BEEF SYSTEMS INITIATIVE ANNUAL REPORT

December 13, 2019

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BEEF SYSTEMS INITIATIVE (BSI)

Second Annual Report

Center for Grassland Studies
December 11, 2019

INTRODUCTION

Nebraska is often described as the epicenter for beef cattle production. The unique combination of forage and water supply, crop and ethanol production, and feeding and packing infrastructure make Nebraska a world-leader in beef production. However, there are critical opportunities to expand our cow/calf production capacity including: 1) efficient utilization of native rangeland as sources of feedstuff for beef cattle is less than its potential and 2) corn stover and cover crops are under-utilized.

Considering existing investments, opportunities for future investments, and the current momentum, The Agricultural Research Division and Nebraska Extension provided funds for a team-based integrated research and extension program for NE/US Beef Systems. Funding ($1.5 million) in collaboration with IANR units (Schools, Centers and Departments) was provided over five years. Funding was designed to encourage strong collaborations (e.g., co-direction of students), address the research, teaching and extension missions of IANR, and fulfill two essential elements:

- Strategic integration and optimization of components of the IANR statewide system to impact specific issues of regional and national importance to Beef Systems, and
- Plans for leveraging this investment towards current and emerging external funding sources (public and private-sector).

A concerted statewide research and extension effort has been established to improve the utilization of rangeland, pastures, crop residues, annual forages, ethanol co-products, and cover crops to optimize Nebraska beef production in an economically and environmentally sustainable manner.

> *The goal of the Beef Systems Initiative, approved in November 2016, is to develop and support implementation of beef production systems that optimize feed resource use, natural resource conservation, and producer success in Nebraska through improved management of perennial grasslands and systems of integrated crop-beef cattle production.*

To identify management practices that achieve optimal harvest efficiency and utilization of perennial grasslands, the initiative will utilize a case study approach. This plan involves a comparison of grassland and beef production systems of ranches in Nebraska that utilize various management and grazing strategies. The cattle grazing distribution, grassland and beef production, range condition/health, alternative feed resources, and harvest efficiency of ranches in Nebraska will be quantified and key factors that impact harvest efficiency and productivity will be determined.

The Beef Systems Initiative (BSI) has been instrumental in catalyzing the efforts of transdisciplinary, systems-based, inclusive team science in IANR to address research, teaching and outreach needs in the beef industry (conception to consumer):

- The BSI served as a partial match for a $1 million grant from the Foundation for Food and Agriculture Research (FFAR) entitled *Enhancing Animal Protein Production through Crops & Cattle*. The research team, which includes members of the BSI, expects an integrated system, which overlays cattle grazing with existing crop production systems, to increase output per acre and reduce greenhouse gas emissions associated with production. The team will also examine if the benefits of using cover crops are retained when they are used for livestock forage. The project is supported through FFAR's Seeding Solutions grant program, which calls for research proposals in the foundation's seven challenge areas. The grant is part of the Protein Challenge, which aims to enhance and improve the environmental, economic and social sustainability production of diverse proteins for a growing global population.
- The BSI was the first project to define the characteristics and attributes of the Nebraska Integrated Beef Systems Initiative (NIBSI) umbrella for research, teaching and extension.

The BSI comprises six projects that are reporting in the second year:

- Enhancing Protein Production through Crops and Cattle
- Production Efficiency of Perennial Grassland Systems
- Outcomes of Integrating Cattle into Cropping Systems
- Utilization of Annual Forages and Crop Residues in Developing a Year-round Grazing System
- Predicting Consequences of Changing Systems: Economic and Production Parameters
- Producer and Community Outreach through Extension

The initiative is housed in the Center for Grassland Studies and engages many faculty from University of Nebraska-Lincoln units; as well as other institutions of higher education, state, federal and private collaborators. The second annual report documents progress on specific objectives during the second year of funding (August 1, 2018 - July 31, 2019) for each project.

BEEF SYSTEMS INITIATIVE PROJECT SUMMARIES

Project 1: Enhancing Protein Production through Crops and Cattle

[The BSI Project 1 is under the umbrella of the Foundation for Food and Agriculture Research project of the same name using BSI funds as a partial match. Outcomes are combined for reporting purposes.]

Lead Project Investigator. James MacDonald, Professor, Department of Animal Science, University of Nebraska-Lincoln.

Justification. Three realities that will affect future beef production systems:

- Rapidly expanding population will require us to feed 9 – 10 billion people with the land base we currently have,
- Traditional perennial grasslands are declining and will continue to do so, thereby reducing the availability of traditional forage resources for beef production, and
- It is difficult for young people to have the capital to invest into land resources to enter into agriculture.

The project will develop a cow/calf system without perennial forage that utilizes crop residues and annual forages following cereal grain production as forage resources for cows.

Collaborators. Tala Awada, Professor, School of Natural Resources, University of Nebraska-Lincoln; Simanti Banerjee, Associate Professor, Department of Agricultural Economics, University of Nebraska-Lincoln; Jay Parsons, Associate Professor, Department of Agricultural Economics, University of Nebraska-Lincoln; Humberto Blanco, Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln; Daren Redfearn, Associate Professor, Department of Agronomy and Horticulture, University of Nebraska-Lincoln; Mary Drewnoski**,** Associate Professor, Department of Animal Science, University of Nebraska-Lincoln; Galen Erickson**,** Professor, Department of Animal Science, University of Nebraska-Lincoln; Jane Okalebo, Geoscientist, School of Natural Resources, University of Nebraska-Lincoln; Andy Suyker, Associate Professor, School of Natural Resources, University of Nebraska-Lincoln; and George Burba, Adjunct Assistant Professor, School of Natural Resources, University of Nebraska-Lincoln and LI-COR Biosciences.

Summary: Our specific objectives for this project are to:

1) Evaluate the effects of traditional and integrated forage production systems on cow/calf production;
2) Quantify the impacts of incorporating beef cows onto existing farmland on crop production and soil health;
3) Quantify GHG emissions and water budgets from replicated production-scale systems utilized in objective 1;
4) Develop applicable budgets and financial performance indicators, and conducting socio-economic analyses associated with adoption of the new crop-livestock system; and

5) Deliver the results of the project to producers, students, and the scientific community.

The milestones for Year 2 were to:

1) Collect production, soil/air, and economic data on the two production systems at the Eastern Nebraska Research and Extension Center (on schedule);
2) Analyze research data (on schedule);
3) Prepare thesis manuscripts (on schedule);
4) Collect information from integrated demonstration farms (ongoing);
5) Conduct field days and producer workshops (ongoing);
6) Update the project web page (completed); and
7) Publish newsletter articles (three articles were completed).

Objective 1. Evaluate the effects of traditional and integrated forage production systems on cow/calf production.

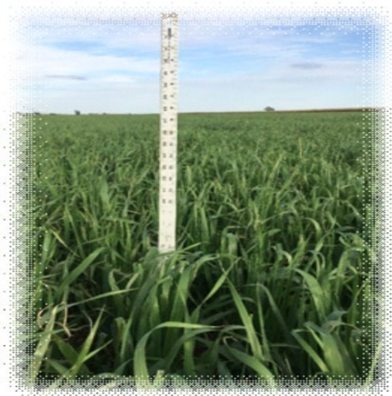
Two cow/calf systems were initiated at the Eastern Nebraska Research and Extension Center near Mead, NE in Year 1. In each system, 80 cows are enrolled. Cows were blocked by age into four blocks allowing for a randomized complete block design. Cows were bred to calve at the planned time for each system (Mid-April to Early-June for the traditional system and Mid-July to Early-September for the alternate system). We have summarized the first year of data for cow/calf performance (Table 1), and post-weaning growing performance (Table 2). The first calf crop for both systems is currently being finished in the research feedlot. The calves from the traditional system are currently being marketed.

In the first year, we observed a numerical reduction in the percentage of calves weaned in the ALT system compared to the TRAD system even though calving % was similar among the two groups. Calves in the ALT system were born during a period of unusual rainfall and dealt with considerable mud. Then the region experienced abnormally high amounts of cold temperatures, snow and precipitation in the winter and spring months. As a result, the ALT calves weaned 90 pounds lighter than the TRAD calves, and weaned 82.5% of their calves compared to 90% for the traditional system. Pounds of calf weaned per cow exposed were 116 pounds less in the ALT system compared to the TRAD system. The unusual weather patterns during Year 1 illustrates the importance of conducting long-term systems research across multiple years. Nevertheless, we have identified calf health and survivability as a potential risk in the ALT system.

We were successful in establishing our double crop annual forage and observed 8189 pounds of forage per acre when cows and calves were turned out to graze. We estimate that cows and calves removed 6959 pounds per acre due to grazing or trampling. This calculates to be 137 pounds per pair per day. This number is extremely useful in making stocking rate recommendations to producers since a portion of the forage is lost to trampling. If we assume the cows and calves consumed 55 pounds of forage per day, the grazing efficiency is calculated at approximately 40%.

Table 1. Effects of traditional (TRAD) or alternative (ALT) production systems on cow/calf performance in Year 1.

Item	TRAD	ALT	SEM	*P*-value
Count, n	80	80	-	-
Conception rate, %	95.2	98.8	2.8	0.30
Pregnancy loss, %	2.5	6.2	1.8	0.34
Calving, %	92.5	92.5	3.0	1.0
Weaning, %	90.0	82.5	4.3	0.22
Weaning weight, lb	516	426	6.7	0.002
Pounds weaned per cow exposed, lb	463	347	15.5	0.01
Cow BCS at weaning	6.2	5.9	-	-



After weaning, calves were placed on a growing diet in the feedlot for 113 days to allow them to grow before fattening. During this time period, the performance of the ALT calves tended to be improved with numerically better ADG and significantly improved feed efficiency. This is classical compensatory growth resulting from restricted growth while they were calves. The 90-pound reduction observed by the ALT calves was reduced to 58 pounds at the end of the 113 day growing period. This calculates to be 35.5% compensation by calves in the ALT system.

Table 2. Effects of traditional (TRAD) or alternative (ALT) production systems on growing calf performance in Year 1.

Item	TRAD	ALT	SEM	*P*-value
Count, n	72	66	-	-
Initial BW, lb	516	426	6.7	0.002
Ending BW, lb	824	766	16.0	0.08
DMI, lb	19.9	19.0	0.34	0.14
ADG, lb	2.73	3.01	0.09	0.12
G:F	0.137	0.159	0.003	0.01
DOF	113	113	-	-

The second year's calf crop has calved for the TRAD system and we are just beginning to calve the ALT system. The TRAD calving rate was 85.0%, down slightly from Year 1. We have met all of our objectives in running and evaluating this system.

Objective 2. Quantify the impacts of incorporating beef cows onto existing farmland on crop production and soil health.

Baseline grain yields from a replicated plot study were very good in 2018 with wheat yields at 80 bushels/acre, corn yields near 222 bushels/acre, and soybean yields about 70 bushels/acre. Oats planted following the wheat crop was grazed this winter along with the corn residue under less than ideal grazing conditions. In 2019, we will collect yields from grazed and non-grazed plots to determine cattle effects on grain yield and soil samples to characterize indicators of soil health.

Objective 3. Quantify GHG emissions and water budgets from replicated production-scale systems utilized in Objective 1.

We deployed our GHG monitoring trailer and have begun collecting GHG data. We have experienced some challenges with the system relating to tracking cows in the paddock area. The system requires knowledge of animal location relative to wind patterns and we have utilized GPS collars to accomplish this requirement. The GPS location of some animals has been intermittent and some animals have lost their collars at times. We are working to achieve more continuous monitoring and we are still confident we can monitor their location at all times. The second challenge we have had with this system is with flooded fields due to heavy rainfalls this spring. Fortunately, we were able to remove the system without damage, but we were unable to collect data during this time period. We are hopeful that we will have more consistent monitoring in 2019-2020. The cows placed in our indoor monitoring facility during the drylot period have worked well and we have good GHG monitoring data during this time period. We continue to leverage funds with the Long Term Agroecosystems Research (LTAR) network to partner on equipment usage and personnel expertise. LTAR has hired a post-doc who will focus on GHG flux calculations and manuscript development. The post-doc will spend some time assisting with the FFAR project.

Objective 4: Develop applicable budgets and financial performance indicators, and conducting socio-economic analyses associated with adoption of the new crop-livestock system.

There were no planned activities for Objective 4 in Year 2. The data collected from Objective 1 and Objective 2 will feed into financial models, which will be developed starting in Year 4.

Objective 5: Deliver the results of the project to producers, students, and the scientific community.

On-farm research evaluating components of integrated crop and cattle systems was conducted at one location where cover crops for forage is being explored following wheat in a low water input system. Due to a late corn and bean harvest in the fall of 2018 plans for evaluating rye in corn-soybean systems at another site was not conducted.

Five focus groups were conducted with 43 innovative cattle-crop producers. These producers were asked to discuss opportunities, barriers, and research needs regarding integrated cow/calf and cropping systems. This information has been used to further develop research questions and extension programming. They also provided information to begin development of regional beef cattle budgets.

In collaboration with Iowa and Missouri Extension, we hosted a workshop on “Reducing Feeding Costs using Cropland” at three sites reaching 120 producers. We also presented information at 32 extension events on components of integrated systems reaching approximately 1,500 producers. Additionally, we published four extension articles.

Our greatest challenge to date has been weather related, but this will not impede the research program and it is important to have a variety of weather conditions represented in our data set. The challenges associated with GHG monitoring will be resolved with improved GPS monitoring devices.

There are currently three graduate students working directly on the project. One student focused on cow/calf production, one student focused on GHG production, and one student focused on soils/agronomic aspects. Additionally, one undergraduate student was employed to assist with the cow/calf project and one summer intern was employed in the same project.

We have recruited two graduate students (Ph.D.) to work on the cow system (Objective 1) and greenhouse gas emissions (Objective 3). Additionally, one graduate student (agronomy) partially funded through a USDA-NIFA CAP grant has helped with data collection and three USDA-NIFA ELI undergraduate fellows have helped with data collection as part of their activities. An additional graduate student was recruited in the School of Natural Resources focusing on vegetation health in pasture sites.

Presentations

Presentations were made to beef and crop producers (1,463 total participants).

1. Incorporating cover crop forage into cropping systems, 24 presentations, 1,051 participants
2. Maintaining the cow herd with limited perennial acres, 1 presentation, 80 participants
3. Using corn residue as a forage source, 7 presentations, 332 participants

Producer Workshops

A workshop on the agronomic and feeding implications of baling corn residue was conducted reaching 97 producers with 100% reporting that the information was helpful to them. A three state beef conference on reducing feeding cost using cropland was held reaching 120 producers with 82% of the producers reporting that they were very likely or likely to make a change on their operation based on the information provided.

Objectives 1, 2, and 3 will continue to generate research data in the systems that were developed in Year 1. We will begin to analyze our production data, and we will have preliminary results from our air quality monitoring. The procedures we are utilizing in these objectives have been reviewed by colleagues and are scientifically valid. There will be no activity for Objective 4 because those methods are not scheduled to start until Year 4. For Objective 5, we will continue to collect data from our producer/collaborators who are using integrated systems. We will continue to update our web page and publish newsletter articles related to production systems. These activities are in accordance with the original grant proposal; no changes have been made.

Proceedings

Drewnoski, M. E., D. D. Redfearn, and J. Parsons. 2018. Considerations for using annual forages cost effectively. Nebraska State of Beef Conference. https://beef.unl.edu/documents/BeefConference/2018/9_Drewnoski_Parsons_forage.pdf

Articles

Rees, J., C. Wortmann, M. Drewnoski, K. Glewen, R. Pryor and T. Whitney. 2018. What is the value of soybean residue? CropWatch Electronic Newsletter. December. https://cropwatch.unl.edu/2018/what-value-soybean-residue

Drewnoski, M. E. and D. D. Redfearn. 2018. Nutrient Removal by Cows Grazing Corn Residue. CropWatch Electronic Newsletter. November. https://cropwatch.unl.edu/2018/nutrient-removal-cows-grazing-corn-residue

Drewnoski, M.E. and A. Conway. 2018. Ammoniated Corn Residue Equal to Medium Quality Grass Hay? Beef Watch Electronic Newsletter. November. https://beef.unl.edu/beefwatch/ammoniated-corn-residue-equal-medium-grass-hay

Redfearn, D., M. Drewnoski, J. Parsons, J. MacDonald, M. Stephenson. 2019. Beef Systems Initiative – Year 1 Milestones. BeefWatch Electronic Newsletter. July. https://beef.unl.edu/beefwatch/beef-systems-initiative-year-1-milestones

Project 2: Production Efficiency of Perennial Grassland Systems

Lead Project Investigator: Mitchell Stephenson, Assistant Professor, Panhandle Research & Extension Center, University of Nebraska-Lincoln

Justification: Cattle production in Nebraska is reliant on the perennial grassland forage resources that compromises about 46% of the state's land area. Grazing management strategies that increase the efficient use of perennial grasslands can help livestock producers become more sustainable and increase the level of production per land area. Increasing harvest efficiency, the amount of forage intake by cattle compared to the amount available, on grazing lands is significant from a beef production potential because small increases in harvest efficiency can result in considerable increases in carrying capacity of grazingland. This on-ranch project will evaluate the relationships between multiple grazing strategies and harvest efficiency, rangeland health and production, and plant species composition on Sandhills rangelands.

Collaborators: Walt Schacht, Professor, School of Natural Resources and Department of Agronomy & Horticulture, University of Nebraska-Lincoln; Jerry Volesky, Professor, West Central Research & Extension Center; Bethany Johnston, Extension Educator, Panhandle Research & Extension Center; Jack Arterburn, Extension Educator, Panhandle Research & Extension Center; Daren Redfearn, Associate Professor, Department of Agronomy & Horticulture, University of Nebraska-Lincoln; and Jay Parsons, Associate Professor, Department of Agricultural Economics, University of Nebraska-Lincoln.

Summary: The main objective of the Perennial Grassland Systems portion of the Beef System Initiative project is to better understand management practices and production efficiency of grazing practitioners on ranches in the Nebraska Sandhills. In 2019, we identified producers and several agreed to collaborate with the initiative and partner with us in collecting data and sharing their grazing management strategies, challenges, and opportunities. Collaborating producers represent a wide range of management and are spread from the southwest Sandhills near Lisco, NE to the central east Sandhills south of Bassett, NE. Annual precipitation varies from ~17 inches in the western Sandhills to over 22 inches in the east. As a result, we felt it important to identify regional level variability in species composition, production, and rangeland health.

From June to August, we initiated ranch visits at nine ranches. As part of the visits, we selected at least three pastures that were part of the ranch's typical grazing management plan (e.g., pastures grazed during the summer growing season). Water was located in each of the pastures and three study sites selected at distances of ¼ to ¾ of a mile from the water on upland sands ecological sites. Because of potential variability based on topography, we varied the study sites across north-facing slopes, south-facing slopes, and dunetops. These study sites will serve as the representative basis for ecological plant communities on the ranches.

In the first year of data collection, we focused on better understanding species composition at the study sites on the ranches. We used a step point quadrat method to collect species frequency of occurrence, ground cover, and dry-weight rank at each study site (See Figure 1). The quadrat frame consisted of a 40 cm by 40 cm frame with a nester 10 cm by 10 cm quadrat (to better evaluate very frequent species). At each of the study sites, we systematically created three transects facing north (340˚ to 360 ˚ compass bearing), southeast (140˚ to 160˚ bearing), and southwest (240˚ to 260˚ bearing). The three transect methodology helped to better measure vegetation characteristics across potential variability that is inevitable on rangelands. Each transect consisted of 11 quadrat placements separated by two large steps in the appropriate compass bearing. This equated to 33 quadrat placements at each study site, 99 placements in each pasture, and nearly 300 placements at each ranch. Currently, we have collected data at over 20 pastures and 60 study sites and have plans to visit several more in late-August and early-September 2019.

At each quadrat placement, we recorded the ground cover at a set location on the frame (e.g., bare ground, litter, or basal plant) and identified all species rooted within the quadrat. Lastly, we made a visual estimate of biomass production and the contribution of each species known as dry weight rank. See Figure 2 for a representation of species frequency of occurrence data collected at one of the study sites.

For Year 1 of data collection we focused on identifying producers, creating vegetation study sites, and collecting baseline vegetation data. In Year 2, we will expand data collection to include plant production, soil samples, and visual obstruction. During the fall and winter of 2019/2020 we will interview and survey producers on their typical stocking rates, time of grazing, and management of the study pastures. This will be the second part of the proposed study. The survey and interview data will then be linked with the vegetation information to determine potential differences among the study locations in terms of species composition, harvest efficiency, and rangeland productivity. As the study continues to expand and more producers are identified, more vegetation data and producer input will be incorporated into the study.

Figure 1. Technicians collecting data at a location in the central Sandhills.

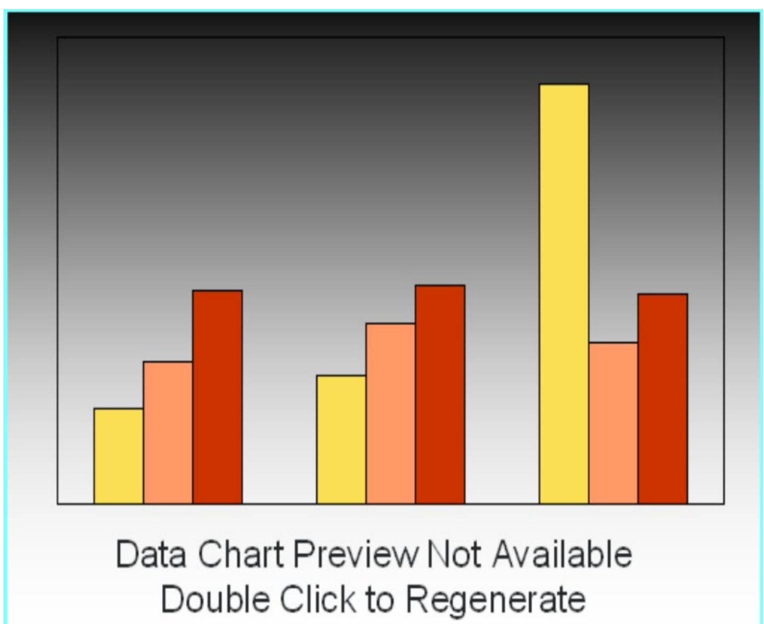


Figure 2. Frequency of occurrence data collected at one study site in the Nebraska Sandhills. Prairie sandreed was the most commonly observed grass species and was rooted in over 75% of the quadrat placements. Lambsquarter was prevalent on this site and was observed in over 90% of the quadrat placements.

Project 3: Outcomes of Integrating Cattle into Cropping Systems

Lead Project Investigator: Daren Redfearn, Associate Professor, Department of Agronomy & Horticulture, University of Nebraska-Lincoln

Justification: Crop producers and ranchers should embrace competition for land resources. Adoption of integrated crop-beef cattle systems will enhance the long-term resiliency of Nebraska's agricultural production systems. Our philosophy is that these diversified crop-forage-livestock systems are more productive, sustainable, and economically competitive with traditional cropping or livestock systems. This project will measure the effects of integrating forage cover crops and crop residues, cropping rotation, and cattle effects on crop agronomic performance and soil properties as indicators of soil health.

Collaborators: Humberto Blanco, Professor, Department of Agronomy & Horticulture, University of Nebraska-Lincoln; Roger Elmore, Professor, Department of Agronomy & Horticulture, University of Nebraska-Lincoln; Robert Mitchell, Adjunct Professor, Department of Agronomy & Horticulture, University of Nebraska-Lincoln, and Research Agronomist, USDA Agricultural Research Service.

Summary: Replicated plots of two cropping rotations (corn-soybean and corn-soybean-wheat) and five cropping sequences (corn-soybean, soybean-corn, corn-soybean-wheat, soybean-wheat-corn, and wheat-corn-soybean) were established in fall 2017. Baseline grain yields were very good during the first cropping season (2018) with wheat grain yield at 80 bushels/acre, corn grain yield near 222 bushels/acre, and soybean grain yield approximately 70 bushels/acre. Oats planted as a cover crop following the wheat crop and corn residue was grazed during the winter. It is important to note that grazing conditions were less than ideal with cold, wet conditions with extended periods of ice and snow during winter coupled with a cold, wet spring that continued through March 2019. This likely affected both crop and soil responses during the 2019 growing season. During the second cropping year (2019), wheat was planted 1 November, 2018. This planting date was later than planned due to wet conditions during fall harvest. Corn was planted on 3 May and soybean was planted on 13 May.

In 2019, corn and soybean grain yields will be harvested from grazed and non-grazed plots and used to measure grazing effects on subsequent grain yield. Pre-planting soil temperature and post-emergence plant population was measured post-grazing. Soil samples were collected from grazed and non-grazed plots on 10 June to determine grazing effects on indicators of soil health.

During 2019, wheat was harvested 29 July with a mean grain yield of 49 bushels/acre. This was approximately 40% less than grain yield for the first cropping year. This occurred most likely because of the late planting date, which resulted in late emergence coupled with cold temperatures and poor spring growing conditions.

‘Jerry’ oats was planted at 90 pounds seed per acre on August 19, 2019 into the harvested wheat stubble. Grazing treatments during the 2019 cropping season for the oats forage cover crop and corn residue are planned to begin in December 2019.

Preliminary Crop and Soil Responses

Because this is a systems project, our interests are to evaluate these two cropping systems and crop and soil responses over a period of six years both with and without grazing. It is important to note that this experiment began with conventional tillage and will transition to a no-till system during the course the study. While some of the early responses were likely due to treatments (Figure 1), other differences appear to be due solely to climatic conditions. At the conclusion of the six-year study, grazing will have occurred in three out of six years for corn residue in the corn-soybean rotation and four out of six years for corn residue and the oats cover crop following wheat in the corn-soybean-wheat rotation.

It is important to note that this is the first year to measure soil responses to grazing. Because soil microbes are so slow to respond to management, we do not currently plan to evaluate soil microbial populations and diversity in the short term. Instead, we plan to evaluate changes in soil physical and chemical properties, which can occur during shorter periods of time.

Figure 1. Early season corn growth planted after grazing an oats cover crop planted following wheat in a wheat-corn-soybean rotation. Two lines of separation can be seen demarcating the effects of grazing and manure application. The left half of the image had manure applied after grazing, whereas the right half did not. The bottom three-fourths shows the effects of grazing oats as a cover crop following wheat. Photo by Daren Redfearn.

Soil Temperature

Spring soil temperature was measured pre-planting for corn and soybean. In the corn-soybean rotation, soil temperature was 4° F less when corn was not grazed compared with grazed corn residue (Table 1). Pre-plant soil temperature following soybean going to corn was similar. This was expected since soybean residue was not grazed and residue amounts were similar for all soybean treatments. In the wheat-corn-soybean rotation, soil temperature following wheat/oats was 2° F less than soil temperature when the oats cover crop was not grazed. Differences in soil temperatures were also reflected in spring plant population. This was particularly evident in soybean in which plant populations were lower when planted into corn residue that was not grazed (Table 2).

Table 1. Post-grazed pre-plant soil temperature from grazed and non-grazed corn residue in a corn-soybean and corn-soybean-wheat rotation and grazed and non-grazed oats cover crop in a wheat-corn-soybean rotation; soybean residue was not grazed.

	Previous crop		
	Corn	Soybean	Wheat/Oats
	---------- °F ----------		
Grazed	62	62	63
Non-grazed	58	62	61

Plant Population

Spring plant population for wheat was near 95,000 plants per acre (Table 2). This was an adequate population, but consequent tiller growth was minimal (8 to 10 tillers per plant). Overall, heads were small with small seed and low test weight. Corn plant population following soybean was between 27,625 and 25,375 plants per acre. We cannot conclude that grazing reduced plant population because soybean residue was not grazed. Alternatively, the similar numerical reduction in corn plant population following the wheat/oats likely was affected by grazing (Figure 1).

Table 2. Plant population of primary crop for grazed and non-grazed corn residue in a corn-soybean and corn-soybean-wheat rotation and grazed and non-grazed oats cover crop in a wheat-corn-soybean rotation. Soybean residue was not grazed before corn in the corn-soybean rotation or the corn-soybean-wheat rotation.

		Plant population	
Crop and Crop Sequence	Previous crop	Grazed	Non-grazed
		---------- No. plants/acre ----------	
Corn			
Soybean-Corn	Soybean	25,375	27,625
Soybean-Wheat-Corn	Wheat/Oats	23,125	25,500
Soybean			
Corn-Soybean	Corn	117,750	115,750
Wheat-Corn-Soybean	Corn	121,875	118,250
Wheat			
Corn-Soybean-Wheat	Soybean	-	95,000

Soil Compaction

Briefly, grazing tended to increase soil compaction at the 0 to 2-inch depth. The 2- to 4-inch depth was more inconsistent, but small increases in soil compaction were observed with grazing (Figure 2).

Figure 2. Post-grazed corn residue in a corn-soybean system. The bottom three-fourths of the image demonstrates the grazing intensity and plainly shows hoof tracking in wet soils. Photo by Daren Redfearn.

Other Soil Physical Properties
Cumulative water infiltration was inconsistent, but tended to be greater in non-grazed treatments, possibly due to increased residue cover in the un-grazed plots. Similarly, soil water content tended to be greater in non-grazed treatments, especially at the 0 to 2-inch depth. However, soil water content was inconsistent at the 2- to 4-inch depth. Soil water content was likely greater at the surface depth due to increased residue cover, which reduced evaporation (Figure 3).

The wind erodible fraction tended to be lower in the non-grazed treatments, likely due to greater residue cover. Soil aggregation refers to how well the soil holds together and resists degradation when disturbed. Soil aggregation, again tended to be greater in grazed treatments, possibly due to cattle compressing the soil into larger clods.

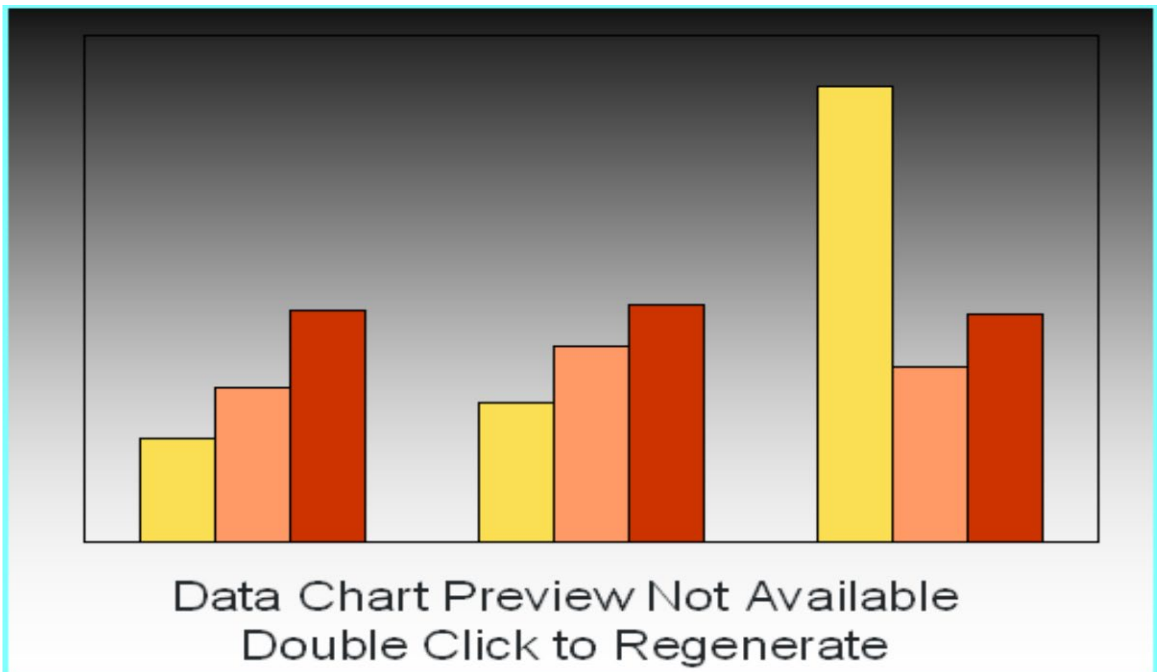


Figure 3. Percent residue cover for grazed and non-grazed corn residue in a corn-soybean rotation and an oats cover crop following wheat in a wheat-corn-soybean rotation.

Soil Chemical Properties
Total nitrogen, total carbon, and soil organic matter were inconsistent. This was expected since these pools are slow to respond to management and were measured with only one grazing period prior to sampling. However, there was a trend for increased soil phosphorus in grazed treatments. This could have been due to manure and urine deposition during grazing.

Integrated Student Learning
Two graduate students in Agronomy and Horticulture began work during 2019 to measure grazing effects on crop and forage cover crop production, soil compaction and soil quality

indicators that result from incorporating cattle into cropping systems. One student was funded through the BSI and one student was funded by leveraged grants from the Foundation for Agricultural Research and the Nebraska Environmental Trust.

This project supported learning activities for two undergraduate courses in Agronomy and Horticulture. During the 2018 fall semester, 20 students from Agronomy 472 (Applied Soil Physics), taught by Dr. Humberto Blanco, evaluated soil compaction methods as part of a laboratory exercise. Also, 110 students from Agronomy 204 (Resource Efficient Crop Management), taught by Dr. Andrea Basche, collected data for the wheat plant populations during the 2019 spring semester.

Prepared by Daren Redfearn, Humberto Blanco, Lindsey Anderson, and Alyssa Kuhn.

Project 4: Utilization of Annual Forages and Crop Residues in Developing a Year-round Grazing System

Lead Project Investigator: Harvey Freetly, Researcher, USDA MARC, and Adjunct Professor, Department of Animal Science, University of Nebraska-Lincoln.

Justification: Fall calving offers potential opportunities of integrating beef cattle production with farming systems. In the Midwest, fall calving helps to distribute the labor of the beef production and the farming enterprises across the year. The input/output relationships of these beef systems are poorly defined. Two management strategies are being examined. The first system is based on the premise that perennial summer forage is available. The system is designed to utilize perennial summer forage to support cows. Utilization of crop residue is incorporated into the system. The second system is based on utilization of harvested crop residue combined with the use of cover crops. This system is meant to integrate beef production into a farming system where perennial grass is not available.

Collaborators: Robert Cushman, Adjunct Professor, Department of Animal Science, University of Nebraska-Lincoln; Kristin Hales, Adjunct Professor, Department of Animal Science, University of Nebraska-Lincoln; Mary Drewnoski, Associate Professor, Department of Animal Science, University of Nebraska-Lincoln; James MacDonald, Professor, Department of Animal Science, University of Nebraska-Lincoln; Brian Vander Ley, Assistant Professor, Great Plains Veterinary Education Center

Summary: In the North Central Region of the U.S., a significant amount of pasture was converted to cropland in the last decade. When asked their opinions on research needs related to cow/calf production, Nebraska and Iowa cattle producers indicated that limited availability of perennial pasture was a significant issue; however, they also suggested that there are opportunities to integrate cattle and crop production. There was interest in late summer/fall calving cow systems because they can help to distribute the labor better over the year. In these integrated systems, pairs can be grazed on annual forages/cover crops in the fall and early spring and corn residue over the winter. During the summer, cows may need to be managed in confinement. However, there are no comparisons of how an integrated system might compare with a perennial forage based system in terms of cow and calf health and performance as well as system economics.

Thus, a replicated study in which late summer calving cows will be managed using cropland grazing and summer confinement compared to a perennial forage based system has been started in February of 2019 at USMARC. Two hundred twenty-five cows were assigned to eight herds containing 28 or 29 cows. Allocations were stratified across replicates by cow age and genetic background. Four herds were assigned to the perennial pasture system and four herds were assigned to the summer confinement system.

From February through early April, cows in the perennial pasture system received hay while on dormant pasture. Hay supplementation was measured and will be used in the future economic analysis of the systems. In early April, they began grazing perennial pasture. Forage samples are being collected from the pastures and exclusion areas to determine dry matter disappearance on the pastures. In November, at the start of breeding, the cows will start being fed harvested feeds on the dormant pasture to ensure they are in a positive energy balance. In January, the pairs will move to grazing corn residue and be supplemented with distillers grains. While cow-calf pairs are being fed harvested feeds on dormant pasture and when grazing corn residue, calves will have access to alfalfa hay via a fence line creep. In the middle of February, the calves will be weaned and moved to a drylot.

For the confinement system, cows have been fed a corn residue and distillers based diet in drylot since February and will remain in drylot until November. Dry matter offered to the drylot system is being recorded and will be used in future economic analysis. In October, pairs will be moved to a late summer planted oats-brassica mix. Each group will be given 80 ac and will graze till January. Then pairs will move to corn residue and be supplemented similar to the perennial based system. When in drylot and on corn residue, calves will have access to alfalfa hay via a fence line creep. At weaning the cows will move back to a drylot.

Calving for the first calf crop started in August. Producers have indicated concern about the health of calves in confinement. Very little information is available to compare confinement situations to traditional pasture-based systems. In both cases, benchmarks would enhance producers' ability to understand and manage disease. Therefore, records to enable use of standardized case definitions for common diseases will be kept to assist in assessing risk of health issues.

An Animal Research Technician was hired in May to support the project.

Project 5: Predicting Consequences of Changing Systems: Economic and Production Parameters

Lead Project Investigator: Jay Parsons, Associate Professor, Department of Agricultural Economics, University of Nebraska-Lincoln

Justification: Agricultural production systems are complex interactions between many biological, environmental, and human factors. A study of such systems, especially integrated crop-livestock production systems, is difficult and time consuming to complete using experimental trials. This project will leverage the data produced from experimental production system trials into computer simulated case study farms that will provide a foundation for testing the proposed systems for robustness and resiliency. The case study models will be used to identify key variables, assess various risk scenarios, and test proposed new systems that will guide future research.

Collaborators: Mary Drewnoski, Associate Professor, Department of Animal Science, University of Nebraska-Lincoln; Daren Redfearn, Associate Professor, Department of Agronomy & Horticulture, University of Nebraska-Lincoln; James MacDonald, Professor, Department of Animal Science, University of Nebraska-Lincoln; Mitchell Stephenson, Assistant Professor, Panhandle Research & Extension Center, University of Nebraska; and Matt Spangler, Professor, Department of Animal Science, University of Nebraska-Lincoln.

Summary: [Objectives III and IV. Model factors that improve beef production efficiency on ranches and farms and simulate production system scenarios with data-driven models.] A simulated case study farm using the systems modeling software AnyLogic was completed this project year. The model was built to simulate a corn-soybean rotation farm incorporating spring grazing of winter rye planted after soybeans with intent to graze with growing calves during April. AnyLogic allows for the inclusion of an object oriented agent (farmer) in the model to make a decision on April 1 each year on how many cattle to purchase for grazing or whether to purchase any cattle at all based on the amount of forage available. A rye growth function is incorporated into the model using local weather data to determine daily changes in accumulated above ground biomass. Eleven years of data (2007-2017) were used in the model. In three of the 11 years, no cattle were purchased due to insufficient biomass production. Net returns to the rye-cattle grazing component of the system were only positive in three of the 11 years. The major risks were weather (rye biomass production) and cattle markets. Declining cattle market prices from April 1 to April 30 presents the major risk to the system. This risk is higher during a high cattle price scenario than it is during a low cattle price scenario. Agricultural Economics M.S. student Eric Coufal orally defended his thesis in November based on this work, completed all revisions to his thesis in the spring and graduated in May 2019.

Katie Cumming also completed her M.S. degree in Agricultural Economics in May 2019. Her thesis was titled "Examining the capacity of Nebraska rangelands for cattle production and evaluating drought management strategies." She used USDA-NASS data from the 2012 Census of Agriculture along with NRCS provided data estimating the potential perennial forage production for grazing on a county-by-county basis to study the supply and demand for perennial grass forage. Her conclusions were that Nebraska cattle demand for grazing and the potential supply of perennial grass for grazing were pretty well matched under the assumption of 25% grazing efficiency. The economic value of the grazing lands in Nebraska were estimated at $875 million annually based on grazing rental rates per AUM across eight different regions of Nebraska. Katie's work was published in the Western Economics Forum in the Spring of 2019.

There are no significant setbacks to report at this time. Two new Ph.D. students will start work on the project in the fall of 2019. Both will be focused on modeling with more focused on the annual forage grazing scenario and the other more focused on perennial grass.

Outputs:

Graduate Students Completing Degrees in 2018-19

Katelyn Cumming, 2017-2019, Masters committee chair. Examining the capacity of Nebraska rangelands for cattle production and evaluating drought management strategies. Department of Agricultural Economics.

Eric Coufal, 2016-2019, Masters committee chair. Modeling and economic analysis of a crop-livestock production system incorporating cereal rye as a forage. Department of Agricultural Economics.

Publications in Peer-Reviewed Journals

Cumming, K., Parsons, J., Schacht, W., and Baskerville, B. (2019). Examining the Capacity of Nebraska Rangelands for Cattle Production. *Western Economics Forum*, 17(1):46-61.

Bastian, C. T. and J. Parsons. (2019). Western rangelands: A tale of conservation, grazing, resource policy, and economic implications. *Western Economics Forum*, 17(1):5-8.

Redfearn, D., J. Parsons, M. Drewnoski, M. Schmer, R. Mitchell, J. MacDonald, J. Farney, and A. Smart. (2019). Assessing the Value of Grazed Corn Residue for Crop and Cattle Producers. *Agric. Environ. Lett.* 4:180066. doi:10.2134/ael2018.12.0066.

Professional Conference Presentations

Proctor, C.A., E. Haramoto, D.D. Redfearn, J. Parsons, A.J. McMechan, R.W. Elmore, L.E. Lindsey, M. Drewnoski, S.R. Everhart, R. Werle, and J. Wehrbein. "Impact of Planting Date on Fall Seeded Cover Crops Biomass Production." Poster presentation. American Society of Agronomy Annual Meeting. Baltimore, MD. November 6, 2018.

Project 6: Producer and Community Outreach through Extension

Lead Project Investigator: Mary Drewnoski, Associate Professor, Department of Animal Science, University of Nebraska-Lincoln

Justification: Decision making in farming and ranching is extremely complex as it often involves several interacting factors such as impacts on the soil, plants, animals, economics as well as social aspects. In addition to using the information produced as a part of the research component of this project, extension personnel will work with producers currently using management practices being examined and those interested in adopting new practices to serve as case studies/ demonstration sites. The team will develop and deliver information, and conduct educational activities that will enhance stakeholder understanding of:

- Grazing management effects on harvest efficiency and long-term productivity of perennial grassland,
- Avenues for developing new or expanding existing beef enterprises by incorporating cattle into cropping systems, and
- Beef cattle impacts on ecosystem services.

Collaborators: Daren Redfearn, Associate Professor, Department of Agronomy & Horticulture, University of Nebraska-Lincoln; Jay Parsons, Associate Professor, Department of Agricultural Economics, University of Nebraska-Lincoln; James MacDonald, Professor, Department of Animal Science, University of Nebraska-Lincoln; Mitchell Stephenson, Assistant Professor, Panhandle Research & Extension Center, University of Nebraska-Lincoln; and Harvey Freetly, Researcher, USDA MARC, and Adjunct Professor, Department of Animal Science, University of Nebraska-Lincoln

Summary: In 2017, the University of Nebraska-Lincoln Institute of Agricultural and Natural Resources (IANR) and Nebraska Extension made a commitment to implement a multidisciplinary Beef Systems Initiative (BSI). The BSI is administered by the Center for Grassland Studies and is comprised of six projects designed to develop and support implementation of beef production systems that optimize feed resource use, natural resources conservation, and producer success in Nebraska through improved management of perennial grasslands and systems of integrated crop-beef cattle production. In addition to the BSI, a parallel project funded by the Foundation for Food and Agriculture Research (FFAR) is studying the best practices for incorporating beef cattle onto cropping systems while improving ecosystem services to ensure sustainability. Both of these efforts include components focused on producer and community outreach through Nebraska Extension. To this end, an agricultural lenders panel and five geographically identified producer panels have been formed to provide input and feedback on the project results as they become available. Recently, the lenders panel met for the first time to provide their perspectives about the important information that should be communicated to producers who are considering developing an integrated beef enterprise.

The lender panel consists of eight agricultural lenders associated with banks located throughout Nebraska. The lenders were asked ahead of time to consider two different scenarios: (1) the possibility of a producer looking to add a new enterprise to their operation and (2) the possibility of a producer looking to expand their operation to accommodate the next generation returning to the farm or ranch. They were then asked to consider the question, "what are the key pieces a lender would like to see from a producer seeking financing that would support one or both of these scenarios, especially in the case where the new enterprise is something in which the producer has very little or no experience?"

The lenders provided many insightful comments, but three key themes came up consistently during the discussion.

Cash flow sensitivity analysis

All of the lenders emphasized the importance of completing a thorough cash flow analysis. Producers need to understand a one-year snapshot of expectations is not enough. A three-year cash flow projection would be ideal to provide to a lender when seeking a loan for a new enterprise or an enterprise expansion. Producers should also consider what will happen in a bad year. A sensitivity analysis that includes a worst-case scenario is extremely important information to have available to share with their lender. Multiple lenders described a need for validation of the cash flow. In particular, it is important to make sure all expenses are included and, in the case of a new enterprise, provide information about the origin of the numbers. If the farm is expanding to support more families, it is especially important to validate that family living expenses are being fully accounted for in the projections.

Cattle industry learning curve

Several lenders expressed concerns about the cattle industry learning curve for producers looking to add a cattle enterprise to their operation. One lender described looking for evidence that the producer has a commitment to the cattle industry with a good network of people to work with including a nutritionist and relationships with feedlot operators. Others described producers new to the cattle industry not understanding the scale needed to make it work from an income standpoint. For example, do they understand how many cows it will take to feed a family? Do they have enough capital and access to enough pasture to make it work? Do potential new cattle producers understand the commitment and effort needed to make a cow herd a success?

Beginning farmer barriers

All of the lenders acknowledged that significant barriers impede the flow of new and beginning farmers and ranchers getting started in the business. Farm Service Agency (FSA) programs and various other beginning farmer programs accessible through banks can help, but there are still major issues of concern. Land costs place a tremendous burden on cash flow commitments. At present, there is little chance for the younger generation to start without investor help or significant off-farm income. One lender mentioned that interest from the next generation in beginning a new enterprise has declined over the last six years. Another lender described how some older producers in their area are actively seeking someone from the next generation that is interested in taking over the farm someday.

One other item came up that seemed to have consensus among the lenders, the need for Standard Performance Analysis (SPA) type of data. SPA data allows cattle producers to compare their operation with other producers in the industry. Among the primary things mentioned during this discussion was the importance of understanding cost of production and costs per cow.

Future plans are to continue online meetings with the lender panel over the next two years and an in-person meeting after that when more research results are available. One of the primary purposes of the in-person meeting will be to elicit input from the lenders on the best approach to synthesizing the research results into effective educational programming for producers and other agribusiness audiences. In the meantime, our conversations with the lenders will continue to explore ways to collaborate on communicating with producers.

Research reported in this publication was supported by the Foundation for Food and Agriculture Research under award number 534675 and the Beef Systems Initiative at the Institute of Agricultural and Natural Resources, University of Nebraska-Lincoln.

Prepared by Jay Parsons, Daren Redfearn and Mary Drewnoski

Other Highlights: The priorities identified in the producer panel last year was used to develop a proposal submitted to North Central SARE to fund work on confinement cows systems and calf health evaluation. The submission was awarded and well provide $199, 642 to support the work at USMARC (in which support for a technician was provided from BSI), new confinement cow work PHREC, on-farm research related to calf health and extension programing (funding to begin in November).

SUMMARY OF EXPENDITURES FOR YEAR 2 OF THE BEEF SYSTEMS INITIATIVE

Funding:

- The unit matches are still being identified. ARD has back-stopped that portion so that we ensure the funds are there for the entire plan-of-work to be completed.
- A no-cost time extension for one year is requested as a result of weather effects on treatments in Year 1.
- Year 3 funding has been loaded for only four accounts ($219,845.00 in total) with negative balances. The remaining three accounts had a carryover from previous years.

	Year 3 budget load requested 09/05		
	Budget Yr 3	Loaded	Remaining
MacDonald	$ 96,496.00	$ 96,496.00	$ -
Drewnoski	$ 60,093.00	$ -	$ 60,093.00
Redfearn	$ 63,345.00	$ 63,345.00	$ -
Blanco	$ 20,663.00	$ -	$ 20,663.00
Parsons	$ 58,649.00	$ 48,334.00	$ 10,315.00
Stephenson	$ 79,126.00	$ -	$ 79,126.00
Data Mgr	$ 11,670.00	$ 11,670.00	$ -
total	$390,042.00	$219,845.00	$ 170,197.00

Expenditures:

WBS	Description	Revenue Received	Carryforward from Y1	Expended Personnel	Non-Pers	Commitments Pers	Non-P	Available Revenue
26-6261-0012	Beef Systems Initiative							
26-6261-0012-001	BSI Overall	11,670	-	0	-6,128	0	0	5,542
26-6261-0012-002	BSI MacDonald	93,895	1,883	-69,323	-1,172	0	0	25,284
26-6261-0012-003	BSI Drewnoski	58,524	36,195	-8,276	0	0	0	86,443
26-6261-0012-004	BSI Redfearn	61,689	5,058	-40,134	-2,858	0	0	23,755
26-6261-0012-041	BSI Blanco	20,018	0	0	0	0	0	20,018
26-6261-0012-005	BSI Parsons	56,853	16,138	-19,791	0	0	0	53,200
26-6261-0012-006	BSI Stephenson	77,077	73,447	-9,263	-5,889	0	0	135,372
26-6261-0012	Total BSI	379,726	132,721	-146,788	-16,046	0	0	349,613

***Land Resource Allocation**:* A Memorandum between ENREC and the Beef Systems Initiative has been developed to ensure adequate land resources dedicated to the BSI to complete the duration of the project. The land will be managed specifically for the BSI experimentation (**Appendix 1**).

APPENDIX 1
PROGRAMMING AGREEMENT EASTERN NEBRASKA RESEARCH AND EXTENSION CENTER – MEAD AND ANIMAL SCIENCE

Programming Agreement
Eastern Nebraska Research and Extension Center – Mead and Animal Science

Beef Systems Project
James MacDonald, Project Leader
October 28, 2019

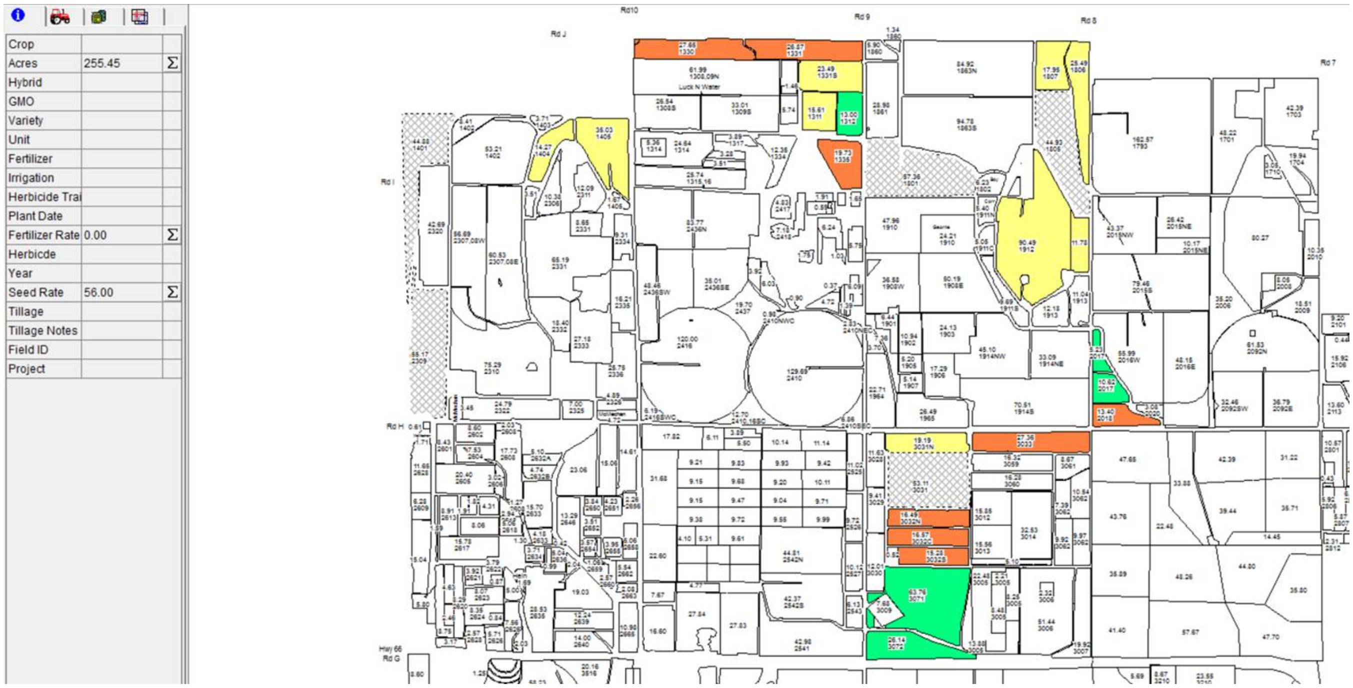
1) In an effort to fully support the Integrated Beef Systems Project, the following outlines that an additional 250 acres of crop ground located on the ENREC – Mead facility, will be provided for each of the crop years, 2020, 2021, and 2022 (see attached maps below). These acres will be utilized by the project for the purposes of Fall/Winter grazing of forage oats by the Alternative Cow group. This will enable the project to keep all cattle involved in this project on the ENREC-Mead facility and will not require seeking acres for this purpose offsite.

2) The following fields will be added to the project to meet the 250 acres per year goal. Fields include 1401, 2309, 1404/05, 1331S, 1311, 3071 and 3072. These fields will be added to the CAP fields/acres provided by Husker Genetics.

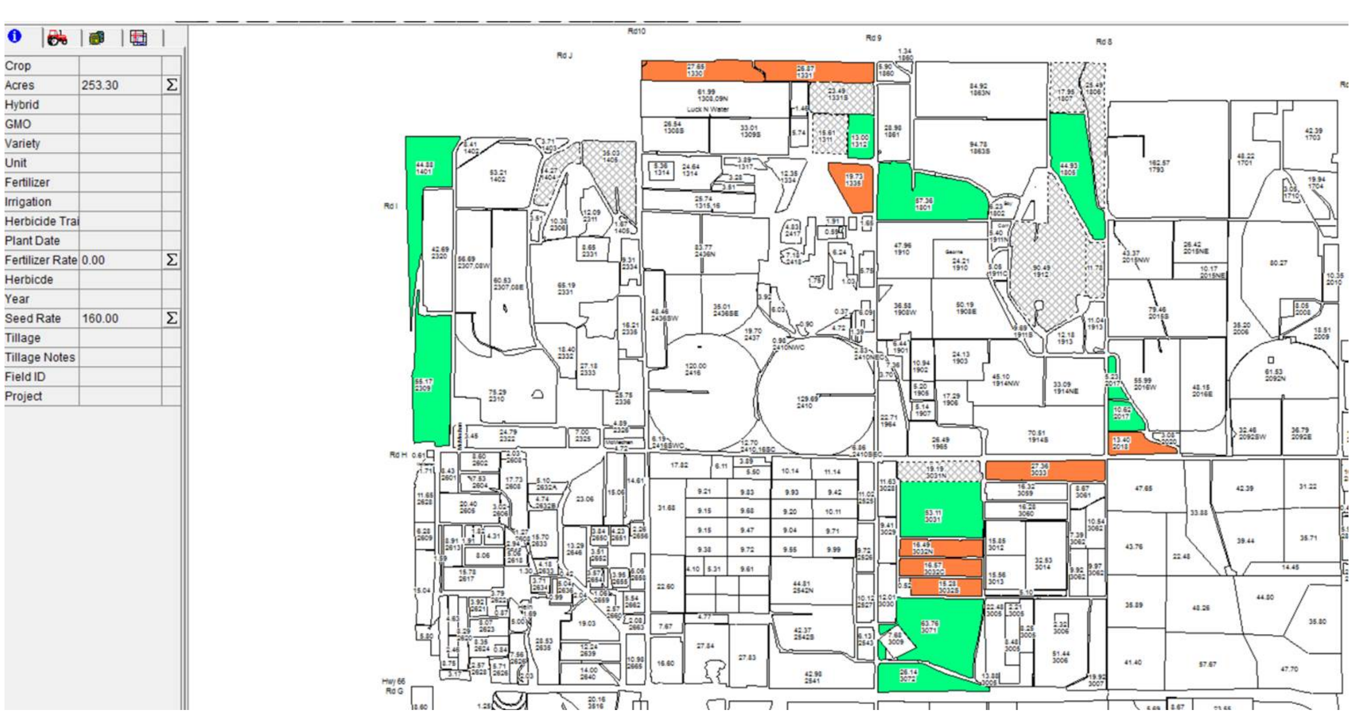
3) While the original intent of this agreement is to provide wheat acres that can subsequently be planted to forage oats, it is possible that crops other than wheat can be planted with forage oats subsequently planted for fall/winter grazing. A decision on specific crops instead of wheat will be jointly decided on by Project Research Faculty, Manager of ENREC – Mead Operations and the Director of Husker Genetics.

4) Any proposed changes to this agreement, by any party involved in the project, will be submitted to the Director of the Eastern Nebraska Research and Extension Center and in consultation with the Project Leader, the Manager of ENREC - Mead Operations and the Director of Husker Genetics, all proposed changes will be considered and made following agreement by all involved.

Crop Year 2020 – Wheat followed by Forage Oats Hatched Fields – 255 acres (Hatched areas to be seeded to wheat 2019 fall) (Crop legends showing only for current 2019 crop)



Crop Year 2021 – Wheat followed by Forage Oats Hatched Fields – 253 acres (Hatched Area) (Crop legends not correct)



Crop Year 2022 – Wheat followed by Forage Oats Hatched Fields – 253 acres (Hatched Area) (Crop legends not correct) **(Last Year of Project)**

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Head, Animal Science Department Date

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Director, Husker Genetics Date

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Director, Eastern Nebraska Research Date

And Extension Center