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Livestock Research

Improving Cool-Season Pastures with Interseeding Annuals and Grazing, Update 2016

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In a Nutshell

- Interseeding annuals into pastures increases forage diversity, quality, and quantity.
- Bruce Carney developed seed mixtures and interseeded them into existing cool season pastures.
- Seed mixtures vastly increased pasture diversity.
- Grazing management to harvest or trample forage at the right time and to a proper degree is essential to feed both livestock and soil microbes.

Key findings

- During the establishment year in 2014, few advantages were seen in grazing days or forage yield, but a baseline was established for future comparison.
- In 2015, two fields were seeded once with a cool season mix, and one field was seeded multiple times with cool and warm season mixes.
- Total tons of dry matter harvested by cattle or baled was greater in 2015 than 2014; animal unit days provided from forage produced were doubled from year 2014 to year 2015.
- After multiple interseedings and two years of rotational grazing on three pastures, compaction near the soil surface (<6 inches) increased but decreased deeper down (>21 inches).

Project Timeline:
May 2014 - April 2016

Bruce and his cattle at Carney Family Farms near Maxwell.

Background

Interseeding cool season grass pastures can increase forage quantity and quality for grazing livestock. While grasses provide fiber and energy as carbohydrates, legume species add essential protein and are often more digestible (Cuomo et al., 2001). Warm-season annual forages flourish during hotter summer months when cool season forages are dormant. Diversifying one- or two-species pastures with other annual grasses, legumes, brassicas, or forbs supports a healthy pasture ecosystem and ensures that there will likely be something in the mix that can grow, whether dealing with drought or excessive precipitation (Sanderson et al., 2005). The soil ecosystem benefits from trampled forage, which adds organic matter (Franzluebbers and Stuedemann, 2010), and from diverse root systems, which relieve compaction, take up and recycle nutrients, and support microbial growth (Karlen and Cambardella, 1996). Over the last two years, PFI farmer-cooperator Bruce Carney has improved three pastures through interseeding multi-species cool and warm season forages mixes, followed by grazing or harvesting the forage.

Methods

This multi-year project was conducted by Bruce Carney of Carney Family Farms who raises grass-fed cattle near Maxwell in NE Polk County. Bruce consulted with Des Moines Feed Company (Des Moines, IA) to develop multi-species forage mixtures based on goals of improving grazing, soil health, nitrogen production and compaction. These mixtures were drilled or broadcast into three existing pastures that had been flash-grazed or mechanically harvested to remove excess forage. Pasture 1 was seeded three times over the course of one year; with a cool season mix in October 2014, a warm and cool season mix in June 2015, and a cool season mix in September 2015. Pastures 2 and 3 were seeded with a cool season mix in April 2015, and then pasture 3 was seeded with a cool season mix again in September (**Table 1**).

Seed mixes planted during the first spring of the project (2014) can be found in the initial report published on the PFI webpage (Chamas, 2015).

Species diversity was determined using the line transect method. The forage species found every six inches along a 100-ft line was identified, at two sites per pasture, once in early spring and once in midsummer, just prior to major grazing events. Also, forage quantity prior to grazing was measured by clipping all forage in five 1-ft^2 quadrats in each pasture, air drying the forage, and weighing it. Bruce also reported the grazing use of pastures by noting when cattle grazed, the duration of grazing and how and how many cattle grazed in each pasture.

Bruce established a baseline for his soil components in 2014 using the Haney test (Ward Labs Inc., Kearney NE), and plans to take Haney tests every three years. Bruce also used a penetrometer to measure soil compaction at five sites per pasture, taking measurements at various soil depths.

Bruce has been seeding annual mixtures for two years and will continue for several more, to continue improving forage production, organic matter and overall soil health. Observed changes in pasture diversity, biomass production, forage quality and soil compaction are discussed in the following section.

Table 1

Interseeded pastures at Carney Family Farms for the 2015 grazing season.

Pasture	Size (ac)	Date Seeded	Treatment
First Seedings			
1	14.9	10/8/14	cool season forages, graze
2	12.7	4/22/15	cool season forages, graze
3	18.6	4/22/15	cool season forages, graze
Subsequent Seedings			
1	14.9	6/17/15	warm/cool season forages, harvest
1	21.1*	9/1/15	cool season forages, graze
3	18.6	9/22/15	cool season forages, graze

*Field 1 changed in size during the project; 6.2 acres were added in late summer 2015

Cows graze warm season annuals in early September 2015.

Results and Discussion

Seed mixes

Bruce drilled a variety of forage mixtures into existing pastures that are rotationally grazed. In the spring, he grazed hard, in order to weaken existing forage stands, giving the newly interseeded species a better chance of establishment and growth. Bruce seeded pasture 1 three different times, pastures 2 once and pasture 3 twice. Bruce had intentions of seeding pastures 2 and 3 with a warm season mix during the summer, but the forage stand was plenty dense all season. "I'm not sure a warm season seeding would have established well because of the abundance of red clover in these pastures. 2015 provided the perfect environment for red clover to thrive, which helped carry my pastures throughout the grazing season," stated Bruce. The seed mixes, seeding dates, costs and harvest dates are shown in **Table 2**.

Table 2

Seed mixes, seeding and harvest dates, and cost for interseeded pastures for the 2015 grazing season.

Pasture	Date Seeded	Seed Mixes	Seed cost ($/ac)	Grazing date
First Seedings				
1	10/8/14	*cool season:* rye, wheat	$23.60	April, May, June
2	4/22/15	*cool season:* oats, buckwheat, rapeseed, turnip, barley, plantain, peas, chicory, crimson clover, kale, forage radish	$44.00	July, October, December
3	4/22/15	*cool season:* oats, buckwheat, rapeseed, turnip, barley, plantain, peas, chicory, crimson clover, kale, forage radish	$44.00	July, September, October, November
Subsequent Seedings				
1	6/17/15	*warm/cool season:* soybeans, German millet, pearl millet, buckwheat, forage radish, turnip, kale	$36.60	August (baled)
1	9/1/15	*cool season:* rye, wheat, oats, forage radish, rapeseed, hairy vetch	$36.55	October, November
3	9/22/15	*cool season:* rye, wheat	$16.00	November

Species Diversity

Forage species diversity increased as a result of the seedings, as shown in **Table 3**. In April 2015, the pastures contained seven to eight different forage species and about 16% bare ground. Data from April 2014 showed that the same pastures, one year before, contained an average of four species and about 25% bare ground (Chamas, 2015). Following interseeding and pasture growth over the 2015 grazing season diversity increased to over 13 species with no visible bare ground.

Table 3 shows that in pasture 1, annual grasses that over –wintered (cereal rye and wheat) made up the majority of the pasture in April. By August, annual legumes (soybeans) predominated, due to the warm season seeding in June. In pasture 2, perennial grasses (bluegrass and orchardgrass) made up half of the pasture in April. By June, the perennial grasses had died off and perennial legumes had taken over (red clover). In pasture 3, perennial grasses (brome and bluegrass) made up two thirds of the pasture in April. By June, brome and red clover each made up one third of the pasture, followed by brassicas (kale, radish, turnip, rapeseed) which made up 20% of the stand.

Table 3

Species diversity present in interseeded pastures in 2015

Pasture	**1**		**2**		**3**	
Sample Date	**4/28**	**8/12**	**4/28**	**7/7**	**4/28**	**7/7**
Species Count	8	13+	8	13+	7	13+
% Ground Cover						
Bare Ground	15.25	0	14.75	0	17.25	0
Annual Grass	37.75	29.25	0.50	16.0	0	5.25
Perennial Grass	4.75	4.0	50.75	4.25	67.5	33.0
Annual Legume	0	36.25	0	0	0	0
Perennial Legume	22.75	17.25	29.5	66.25	11.25	27.0
Brassicas	0	1.75	0	2.0	0	20.25
Weeds	19.50	11.50	4.50	11.50	4.0	14.50

The brassicas grew significantly better in pasture 3 than in pasture 2, even though both pastures were seeded with the same mix on the same date. Bruce attributes this two to things. The previous winter, Bruce fed hay on pasture 3 and not on pasture 2, which may have contributed to better fertilization of pasture 3 from deposition of dung and urine. Also, red clover made up 66% of forage in pasture 2, compared to 27% in pasture 3. "The flourishing red clover must have impeded brassica establishment and simply out-competed them," suggested Bruce. Although brassicas only made up a small portion of the pastures, Bruce noted, "I included brassicas in my warm season mix knowing they will grow late into the year, even after their first grazing, persisting after rye and wheat die off." Persistent growth and high nutrient content make these plants an important forage source for Bruce.

Table 4 shows species present as of April 2016. Cereal rye, a winter annual grass, was seeded in pastures 1 and 3 in September 2015 and grew back the following spring. Brassicas included in the September 2015 seeding did not overwinter. Orchardgrass, bromegrass and bluegrass made up the perennials grasses present, while white clover made up the majority of the perennial legumes present. Forage chicory, a perennial forb, was seeded for the first time in April 2015 in pastures 2 and 3, but by April 2016 was only observed in pasture 3.

Table 4

Species diversity present in interseeded pastures in April 2016

Pasture	**1**	**2**	**3**
Sample Date	**4/19**	**4/19**	**4/19**
Species Count	10	8	10
% Ground Cover			
Bare Ground	8.75	26.25	15.0
Annual Grass	14.25	0	7.25
Perennial Grass	20.75	49.0	42.25
Annual Legume	0	0	0
Perennial Legume	34.75	20.25	28.5
Brassicas	0	0	0
Forbs	0	0	1.25
Weeds	21.50	4.5	5.75

Biomass

Aboveground forage biomass was sampled in all pastures just prior to grazing (**Table 5**). All pastures produced three or more tons of dry matter (DM) per acre. Pasture 1, which received cool and warm season seedings, produced a total of 7.3 tons of DM per acre from May to August.

Bruce doubled his warm season forage production in pasture 1 from 2.1 tons DM/ac in 2014 (Chamas, 2015) to 4.3 tons DM/ac in 2015. June and July rainfall at Carney Family Farms totaled 17.5 inches in 2014 and 12.3 inches in 2015, compared to the long-term average of 9.5 inches (Iowa Environmental Mesonet, 2016). The abundant summer rainfall came when the warm-season forages were germinating and growing and helped to provide forage during the typical summer slump in August.

Table 5

Total aboveground forage dry matter (DM) yields from the interseeded pastures. Forage biomass was sampled just prior to grazing.

Pasture	**Treatment**	**Seeding**	**Sampling Date**	**Forage Production (lb DM/ac)**	**Forage Production (tons DM/ac)**
1	cool season	10/8/14	5/10/15	5,973	3.0
2	cool season	4/22/15	7/7/15	8,432	4.2
3	cool season	4/22/15	7/7/15	7,894	3.9
1	warm/cool season	6/17/15	8/12/15	8,528	4.3

Bruce thinks there are a number of factors at work in pasture 1 that are contributing to forage production. "The Haney Soil Health Test in 2014 told me that pasture 1 had more soil OM than the other pastures (4% compared to 2%), more N availability, a higher Solvita CO2 Burst score and an overall better soil health score. I know this pasture is holding more water, and root exudates from the multiple plant species are interacting to activate soil biology. The magic is happening in that field!" Bruce also added that this is the field closest to his house, so he's spread manure and fed hay on it more often than the other fields.

Table 6 **Grazing days and forage harvested by cattle or machine on interseeded pastures.**

Pasture	Size (ac)	Total grazing days	Total AUD	Total tons forage DM harvested	Total tons forage DM/ac harvested	Total AUD/ac
First Seedings						
1	21.1	20	2,829	36.8	1.7	130.7
2	12.7	19	1,572	20.4	1.6	123.8
3	18.6	21	1,894	24.6	1.3	101.8
Subsequent Seedings						
1 (baleage)	21.1	N/A	2,487	32.3	1.5	115.5
1	21.1	15	945	12.3	0.6	45.2
3	18.6	6	216	2.8	0.2	11.6

Table 7 **Forage quality from interseeded pastures just prior to grazing or harvesting.**

Pasture	Date Planted	Date Sampled	CP (%)	ADF (%)	aNDF (%)	Lignin (%)	Neg (Mcal/ctw)	RFV	RFQ
1	10/8/14	6/13/15	20.45	33.18	47.38	6.07	41.57	123.66	152.86
1 (baleage)	6/17/15	11/6/15	16.72	38.13	51.73	7.67	31.91	106.47	121.03
2	4/22/15	7/7/15	18.13	33.99	45.74	6.67	39.31	126.78	147.79
3	4/22/15	7/7/15	18.63	38.27	50.81	7.39	35.53	108.1	123.97

Grazing

Bruce grazed the pastures with mixed herds of cattle: fall- and spring-calving cows and calves, and grass-finishing calves from the previous year. His goals were both to feed the animals and the soil. "I'm always trying to use half and leave half of the forage," said Bruce, in order for uneaten forage to be trampled and incorporated into the soil to improve organic matter and nutrient cycling. "Hopefully the Haney Soil test will positively show this in a couple more years." Comparing forage produced to forage grazed shows that the herd was managed in a way where they were only allowed to graze around half or less of the biomass available. Forage utilized by the cattle and the forage harvested for baleage is shown in **Table 6**. Tonnage harvested was calculated by converting the animal unit days (AUD) into pounds of forage. Bruce knew the approximate weights of grazing cattle; every 1,000 lb is an animal unit (AU) and consumes about 26 lb forage DM per day (an AUD).

Pasture 1, which had three seedings, provided 291.4 AUD/ac. This includes 115.5 AUD/ac provided from the forage Bruce mechanically harvested on August 15, 2015 to make baleage, which he fed from January to March 2016. The baleage was fed in the same field it was harvested from, to return fertility to the soil. Not only did this seeding and harvest of annuals help carry his cattle through winter, it also provided better quality feed than the dry hay he would normally feed during cold months. Pasture 2, which was seeded once, provided 123.8 AUD/ac. Cattle were able to graze this pasture for 19 days, harvesting 1.6 tons of DM/ac, compared to 2014, when cattle harvested 0.75 tons of DM/ac in 10 days. Pasture 3, which was seeded twice, provided 113.4 AUD/ac. The second seeding of rye and wheat in late September of 2015 was grazed for six days in November.

In total, Bruce received 528.6 AUD/ac from the combined pastures, compared to 264.6 AUD/ac in 2014. He has worked out the math with other producers, and they have come to the conclusion that they need at least 400 AUD/ac to make a profit from grazing comparable to profits if the land was in row crop production.

Forage Quality

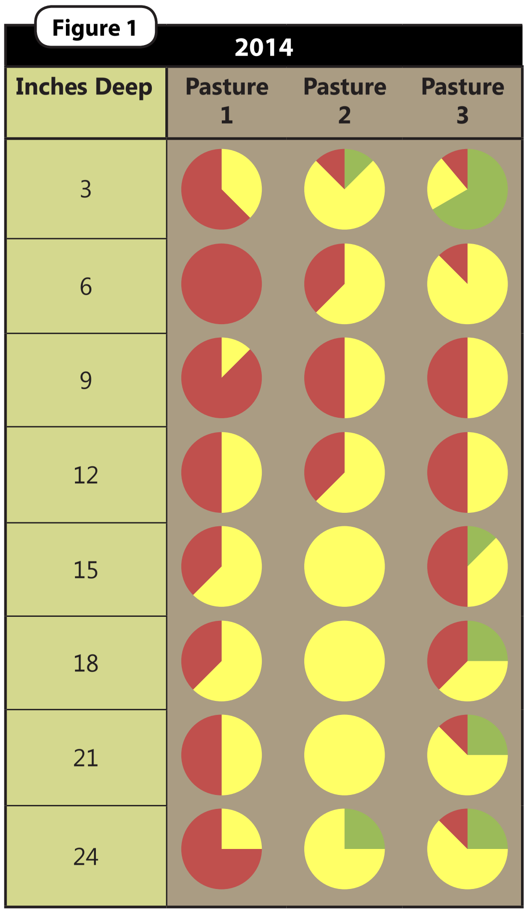
Not only did Bruce use annual forages to boost forage quantity, but also to increase forage quality, which is important for grass-finishing cattle. Forage quality just prior to grazing was fairly high for all pastures (**Table 7**). All pastures had adequate crude protein (CP) concentrations for cattle, and forage quality (RFQ) ranged from 121-152, indicating good-quality pasture. "The forage mixes I have in the pastures are higher quality for finishing grass-fed beef, which raise the total quality of my pasture, resulting in more pounds of beef produced than if I just had perennial pastures," stated Bruce.

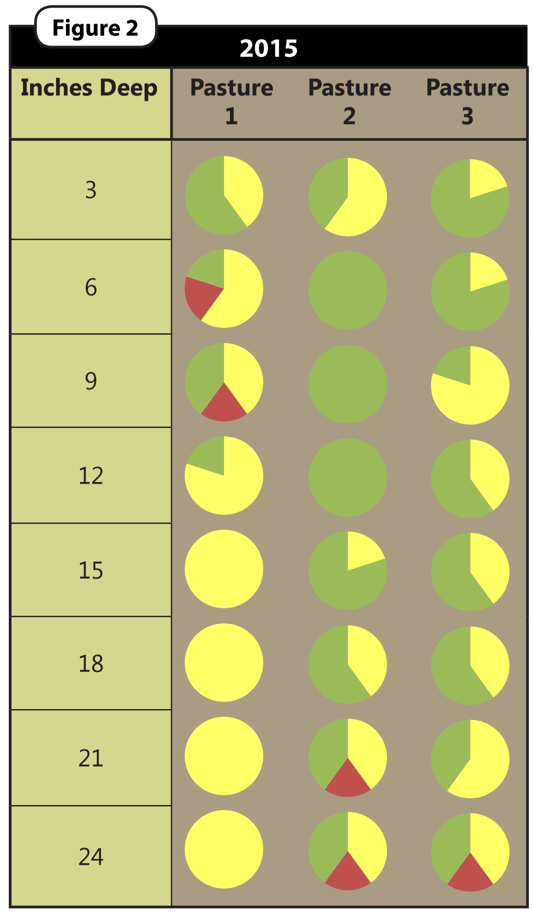
Cows graze at Bruce Carney's farm.

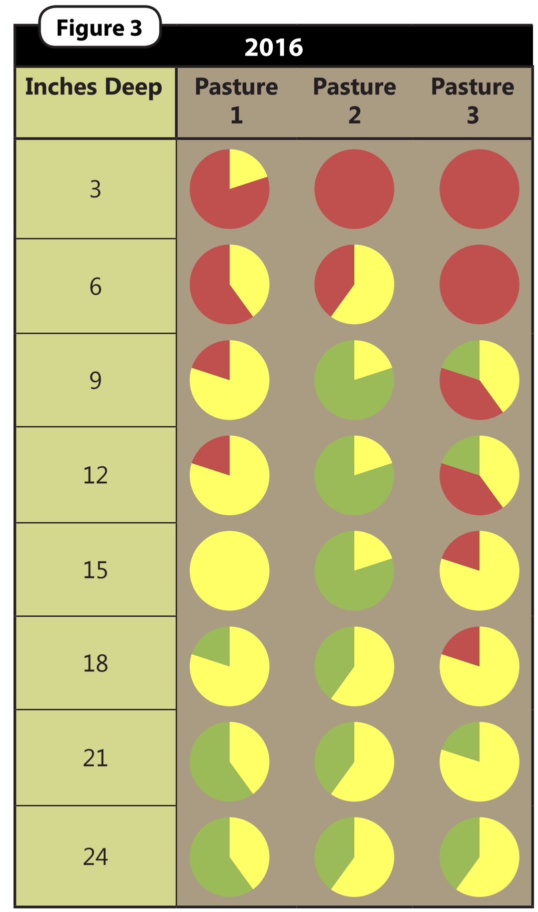
Soil penetration resistance (**Figures 1, 2, 3**) was measured with a probe penetrometer to determine soil compaction in April of 2014, 2015, and 2016. The resistance required to push the probe through the soil profile was recorded every three inches to a depth of 24 in. Penetration resistance is represented in the figures as green (low), yellow (medium) and red (high).

In 2014, baseline penetration resistance readings were taken prior to interseeding. **Figure 1** shows pasture 1 has the greatest compaction, which may be due to this pasture receiving the most livestock traffic over the years, as it is closest to the house. All of the pastures show the greatest resistance between six to 12 in., and above and below those depths, there is less compaction. Based on these results, Bruce keyline plowed pastures 2 and 3 in early April 2015, at a depth of 12 to 18 in., to break up existing compaction layers. Keyline plowing was achieved using a Yeoman's plow, which is designed to aerate the subsoil while minimizing soil surface disruption.

From April 2014 to April 2016, the pastures all received at least three seedings of annuals (Chamas, 2015; **Tables 1 and 2**) and were rotationally grazed. One of Bruce's project goals is to alleviate compaction in his pastures. He interseeded with species that grow deep roots, in particular the radish, to penetrate and break up compaction layers. **Figure 2** represents penetrometer readings from April 2015, which shows improvements in penetration resistance in all pastures, especially between six to 18 in. This alleviation may be due to the keyline plowing that Bruce did before taking penetrometer readings, although he carefully took measurements in-between the plow slits. **Figure 3** represents penetrometer readings from April 2016, which shows more compaction above six inches and less compaction below 21 in. than the previous years. United States Department of Agriculture (USDA) researchers in Georgia have shown greater penetration resistance in grazed than ungrazed fields, but only at a depth of 0 to 4 in. From 4 to 11 in., there was less compaction where grazing took place (Franzluebbers and Studemann, 2008). Researchers have also stated diverse forages and their active, extensive root systems improve soil structure and contribute to organic matter, helping to alleviate compaction below the ground (Hoorman et al., 2011). Bruce noted that the soil surface was dryer in 2016, compared to when he took penetrometer readings in past years. "We received 1.3 in. of rain between April 1 and April 19, and the penetrometer was much harder to push in this time. I think dry soil has more to do with compaction near the surface level than grazing does," stated Bruce. These observations imply that lack of soil moisture, plus hoof action from the cattle grazing, contributed to compaction near the soil surface, but root systems are working to break up compaction deeper down in the soil.







Figures 1-3. Penetration Resistance (psi) from 3-24 in. depth in interseeded pastures. Green represents compaction ranging from ≤200 psi, yellow represents 200-300 psi, and red represents ≥300 psi. Measurements were taken on the following dates: Figure 1 - April 11 and 14, 2014; Figure 2 - April 28, 2015; Figure 3 - April 19, 2016.

Conclusions and Next Steps

Bruce found that interseeding annual forage species into existing perennial pastures boosted forage production and increase forage diversity while provided adequate nutrition to his grass-fed cattle. Over two years, these seed mixes and their root structures have shown to alleviate compaction 21 in. below the soil surface.

Bruce will continue to interseed annuals and monitor the same pastures in 2016, but will also collect data from two perennial pastures that are not being seeded with annuals. This will help him compare the quantity and quality of the forage produced in both systems.

"My next steps forward are even more diverse seed mixes and continuing to bale annual species for high-quality winter feed. I heard that you need to plant a mix of eight to 15 species to start getting plants to feed each other and improve the biology of the soil," stated Bruce. Haney soil tests will be taken again in April 2017. In the meantime, Bruce will continue to experiment with seed mixtures in hopes to produce high quality grass-finished cattle while building soil health.

Cows graze warm-season pasture at Bruce Carney's farm.

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