FINAL REPORT
Dickinson Research Extension Center

This is the final report for USDA/NIFA/AFRI project titled, "Back to the Future: Enhancing Food Security and farm Production with Integrated Crop-Livestock Production Systems"

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Project Summary

The Dickinson Research Extension Center is conducting a long-term (10-year) integrated crop and livestock study to evaluate change in soil health parameters, greenhouse gas emissions, rotation crop production, and beef cattle production from selected crops within the rotation. Improving soil health is a primary objective of the research with a goal to reduce crop inputs as much as possible while at the same time maintaining crop and beef cattle production. The integrated crop and livestock system incorporates the five soil health principles: 1) maintaining soil armor through residue maintenance, 2) minimizing soil disturbance using no-till seeding and planting, 3) employing plant diversity using a 5-crop rotation of cool- and warm-season grass and broadleaf plants, 4) maintaining a live plant or root in the soil as long as possible, and 5) integrating livestock grazing into the cropping system. Fertilizer inputs have been reduced and net return for spring wheat grown in rotation is $37/ha greater than control continuously grown spring wheat. During the 2-year period of this study, in 2016 crop and yearling steer growth was normal and tended to favor steers that were grown grazing annual forages in the integrated cropping system. However, 2017 was extremely dry. Annual forage grazing crop yields were reduced. Steer grazing gain from field pea-barley and cover crop were reduced, and in the case of cover crop the number of days of grazing was reduced by more than 50% and average daily gain (ADG) loss was -1.25 kg/ha. However, when grazing corn, the number of steer grazing days was reduced as well, but ADG was 1.62 kg/ha, which was remarkable considering the season. Soil samples were collected from 0 to 60 cm in 2016 and 2017. Preliminary results indicate that the cropping sequence did not impact soil bulk density, organic carbon, total nitrogen, microbial biomass carbon and nitrogen, water retention, carbon fractions, urease and beta-glucosidase enzyme activity. However, soil surface depth BD (0-5 cm) was greater in grazed areas compared to the ungrazed sites. The integrated crop-livestock system can be considered neutral to beneficial for soil. Greenhouse gas emissions for nitrous oxide (N_2O) were highest in the spring wheat (Control) treatment. Crop rotation did not affect N_2O fluxes, but grazing did affect N_2O emission. With respect to carbon dioxide - CO_2 and methane - CH_4 fluxes, rotation and grazing treatments did not influence these fluxes. Extension outreach and publication are critical aspects of the research. During the 2-year period of this

research, there were nine Café style crop-livestock producer group meetings, seven invited program speaker presentations, three North Dakota Beef Reports published, two referred journal manuscripts submitted and under review, and three professional society abstracts. Specific details of the research follow in the sections below.

Objective 1 Environmental Sustainability

Task 3. ***Trace gas fluxes from ICL systems*** (Samples collected by Douglas Landblom and Songül Şentürklü)

A second GHG sampling regime for the project included the 2017 growing season from July 10 through October 16, 2017. When ambient temperature declined to 0 º C, weekly sampling was discontinued. The trace gas flux (carbon dioxide – CO_2, methane – CH_4, and nitrous oxide – N_2O) collections obtained from control spring wheat and forage grazing crops (field pea-barley, unharvested corn) were from within the 5-crop rotation that included grazed and ungrazed chamber sampling sites. Data collection included 12 ml of gas aspirated from the chambers at 0, 20, and 40-minute intervals, and stored in sealed vials. Chamber temperatures were recorded at start time (0 minutes) and end of sampling (40 minutes), and soil moisture was taken at start time (0 minutes) and end of sampling (40 minutes) in close proximity to the collection chambers via portable soil moisture meter.

Soil Bulk Density (Samples collected by Douglas Landblom and Songül Şentürklü)
Soil samples for bulk density determination were collected in late June for subsequent analysis using a soil bulk density hammer collection tool.

Objective 2. Crop and Livestock Performance in Integrated Crop-Livestock Systems

Task 2. ***Livestock Performance*** (NDSU - Dickinson Research Extension Center – Douglas Landblom and Songül Şentürklü, Animal Scientists)

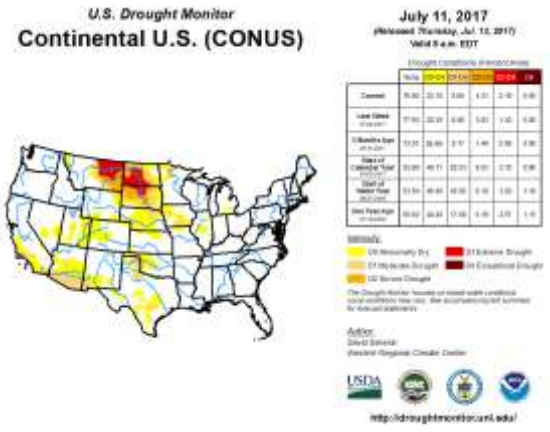

Figure 1

During the 2017 grazing season, yearling Angus x Red Angus x Simental crossbred beef cattle steers grazed within a diverse crop rotation established in 2011that included annual crops (ANN) and compared to similar steers that grazed native range pastures (NR). The cropping system compares spring wheat grown continuously with spring wheat grown within a 5-crop rotation consisting of spring wheat, relay cover crop (fall seeded winter triticale and hairy vetch (THV) followed by cover crop after hay harvest), forage corn, field pea-forage barley intercrop (pea-barley), and sunflowers. In the rotation, spring wheat and sunflower are grown as cash crops whereas pea-barley, corn, and cover crop are grown for grazing and future sale at the end of grazing (calculated sale based on current market price), or retained through finishing and slaughtered.

The 2017 growing season was extremely dry and classified as D3 according to the U.S. Drought Monitor classification system (Figure 1). September and October 2016 were months with above average precipitation, which was instrumental for cool-season spring wheat and field pea-barley crop yields in 2017. Spring wheat yields for rotation and control treatments were 68 to 90% of the preceding 6-year average yield. Field pea-barley intercrop yield was 62% of the preceding 6-year yield history. Winter triticale-hairy vetch (THV) yield was 42% of the 6-year yield history. Winter crop injury contributed to the THV stand reduction.

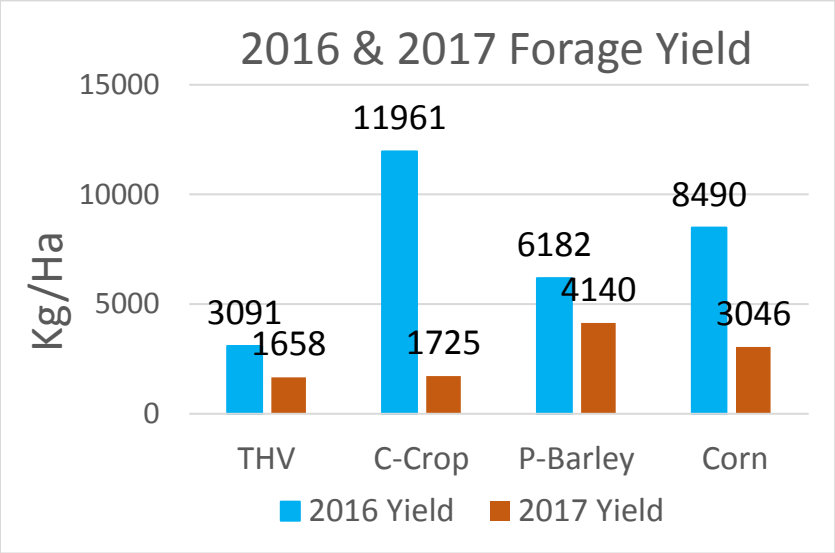

Figure 2

Comparing cool-season crops to warm-season crops (sunflower, corn, and cover crops), yield reduction for warm-season crops in the rotation was more pronounced. Sunflower and corn germination issues reduced plant density/ha. Corn and sunflower yields were 33 and 37% of the 6-year average, respectively. Cover crop planted late in June after THV hay harvest did not germinate until measureable precipitation occurred 5 weeks later. Delayed germination reduced cover crop yield to 28% of long-term 6-year yield. Forage yields shown in Figure 2; illustrate large forage yield differences measured between 2016 and 2017. Before the integrated systems annual forage grazing started, yearling steers grazed NR from May 4 to July 11 (68 d). Annual forage grazing started with field pea-barley from July 12 to August 16 (36 d). Forage corn grazing ran from August 16 to September 28 (43 d). Because of the drought, the 13-species cover crop was not ready to graze on September 28; therefore, the steers grazed a set aside holding pasture comprised of mature bromegrass and crested wheatgrass from September 28 to October 11 (13 d) and then grazed cover crop fields from October 11

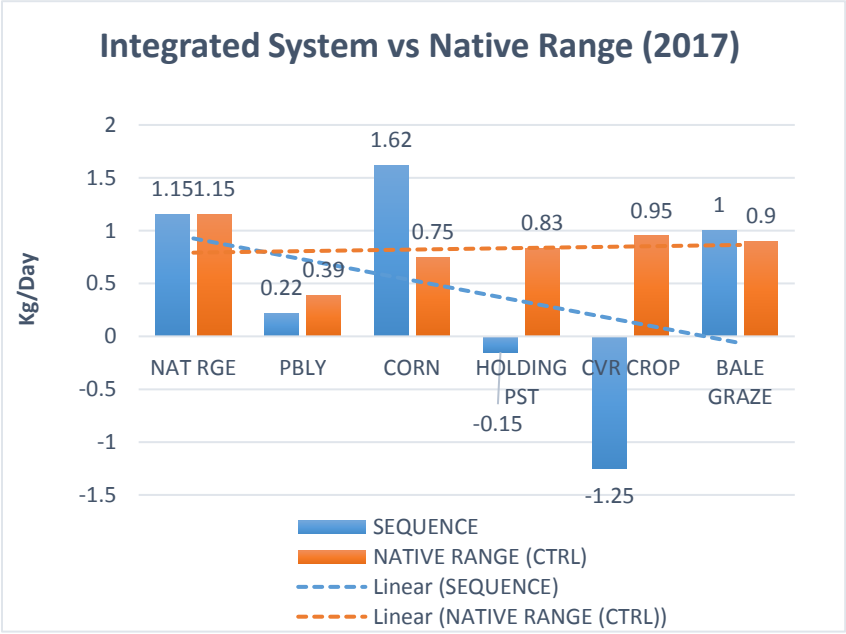

Figure 3

to October 23 (12 d). When the ANN steers were grazing in the set aside field, frost damaged cover crop plant tissue resulting in steer average daily gain losses of -1.25 kg/day (Figure 3). Steers grazing NR, however, did not experience the negative impact of the drought like that of the ANN forage steers, as depicted by the ANN sequence linear trend line in Figure 3. The NR steers gained 0.91 and 0.90 kg/day in 2016 and 2017, respectively (Figure 3 and Figure 4) in spite of the extreme drought of 2017. Evaluating the effect of growing season precipitation more closely, 2016-weight gain per day for the integrated system steers varied, but fluctuated less for the ANN forage steers compared to the NR control steers as depicted by the linear trend line (Figure 4). Precipitation in year-1 (2016, Figure 4) and year-2 (2017, Figure 3) impacted grazing treatment animal performance both years, however, the effect was greatest for the NR control in year-1 and the ANN forage sequence grazing year-2. With normal precipitation, ANN forages supported a more consistent steer growth profile compared to NR steers in 2016, in which gain stalled during the warmest part of the summer. Above normal 2016 fall precipitation in September and October effected 2017 spring NR pasture growth and subsequently NR steer gain performance depicted by the NR trend line for NR in Figure 3. There was sufficient available NR forage to support steer gains that fluctuated less compared to the ANN forage steer gains that were dependent on in-season precipitation for forage plant germination and crop yield.

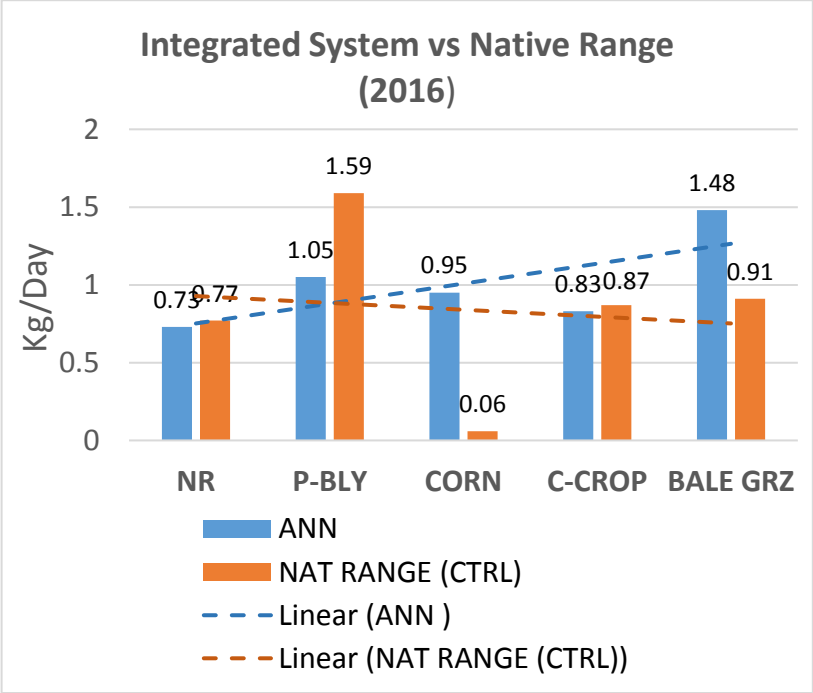

Figure 4

Relay crops such as the combination of winter THV followed by cover crop in the same growing season are very dependent on in-season precipitation as evidenced by cropping history from 2011 to 2017. During the 7-year period, 57.1% of the years relay crop yield received a very good rating, 28.6% of the years relay crop yield was reduced, and 14.3% of the years, at least one of the relay crop plantings did not germinate and were abandoned. Cover crop growth in 2017 impacted by insults from drought and frost damage to the extent that the crop would not support adequate ADG. This 7-year period is a relatively short; however, this crop history data indicate that relay crops similar to the one evaluated in this study in western North Dakota have a probability for successful crop yields 6 out 10 years.

Further extending the period of non-confinement outside of feedlots by feeding cover crop bales (Bale Grazing) 42 d (2016) and 56 d (2017) from October 23 to December 18 resulted in gain recovery from losing -1.25 kg/day to gaining 1.0 kg/day (Figure 3). During the same timeframe, NR steer gain was unchanged ranging from 0.95 to 0.90 kg/day for the 2017 ANN forage steers. Feeding cover crop hay bales after ANN forage and NR grazed increases non-

confinement steer gain prior to feedlot entry and, for the 2-year extended grazing study, daily gains averaged 1.24 and 0.91 kg/d for the ANN and NR steers, respectively.

Steer feedlot performance was not reported during the last reporting period, because the steers remained on feed in the feedlot at the end of the reporting period. Feedlot performance for both treatment groups paralleled one another for all criteria measured. Steer ratio of gain to feed efficiency was 0.127 vs. 0.124 gain units for the NR and ANN forage sequence steers, and total feedlot cost per steer was $346.11 vs. $351.93 for the NR and ANN steers, respectively.

Objective 5 Education and Outreach

Task 1. ***Educate stakeholders and producers*****.** (NDSU - Douglas Landblom and Songül Şentürklü, Animal Scientists; F. Brummer, Resigned;)

During the reporting period, Songül Şentürklü and Douglas Landblom representing the Dickinson Research Extension Center, in conjunction Dickinson State University and NRCS personnel, coordinated and conducted a Soil, Crop and Livestock Workshop titled, "Healthy Soils = Healthy Environment & More Profit". The workshop attendees included interested university students from the 3-state region (North and South Dakota and Montana), research and agency personnel, and individuals from the urban and farming community, news media, and other interested stakeholders. Attendees heard presentations by Jon Stika, retired NRCS soil scientist, Dr. Dwayne Beck, Agronomist and Director, Dakota Lakes Research Farm, Dr. Joshua Steffan, DSU Natural Resources Educator, Hal Weiser, NRCS Cover Crop Specialist, farmers Darrell Oswald and Derrick Dukart, and Songül Şentürklü presented a discussion on the effect of soil health on crop and livestock production. During the afternoon program, attendees toured the cropping system, participated in hands-on field soil discussions of aggregation, mycorrhizal fungi, residue, earthworms, farming practices, and the potential for farming without fertilizer. One hundred-ten people attended the workshop.

Extension Meetings, Invited Speaker Presentations, and Publications: (data and PPT presentations prepared by Songül Şentürklü and Douglas Landblom)

Songül Şentürklü and Douglas Landblom summarized data and prepared PowerPoint presentations for outreach programming delivered to farmers and ranchers in small group and scientific meetings, and publications during the reporting period.

Small Group County Café Meetings and Crop Improvement Association Meetings:

Pierce, McIntosh, Logan, McLean, Adams, Hettinger, Stark, Bowman, and Ward counties in North Dakota.

Invited Program Speaker (Doug Landblom):

Northern Nebraska Cattlemen's Alliance Annual Meeting:
Chadron State College – Farm and Ranch Management class guest speaker (Ron Bolze, class)

South Dakota State University, Extension Agronomy Program, Managing Soil:
Maximizing Profit, Sioux Falls, SD

North Dakota Soil Conservation Districts Annual Meeting, Bismarck, ND

ND Soil and Water Conservation Society Annual Meeting, Bismarck State College, Bismarck, ND

Midwest Soil Health Summit Annual Meeting, Fergus Falls, MN (Two Invitations)

Publications:

Songül Şentürklü and Douglas Landblom, 2017. Stockpiled grass and crop-residue grazing reduce cow wintering cost. North Dakota Beef Report (AS1862), pp 25-29.

Songül Şentürklü, Douglas Landblom and Steve Paisley. 2017. Steer performance, carcass measurements and value of rotation crop, cover crop and bale grazing in western North Dakota. North Dakota Beef Report (AS1862), pp 49-52.

Şentürklü, S., D. G. Landblom, R. J. Maddock, T. Petry, and S. I. Paisley. 2017. Effect of retained ownership and vertical integration within an integrated cropping system among yearling steers of differing frame score on feedlot performance, carcass measurements, and systems economics following delayed feedlot entry. Proceedings, West. Sec., Am. Soc. Anim. Sci., Vol. 68:203-207 (Abst.).

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Şentürklü, S., D. G. Landblom, R. J. Maddock, and S. I. Paisley. 2016. Effect of two beef cattle yearling steer production systems on grazing and feedlot performance, carcass measurements and systems economics. North Dakota Beef Report (AS1815), pp 15-20.

Prashansa Shrestha, Songül Şentürklü, Heidi L. Sieverding, Douglas Landblom, and James J. Stone. 2017. Life cycle assessment on overwintering bred beef cattle for integrated crop-livestock potential in North Dakota, USA. Animals Journal (Submitted – In Review).

Liming Lai, Navdeep Singh, Hanxiao Feng, Douglas Landblom, Songül Şentürklü, Kris Ringwall, and Sandeep Kumar. 2017. Effects of crop rotation and grazing in an ICLS on greenhouse gas emissions in Northern Great Plains. Proceedings, Managing Global resources for a Secure Future Annual Meeting, Tampa, Florida (Abst). https://scisoc.confex.com/crops/2017am/webprogram/Paper105818.html (Accessed 9-2-2018).

Hanxiao Feng, Douglas Landblom, Songül Şentürklü, Liming Lai, Kris Ringwall, and Sandeep Kumar. 2017. Impacts of integrated crop-livestock system on soil health parameters in North Dakota. Proceedings, Managing Global resources for a Secure Future

Annual Meeting, Tampa, Florida (Poster 1126). https://scisoc.confex.com/crops/2017am/webprogram/Paper105795.html (Accessed 9-2-2018).