrass Management. Online. doi:10.2134/cftm2018.08.0065.

Smart, A.J., **K. Harmoney**, J.D. Scasta, M.B. Stephenson, J.D. Volesky, L.T. Vermeire, J.C. Mosley, K. Sedivec, M. Meehan, T. Haigh, J.D. Derner, and M.P. McClaran. Forum: Critical decision dates for drought management in central and northern Great Plains rangelands. 2021. Rangeland Ecology and Management 78:191-200. https://doi.org/10.1016/j.rama.2019.09.005

Guretzky, J.A., Volesky, J.D., Stephenson, M.B., **Harmoney, K.R**., and J.L. Moyer. 2020. Interseeding annual warm-season grasses into temperate pasturelands: Forage accumulation and composition. Agron. J. 112: 2812-2825. https://doi.org/10.1002/agj2.20250
Redfearn, D.D., **K.R. Harmoney**, and A.J. Smart. 2020. Chapter 17 Grasses for Arid and Semiarid Areas, in Forages: The Science of Grassland Agriculture, 7th edition, K.J. Moore , M. Collins, C.J. Nelson, and D.D. Redfearn eds. Pgs. 313-330. ISBN: 978-1-119-30064-9

Guretzky, J.A., **K.R. Harmoney**, J.L. Moyer, J.D. Volesky, M.B. Stephenson. 2021. Interseeding annual warm-season grasses into pastures: Forage nutritive value and yields. Agronomy Journal. 113:2544-2556.

Jaeger, J.R., G.W. Preedy, J.W. Waggoner, **K.R. Harmoney**, and K.C. Olson. 2022. Effects of weaning method on post-weaning performance by early weaned beef calves. Translational Animal Science. https://doi.org/10.1093/tas/txac030

Harmoney, K.R., C. Adams, and D. Rice. 2022. Interseeding legumes into semi-arid established smooth bromegrass pasture. Crop Forage and Turfgrass Management. DOI: 10.1002/cft2.20145

Jaeger, J.R., G.W. Preedy, J.W. Waggoner, **K.R. Harmoney**, and K.C. Olson. 2022. Effects of early or conventional weaning on beef cow and calf performance in pasture or drylot environments. Translational Animal Science. https://doi.org/10.1093/tas/txac052

Lin, C.H., N. Namoi, A. Hoover, R. Emerson, M. Cortez, E. Wolfrum, C. Payne, J. Egenolf, **K. Harmoney**, R. Kallenbach, and D.K. Lee. 2022. Harvest and nitrogen effects on bioenergy feedstock quality of grass-legume mixtures on conservation reserve program grasslands. GCB Bioenergy DOI:10.1111/gcbb.12980

Proceedings or Citable Non-Refereed:

Harmoney, K.R., K.J. Moore, J.R. George, and E.C. Brummer. 1998. Establishment and persistence of legumes at sites varying in aspect, landscape position, and soil type. p. 166-170. *In* Proc. American Forage and Grassland Council. Indianapolis, IN.

Johnson, S.K. J.S. Stevenson, **K.R. Harmoney** and J.R. Brethour. 2001. Effect of feeding sunflower seeds to mature beef cows on reproduction and calf performance. KAES Report of Progress 891. pg 31-33.

Johnson, S., B. Browleit, and **K. Harmoney**. 2002. Timed Insemination of suckled beef cows after ovulation synchronization with Cosynch + CIDR. KAES Rep. of Progress 890. pg. 121-123.

Johnson, S., B. Browleit, and **K. Harmoney**. 2002. Timed Insemination in beef heifers after synchronization of estrus and ovulation with melengesterol acetate and prostaglandin $F_2\alpha$. KAES Rep. of Progress 891. pg. 27-29.

Harmoney, K., C. Thompson, J. Brethour, and S. Johnson. 2002. Growth characteristics and development of cool-season grasses for grazing. KAES Rep. of Progress 891. pg. 41-46.

Harmoney, K.R., S. Johnson, R. Cochran, E. Vanzant, T. Jones, J. Wilson, D. Yauk, M. Ploger, G. McClure, M. Holder, B. Allen, W. Bell, and H. Jansonius. 2002.

Seasonal forage quality of rangelands across Kansas. KAES Rep. of Progress 891. pg 9-13.

Harmoney, K.R., S. Johnson, R. Cochran, E. Vanzant, T. Jones, J. Wilson, D. Yauk, M. Ploger, G. McClure, M. Holder, B. Allen, W. Bell, and H. Jansoniuus. 2002. Seasonal forage quality of rangelands across Kansas. KAES Rep. of Progress 890. pg. 168-171.

Harmoney, K., and J. Brethour. Modified intensive-early stocking on shortgrass rangeland. 2002. KAES Rep. of Progress 891. pg. 51-54.

Harmoney, K., and J. Brethour. 2002. Forage quality and animal production from brown mid-rib forage sorghum. KAES Rep. of Progress 891. pg 14-16.

Harmoney, K. Control and utilization of Japanese brome. 2002. KAES Rep. of Progress 891. pg. 47-49.

Brethour, J., S. Johnson, and **K. Harmoney**. 2002. Comparison of wagyu- and angus-sired steers. KAES Rep. of Progress 891. pg 7-8.

Johnson, S.K., **K.R. Harmoney**, and J.S. Stevenson. 2004. Addition of estradiol cypioinate and(or) calf removal to a modified MGA + CO-Synch protocol for fixed-timed artificial insemination in beef cows. KAES Rep. of Progress 923. pg13-16.

Roozeboom, K., W. Heer, P. Evans, K. Koifoid, **K. Harmoney**. 2004. Kansas Performance Tests with Summer Annual Forages. KAES Report of Progress SRP 938. 18 pgs.

Roozeboom, K., W. Heer, P. Evans, K. Koifoid, **K. Harmoney**. 2005. Kansas Performance Tests with Summer Annual Forages. KAES Report of Progress SRP 955. 16 pgs.

Jaeger, J.R., S.R. Goodall, **K.R. Harmoney**, and KC Olson. 2008. Beef cow performance following rumen-protected choline supplementation during the periparturient period. Proc. West. Sec. Amer. Soc. Anim. Sci. 59:114-117.

Jaeger, J.R., S.R. Goodall, **K.R. Harmoney**, and KC Olson. 2009. Beef cow performance following rumen-protected choline supplementation before and after calving. KAES Report of Progress 1016:1-6.

Jaeger, J.R., S.R. Goodall, **K.R. Harmoney**, J.W. Bolte, and KC Olson. 2009. Beef cow performance following rumen-protected choline supplementation for 40 days before calving. KAES Report of Progress 1016:7-10.

Johnson, S.K., J.R. Jaeger, **K.R. Harmoney**, and J.W. Bolte. 2009. Comparison of a modified 5-day CO-synch plus CIDR protocol with CO-synch plus CIDR in mature beef cows. Proc. West. Sec. Amer. Soc. Anim. Sci. 60:254-256.

Johnson, S.K., J.R. Jaeger, **K.R. Harmoney**, and J.W. Bolte. 2009. Comparison of a modified 5-day CO-synch plus CIDR protocol with CO-synch plus CIDR in mature beef cows. KAES Report of Progress 1016:11-13.

Harmoney, K.R., and J.R. Jaeger. 2009. Beef production and vegetation trends from modified intensive-early stocking. KAES Report of Progress 1016:36-42.

Harmoney, K.R. and P.W. Stahlman. 2009. Glyphosate application rate and timing to control old world bluestems. KAES Report of Progress 1016:43-45.

Harmoney, K. and J. Jaeger. 2011. Using wet distillers grains as a late-season protein supplement for grazing steers. KAES Report of Progress 1050:4-5.

Harmoney, K., C. Adams, D. Rice, and H. Jansonius. 2011. Establishing different legumes in grass: an on-farm research trial. KAES Report of Progress 1050:35-39.

Harmoney, K. and H. Jansonius. 2011. Conservation Reserve Program land management for biomass feedstock production. KAES Report of Progress 1050:40-43.

Johnson, S.K. and **K.R. Harmoney**. 2011. Grazing wheat did not reduce beef cow pregnancy rates. KAES Report of Progress 1047:23-27.

Johnson, S.K. and **K.R. Harmoney**. 2011. Grazing wheat pre-breeding did not reduce beef cow pregnancy rates. Proceedings of Western Section American Society of Animal Science 62:278-281.

Lamm, F. R., **K. R. Harmoney**, A. A. Aboukheira, and S. K. Johnson. 2011. Subsurface drip irrigation of alfalfa. In: Proc. 2011 Irrigation Association Tech. Conf. 10 pg.

Lafantasie, J., **K. Harmoney**, A. Pettibone, A. Rusk, B. Nicholson, and S. Casey. 2013. Spread of old world bluestem in native rangeland pastures. KAES Report of Progress 1086:32-35.

Harmoney, K.R., and J.R. Jaeger. 2013. Precipitation effects on shortgrass rangeland: Vegetation production and steer gain. KAES Report of Progress 1086:36-41.

Harmoney, K.R., and J.R. Jaeger. 2014. Comparing season-long stocking and a modified intensive early stocking strategy for western Kansas. KAES Report of Progress 1104. Pg. 110-114.

Harmoney, K., J. Lafantasie, A. Pettibone, A. Rusk, B. Nicholson, and S. Casey. 2014. Spread of Yellow Old World Bluestem in Native Rangeland Pastures, *in* Glaser, A., ed., America's Grasslands Conference: The Future of Grasslands in a Changing Landscape. Proceedings of the 2nd Biennial Conference on the Conservation of America's Grasslands. August 12-14, 2013, Manhattan, KS. Washington, DC and Manhattan, KS: National Wildlife Federation and Kansas State University.

McMullen, C.J., J.R. Jaeger, **K.R. Harmoney**, J.W. Waggoner, and K.C. Olson. 2015. Performance of beef replacement heifers supplemented with dried distillers grains or a mixture of soybean meal and ground sorghum grain. Proc. West. Sec. Amer. Soc. Anim. Sci. 66:209-212.

McMullen, C.J., J.R. Jaeger, J.W. Waggoner, **K.R. Harmoney**, and K.C. Olson. 2015. Effects of altering supplementation frequency during the pre-partum period of beef cows grazing dormant native range. Proc. West. Sec. Amer. Soc. Anim. Sci. 66:213-216.

McMullen, C.J., J.R. Jaeger, **K.R. Harmoney**, J.W. Waggoner, and K.C. Olson. 2016. Performance of beef replacement heifers supplemented with dried distillers grains or a mixture of soybean meal and ground sorghum grain. Contribution 16-293-S of the Kansas Agricultural Experiment Station, Roundup 2016, pgs. 15-18

McMullen, C.J., J.R. Jaeger, J.W. Waggoner, **K.R. Harmoney**, and K.C. Olson. 2016. Effects of altering supplementation frequency during the pre-partum period of beef cows grazing dormant native range. Contribution 16-293-S of the Kansas Agricultural Experiment Station, Roundup 2016, pgs. 19-22

Harmoney, K.R. 2016. Old world bluestem seedling emergence and vegetative cover following glyphosate treatment. Contribution 16-293-S of the Kansas Agricultural Experiment Station, Roundup 2016, pgs. 23-25. Vol. 2: Iss. 2. https://doi.org/10.4148/2378-5977.1182

Harmoney, K.R. 2016. Ropewick application to control old world bluestems. Contribution 16-293-S of the Kansas Agricultural Experiment Station, Roundup 2016, pgs. 26-28. Vol. 2: Iss. 2. https://doi.org/10.4148/2378-5977.1183

Harmoney, K.R. 2016. Control of individual honeylocust trees in grazed pasture. Contribution 16-293-S of the Kansas Agricultural Experiment Station, Roundup 2016, pgs. 29-30

Brummer, J., S. Johnson, A. Obour, K. Caswell, A. Moore, J. Holman, M. Schipanski, and **K. Harmoney.** 2018. Managing spring planted cover crops for livestock grazing under dryland conditions in the High Plains Region. Fact Sheet No. 309, Colorado St. University Extension, Ft. Collins, CO.

Harmoney, K.R. and Guretzky, J.. 2018. Interseeding Warm-Season Annual Grasses into Perennial Cool-Season Western Wheatgrass Pasture. Kansas Agricultural Experiment Station Research Reports: Vol. 4: Iss. 2. https://doi.org/10.4148/2378-5977.7560

Harmoney, K.R. and Jaeger, J. R.. 2018. Using Modified Intensive Early Stocking for Grazing Replacement Heifers. Kansas Agricultural Experiment Station Research Reports: Vol. 4: Iss. 2. https://doi.org/10.4148/2378-5977.7558

Harmoney, K.R. and Jaeger, J. R.. 2018. Can Modified Intensive Early Stocking Be Used in Cow/Calf Production?. Kansas Agricultural Experiment Station Research Reports: Vol. 4: Iss. 2. https://doi.org/10.4148/2378-5977.7559

Hill, S.L., Grieger, D.M., Olson, KC., Jaeger, J.R., **Harmoney, K.R.**, Dahlen, C.R., Crosswhite, M.R.., Negrin Pereira, N., Underdahl, S. R., Neville, B. W., Ahola, J., Fischer, M.C., Seidel, G.E., and Stevenson, J. 2018. Gonadotropin-Releasing Hormone Increased Pregnancy in Suckled Beef Cows Not Detected in Estrus and Subjected to a Split-Time Artificial Insemination Program. Kansas Agricultural Experiment Station Research Reports: Vol. 4: Iss. 2. https://doi.org/10.4148/2378-5977.7556

Preedy, G.W., Jaeger, J.R., Waggoner, J.W., Olson, K.C., and **Harmoney, K.R.** 2018. Effects of Early or Conventional Weaning on Beef Cow and Calf Performance in Pasture and Drylot Environments. Kansas Agricultural Experiment Station Research Reports: Vol. 4: Iss. 2. https://doi.org/10.4148/2378-5977.7554

Stevenson, J., Hill, S.L., Grieger, D.M., Olson, KC., Jaeger, J.R., **Harmoney, K.R.**, Ahola, J., Seidel, G.E., and Kasimanickam, R.K. 2018. Two Split-Time Artificial Insemination Programs in Suckled Beef Cows. Kansas Agricultural Experiment Station Research Reports: Vol. 4: Iss. 2. https://doi.org/10.4148/2378-5977.7557.

Harmoney, K.R. and Jaeger, J.R. 2020. An Efficient Stocking Strategy for Grazing Replacement Heifers. Kansas Agricultural Experiment Station Research Reports: Vol. 6: Iss. 3. https://doi.org/10.4148/2378-5977.7898

Jaeger, J.R., Waggoner, J.W., **Harmoney, K.R.**, and Rupp, Q. 2020. Effect of Exercise on Health and Performance by Long-Haul, High-Stress Steers During the Receiving Period. Kansas Agricultural Experiment Station Research Reports: Vol. 6: Iss. 3. https://doi.org/10.4148/2378-5977.7900

Harmoney, K.R. 2020. Saline Experimental Range Dormant Season Wildfire: Short-Term Effect on Forage Production and Plant Composition. Kansas Agricultural Experiment Station Research Reports: Vol. 6: Iss. 3. https://doi.org/10.4148/2378-5977.7901

Harmoney, K.R. and Jaeger, J.R. 2020. Using Modified Intensive Early Stocking for Cow/Calf Production. Kansas Agricultural Experiment Station Research Reports: Vol. 6: Iss. 3. https://doi.org/10.4148/2378-5977.7899

Fiehler, C.; Jaeger, J., Waggoner, J., **Harmoney, K**., and Olson, K.C. 2022. Effect of Feeding Interval on Finishing Performance of Beef Steers. Kansas Agricultural Experiment Station Research Reports: Vol. 8: Iss. 2. https://doi.org/10.4148/2378-5977.8274

Harmoney, K. and Guretzky, J. 2022. Interseeding Sorghum-Sudangrass into Perennial Cool-Season Western Wheatgrass Pasture. Kansas Agricultural Experiment Station Research Reports: Vol. 8: Iss. 2. https://doi.org/10.4148/2378-5977.8276

Harmoney, K. and Jaeger, J. 2022. Vegetation and Animal Production in Pastures Sprayed for Western Ragweed Control. Kansas Agricultural Experiment Station Research Reports: Vol. 8: Iss. 2. https://doi.org/10.4148/2378-5977.8275

Harmoney, K. 2022. Herbicide Activity on Old World Bluestems. Kansas Agricultural Experiment Station Research Reports: Vol. 8: Iss. 2. https://doi.org/10.4148/2378-5977.8277

Harmoney, K. 2022. Reclaiming Old World Bluestem Pasture with Imazapyr Application and Native Grass Overseeding. Kansas Agricultural Experiment Station Research Reports: Vol. 8: Iss. 2. https://doi.org/10.4148/2378-5977.8278

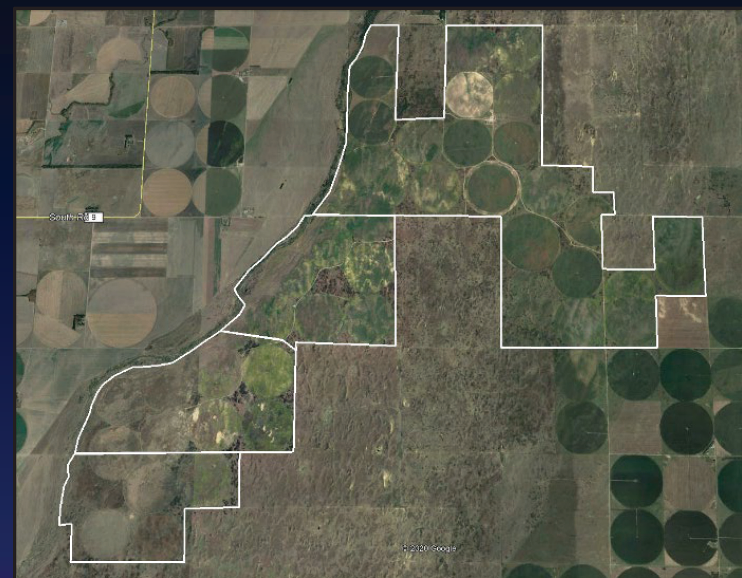
Fiehler, C., Jaeger, J., Waggoner, J., **Harmoney, K**., and Olson, K.C. 2022. The Effects of Intensive Early Stocking and Early Weaning on the Onset of Puberty and Reproductive Success in Beef Replacement Heifers. Kansas Agricultural

Experiment Station Research Reports: Vol. 8: Iss. 2.
https://doi.org/10.4148/2378-5977.8273

Giefer, H.P., **K.R. Harmoney**, M.P. Ramirez, A.J. Tajchman, Z.M. Duncan, J. Lemmon, and K.C. Olson. 2023. Effects of Late-Summer Prescribed Fire on Botanical Composition, Soil Cover, and Forage Production in Caucasian Bluestem-Infested Rangeland in the Kansas Smoky Hills: Year 4 of 5. Kansas Agricultural Experiment Station Research Reports: Vol. 9: Iss. 1.
https://doi.org/10.4148/2378-5977.8411

APPENDIX A

Assessment of Grass Seeding on the R9 Ranch



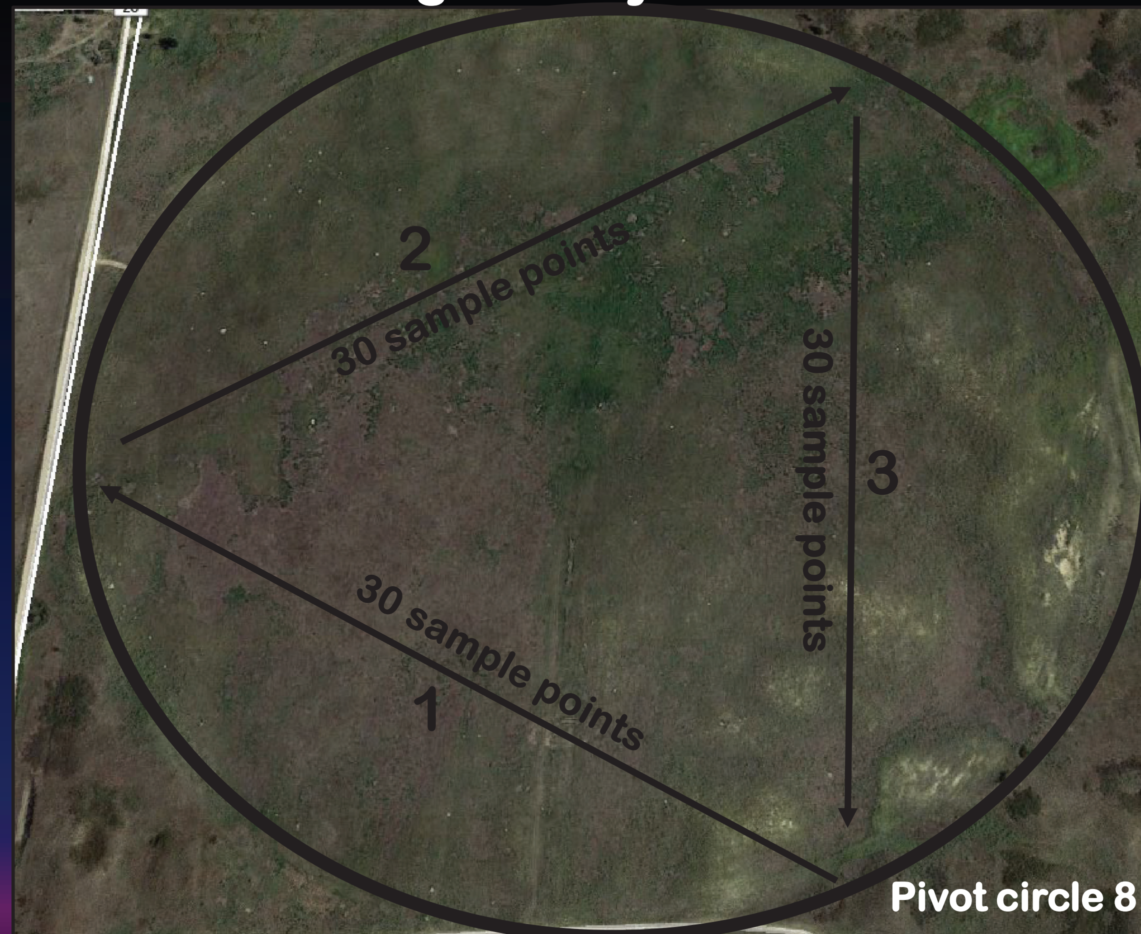
by Dr. Keith Harmoney, Rangeland Scientist

My role is to give management, grazing, and overall grassland health advice for a goal.

Goal: Convert a monoculture crop field into a naturalized diverse grassland

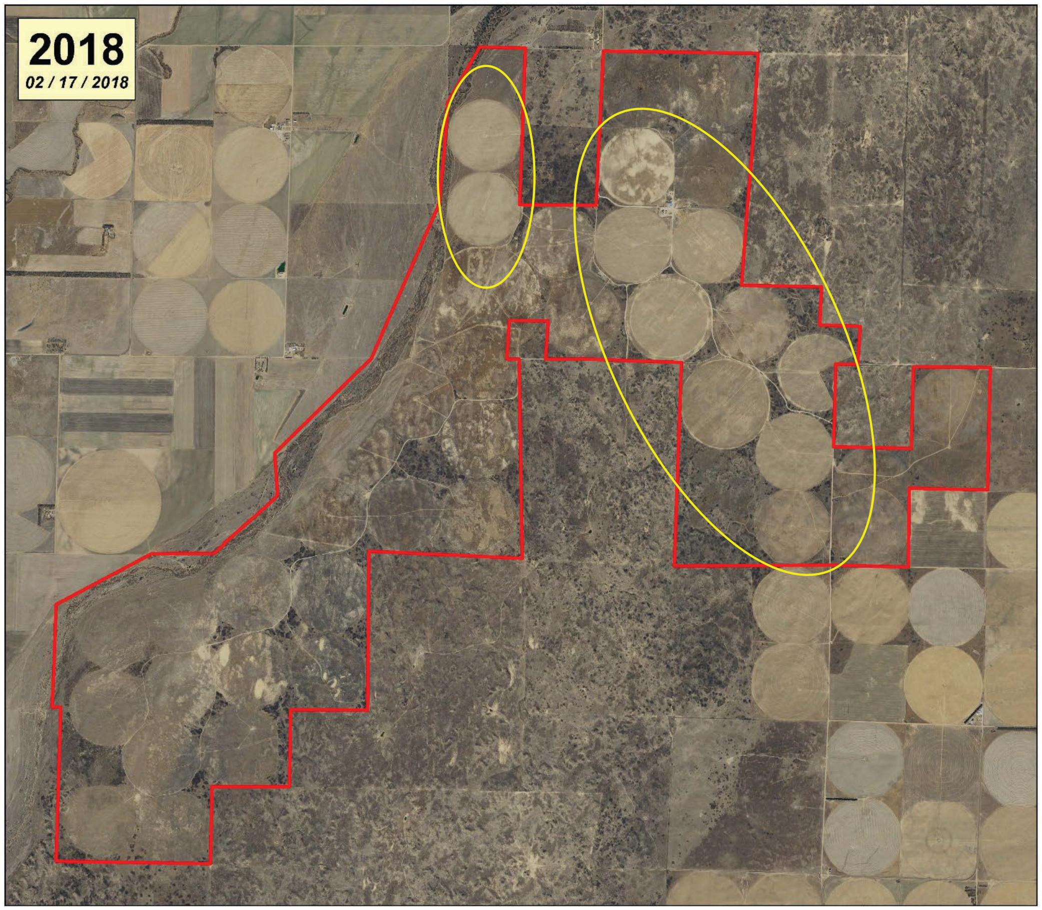
Challenge: on a sandy soil in a temperate, dry-mesic zone

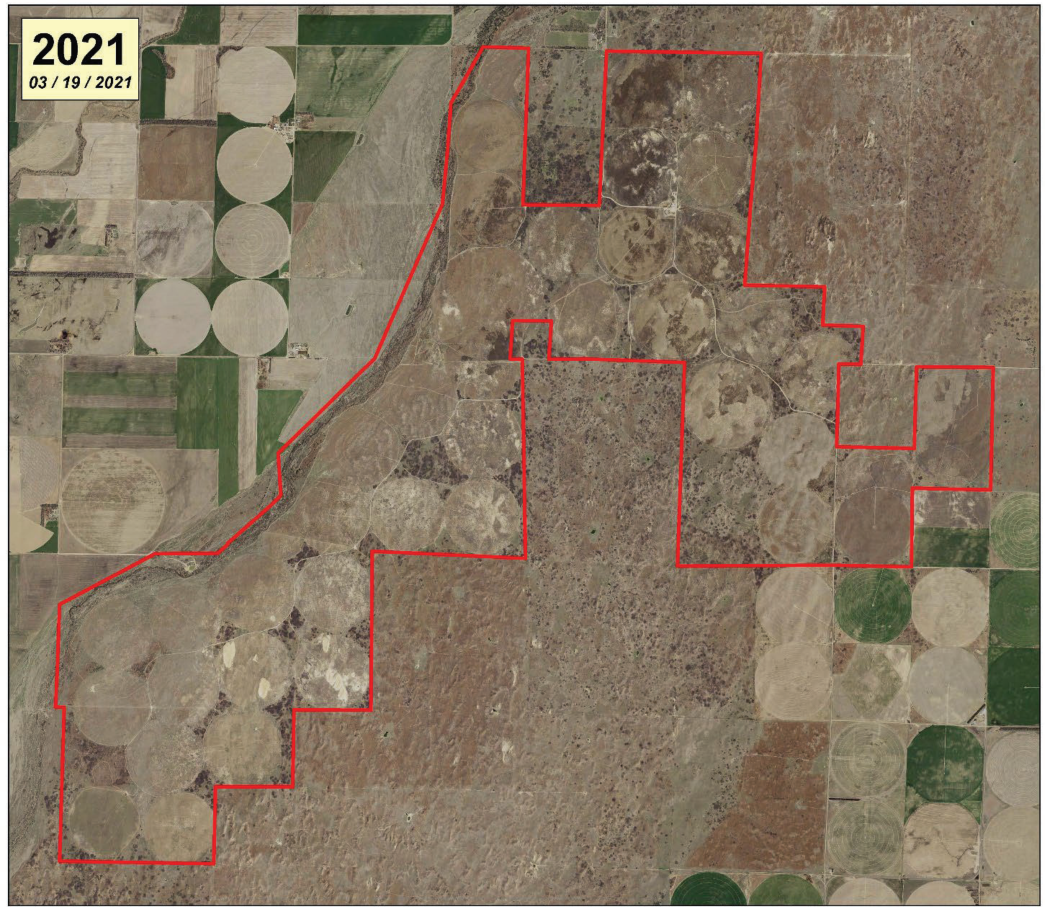
Hard to manage what you don't measure…



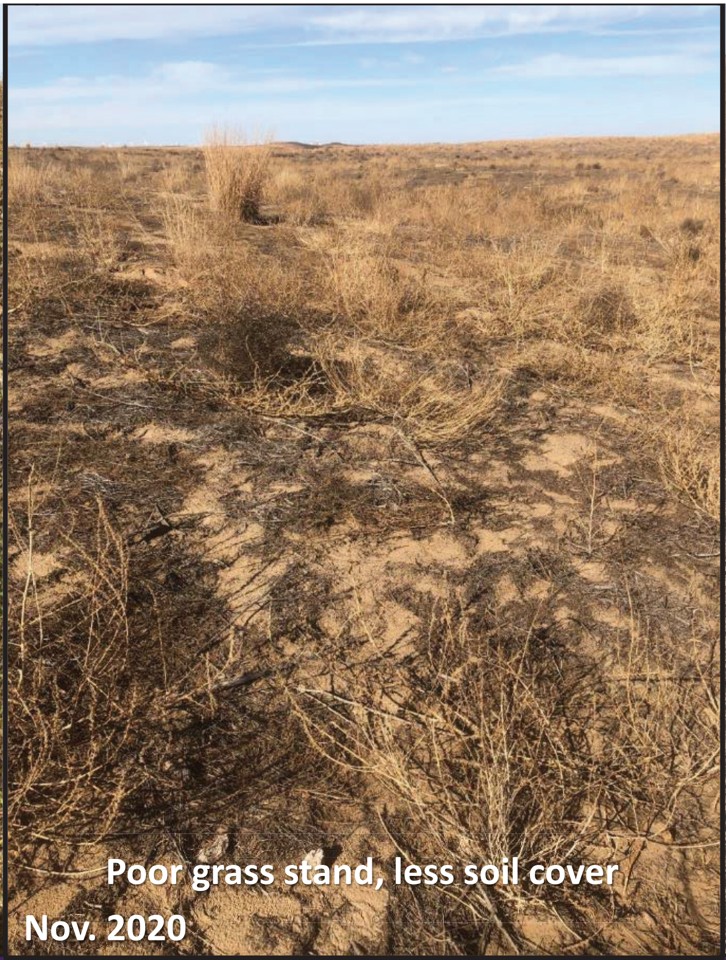
…sampling schematic for a pivot circle.

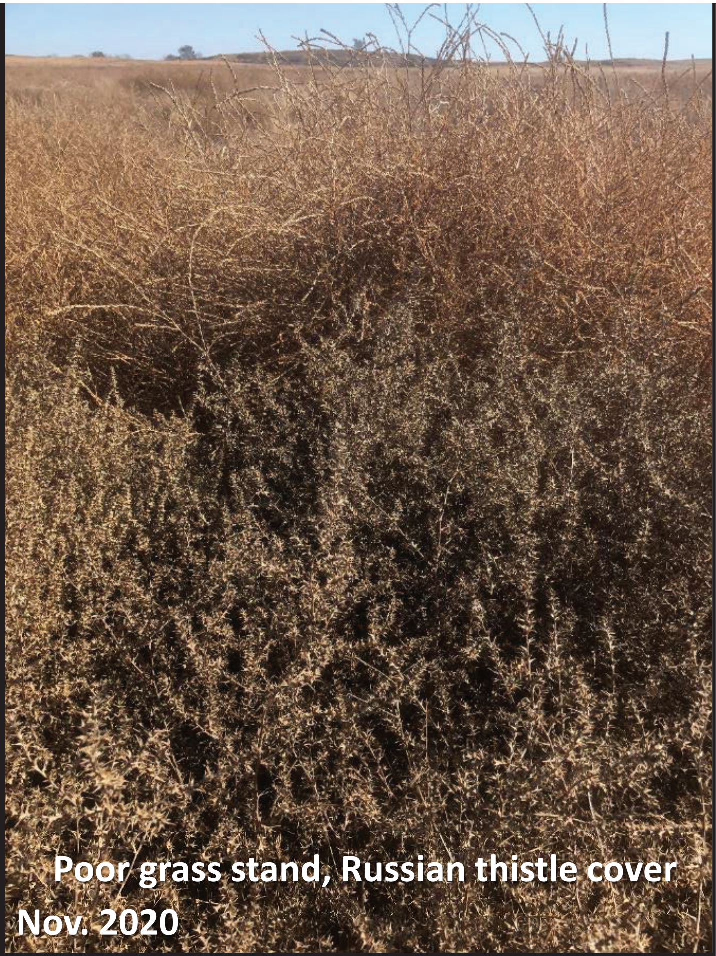
Satellite imagery of the R9 Ranch before the 2018 growing season and before the 2021 growing season.



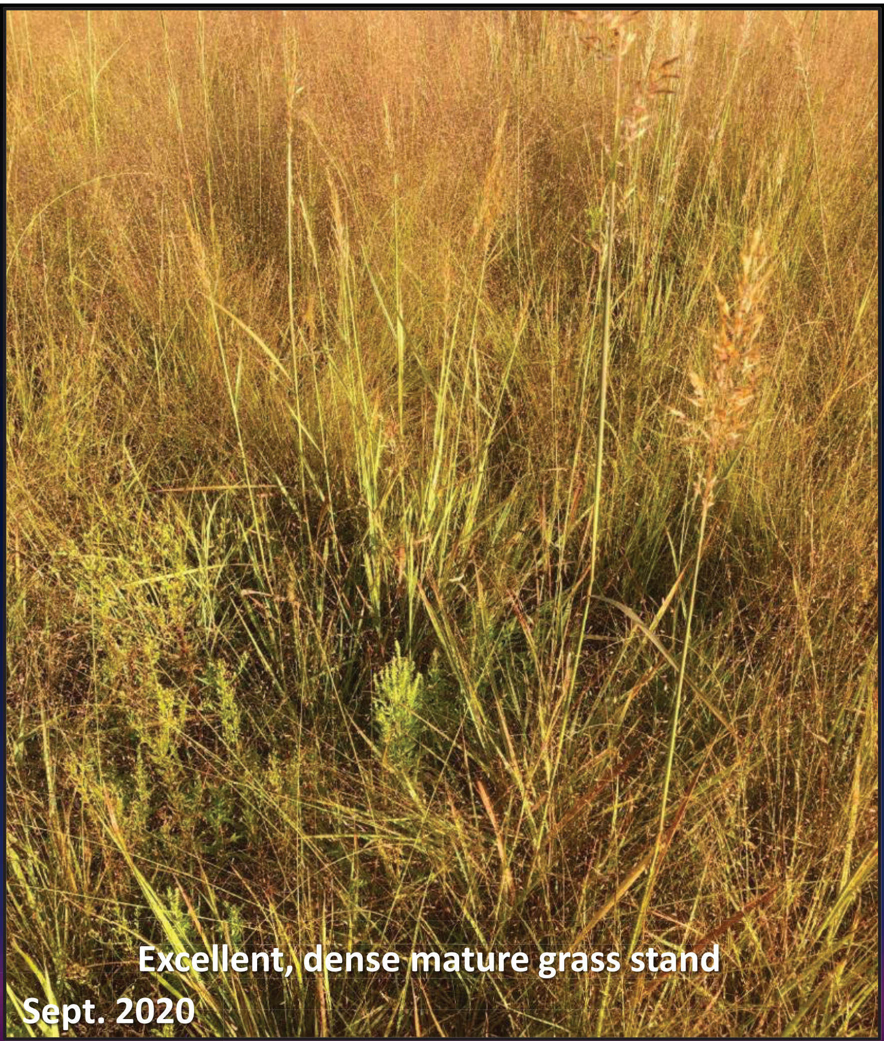


Light shading in circled areas indicates exposed sandy soil surface and crop residue. All circles had been overseeded by 2019. Image of 2021 shows some form of vegetative cover on all circles.

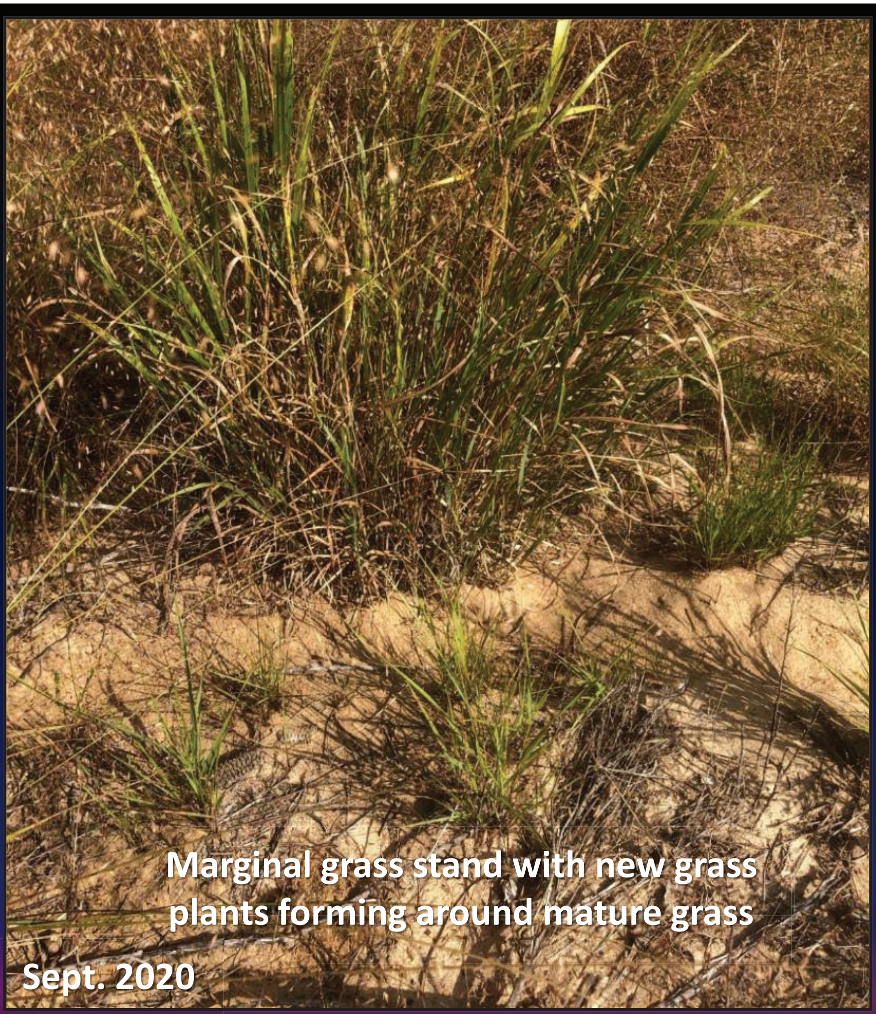




Needed to assess the makeup of that vegetative cover.
Very poor grass establishment on some circles.



Excellent establishment on some circles.



Several circles had establishment in between the extremes.


Pivot circle 27 in fall of 2022, showing sparse first mature grass stand, and dense new stand after overseeding in 2021.

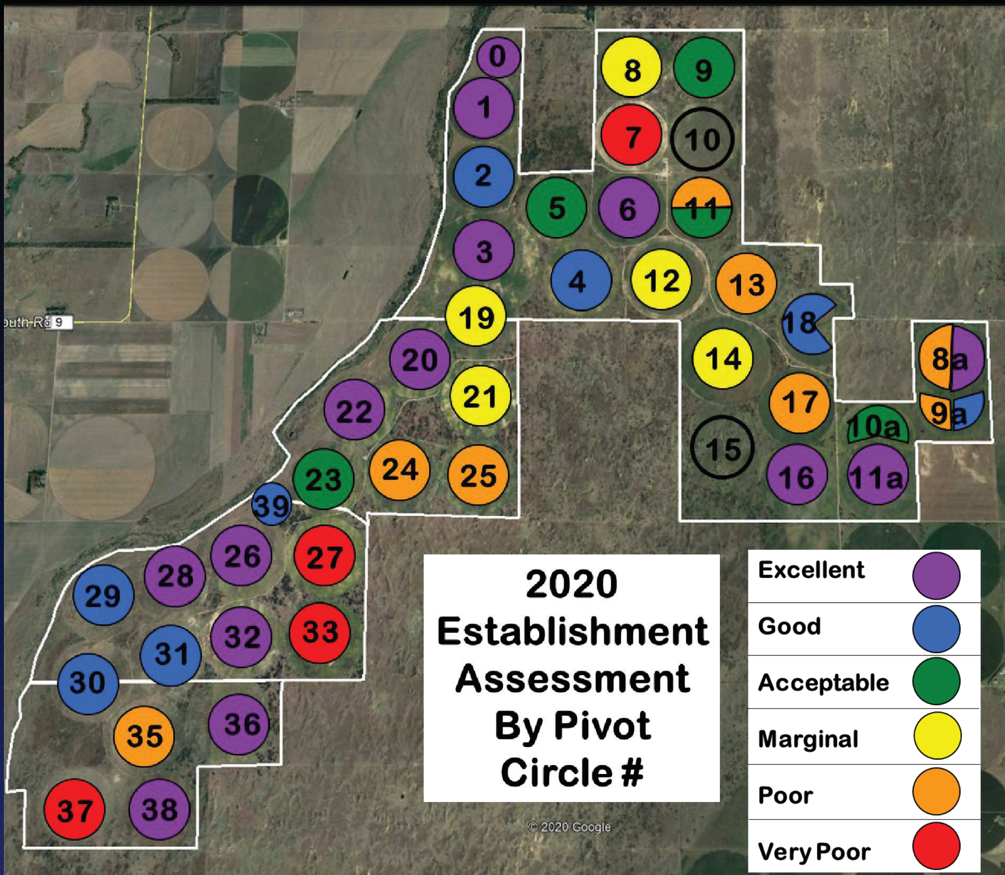
Recommended reseeding very poor and poor circles:

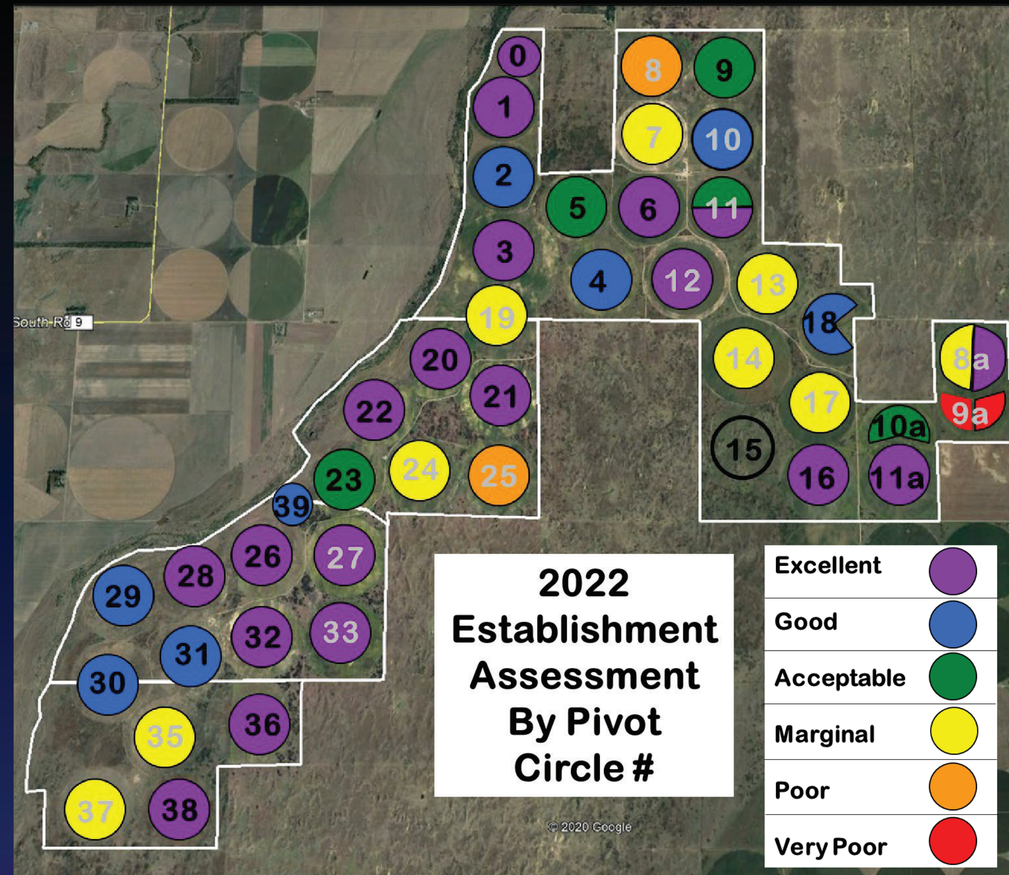
Reseeded 4 very poor circles in 2021 with good to excellent initial establishment. In 2022, 2 of the circles remained excellent while drought slipped the other 2 circles back into marginal establishment.

Another 4 poor circles recommended for reseeding in 2022 remained in poor to marginal establishment at the end of 2022.

Excellent new stand of small grasses on Pivot circle 27 in Nov. 2021

Excellent new stand of Pivot circle 27 showing larger plants with more tillers in Nov. 2022





Circles with gray letters were evaluated again in 2021 and/or 2022. Note the change in establishment grade between some circles in the 2 years.

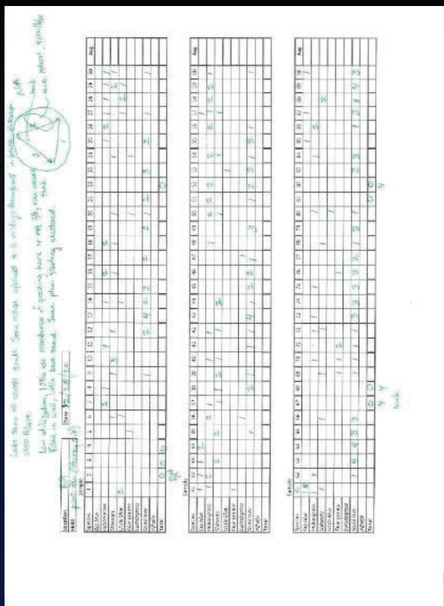
Pastures should eventually include permanent locations to monitor pasture health trends over time.

Examples of items used at other locations to incorporate at the R9 Ranch would include establishing transects for sampling, establishing grazing exclosures for sampling, and canopy cover measurements.

Canopy cover and clipping frame

Permanent transect sampling area between poles

Grazing exclosure area



Plan on performing similar tasks for 2023